BOOK OF PROCEEDINGS

10th International Congress on "Environment and Soil Resources Conservation"

Soil Science Society of Kazakhstan Cooperation with the Federation of Eurasian Soil Science Societies and U.U. Uspanov Institute of Soil Science and agrochemistry

17 - 19 October 2018, Almaty, Kazakhstan

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UDC 631.4
LBC 40.3
E 54

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E54 Environment and Soil Resources Conservation: book of proceedings 10th International Soil Science Congress. Almaty, 2018. – 435 p.

ISBN 978-601-7567-21-7

Annotation. The materials of the 10th International Congress are related to the theme of environmental protection and soil resources. The Congress will provide an opportunity to exchange views on a wide range of issues of modern soil science and prospects of its development. Leading scientists of the world will share innovations that have positive impact on ecology of soil surface. The proceedings present the material of current progress in soil science, the development of a new methodology based on new concepts and achievements, modern methods of soil analysis that will change the future in soil science, as well as our attitude to the environment and agriculture, will facilitate rapid transfer of knowledge on soil science to the welfare of the society and the environment.

This Book of Proceedings has been prepared from different articles sent to the congress secretary only by making some changes in the format. Scientific committee regret for any language and/or aimscope.

Publication date : 1 October 2018

UDC 631.4
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Press
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FOREWORD

The world food issue is one of the most acute global problems which the humanity is facing. The solution of this issue which is a challenge, and in fact a tragedy of modern civilization which has many achievements in the field of science and technology, the level of productive forces development, the possibilities of food production, has been in the focus of attention of the world community for several decades.

Healthy soils are not only the basis for production of food, fuel, fibers and medical products, but also play a key role in the carbon cycle, storage and filtration of water and increased resistance to floods and droughts. However, FAO estimates that 33% of global land resources have already degraded, while human impact on soil is increasing and often reaching critical levels. Land degradation occurs in various forms, including erosion, compaction, sealing and salinization of soil, washing out its organic and nutrient substances, acidification, pollution and other processes associated with unstable land management practices. FAO calls for the joint international efforts aimed to preserve fertile soils for present and future generations.

The aim of the 10th International Soil Congress (3rd EURASIAN SOIL CONGRESS 2018) under the scientific motto "Protection of soil resources and the environment" is to raise the awareness and importance of soils for food security and critical ecosystem functions, as well as promote rational methods of soil use.

The world researchers in their research results shared with recent innovations in relevant fields. The raised and discussed issues of soil scientists are diverse, much attention is paid to the possibilities of natural resource management that affect soil quality, they offer specific solutions to theoretical and practical methods, as well as their influence on the development of soil science.

The results of the researches are presented in the relevant areas of soil science: soil genesis, classification and cartography, geostatistics, remote sensing and GIS; soil physics, erosion and conservation, management of soil fertility; chemical composition and soil contamination; soil biology and biochemistry, soil health and quality; plant nutrition and soil ecology, which give reason to judge not only on the current state, but also the prospects for further development of soil science, which has a scientific and practical interest.

We are confident that the collection of published articles will supplement the series of publications on the most important issue - preservation of soil fertility, protection of soil resources and the environment.

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Taxonomic distance as a tool for finding correlation between soil taxonomy and world reference base classification systems, in calcareous, gypsiferous and saline soils

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Abstract

Nowadays, Soil Taxonomy (ST) and World Reference Base (WRB) are the most popular soil classification systems in the world. Finding correlation between ST and WRB is important to achieve a comprehensive and universal soil classification system especially in salt affected soils. For this, 40 profiles of calcareous, gypsiferous and saline soils in 10 regions of East and West-Azerbaijan provinces in Iran were selected, described and sampled. In addition, physicochemical and semi-quantitative clay mineralogical analysis (in B-horizons) were carried out. Thereafter, soil classification was performed using ST and WRB systems, and Taxonomic distance between soil units, calculated by concept-based (using dominant identifiers) and centroid-based (using physicochemical characteristics) approaches, to obtain the similarities and differences or general relationships between suborders of Salids, Calcids, Gypsids, Xerolls, Aquolls, Xerepts, xerrerts, and Argids and reference soil groups (RSGs) of Solonchaks, Solonetzs, Calcisols, Gypsisols, Kastanozems, Gleysols, Vertisols, and Luvisols. The foundation of both methods was Mahalanobis distance, calculated by the R software. Remarkably, the concept and centroid-based results showed that Calcids were closest suborder to Kastanozem, Gleysols, Solonetzs and Vertisols RSGs rather than Calcisols, but the first closest group to Gypsids was Gypsisols. Also, the both methods referred to the closest RSGs of Solonchaks and Solonetzs for Salids. It can be concluded that the expert based, the concept- and the centroid based methods does not always give the same or predictable results.
Key words: Correlation, Salt affected soils, Soil Taxonomy, Taxonomic Distance, World Reference Base.

Introduction

Based on Gerasimova report (2010) the most accepted and worldwide used classification systems are the Soil Taxonomy (ST 2014) and World Reference Base for soil resources (WRB 2015). Linking two systems together and an attempt to homogenize them was a concern for the soil science experts. Modern classification systems are based on the quantitative characteristics such as diagnostic horizons, properties, and containing materials. This permits opportunities for pedologists with different experiences to classify soils in a similar way and to compare several systems in an easy way. Soil Taxonomy classification system proposes six levels of class names, i.e., order, suborder, great group, subgroup, family, and series (Soil Survey Staff, 2014), while WRB distinguishes only two categorical levels, the first level having, reference soil groups (RSGs) and the second level, consisting of the name of the RSG combined with a set of principal and supplementary qualifiers (IUSS Working Group WRB, 2015). Soil Taxonomy is one of the most accurate soil classification systems, that defines a quantitative frontier for each segment at each level and the role of moisture and temperature regimes is important in this system. According to Bockheim et al. (2014), climate is the most important factor in soil formation at the highest level to define (or to separate) orders or suborders of ST. On the other hand, WRB has been an opportunity to create a common language for naming the soils of the world (ISSS Working Group RB, 1998).In several research works the this two classification systems performance were compared in different conditions such as calcareous soils (Jafarzadeh1988, Esfandiarpour et al 2013, Sarmast et al 2016), gypsiferous soils (Jafarzadeh1991, 1996 Toomanian et al, 2003, Sarmast et al 2016) and saline soils (Jafarzadeh, Esfandiarpour Borujeni et al 2013).

Toomanian et al. (2003) reported that the WRB system was more appropriate than the ST to classify gypsiferous soils in northwest of Isfahan, Iran. Esfandiarpour Borujeni et al. (2011) also observed various qualifiers and higher flexibility of the WRB system for classification of saline soils of Kerman province in Iran, which refer to capability of this system in reflection of field parameters in both horizontal and vertical dimensions of the landscape compared to ST. Also, the same results were reported by Esfandiarpour et al (2013) for Loot area arid soils and calcareous soils of semiarid and arid areas of Iran, respectively. They proposed several subgroups for ST and some qualifiers for WRB to establish better correlation between two systems. In the past, the solidarity was often based on the quality properties and expert opinions, but now solidarity is evaluated by means of both quantitative and qualitative properties and or numerical similarities (Krasilnikov et al. 2009a, 2009b). Due to the importance of relationships and correlations between the soil levels in different soil classification systems, the taxonomic distance and numerical classification were employed in this study. The taxonomic distance as a tool for classification of soils was introduced by Minasny and McBratney (2007) and most common method of taxonomic calculation is Euclidean distance (Dunn and Everitt, 1982), which calculated based on the constitution of the matrix between different classification levels by using the R software package (Baier and Neuwirth, 2007).

In the present research work, both concept and centroid based approaches of taxonomic distance were used for finding correlations between the ST suborders and WRB reference soil groups (RSGs) in classification of calcareous, gypsiferous and saline soils in the arid-semi arid regions East and West Azarbaijan provinces in Iran.

Materials and Methods

The study was carried out in 10 regions of East and West-Azarbayjan provinces such as Dashte-Tabriz, Khaje, Marand, Sardasht, Piranshahr, Oshnaviye, Mahabad, Urmia, Salmas and Khoy (Figure 1) with cold winters and warm summers(IRIMO) and soil moisture and temperature regimes of Xeric and Mesic, respectively (Banaie, 1998).

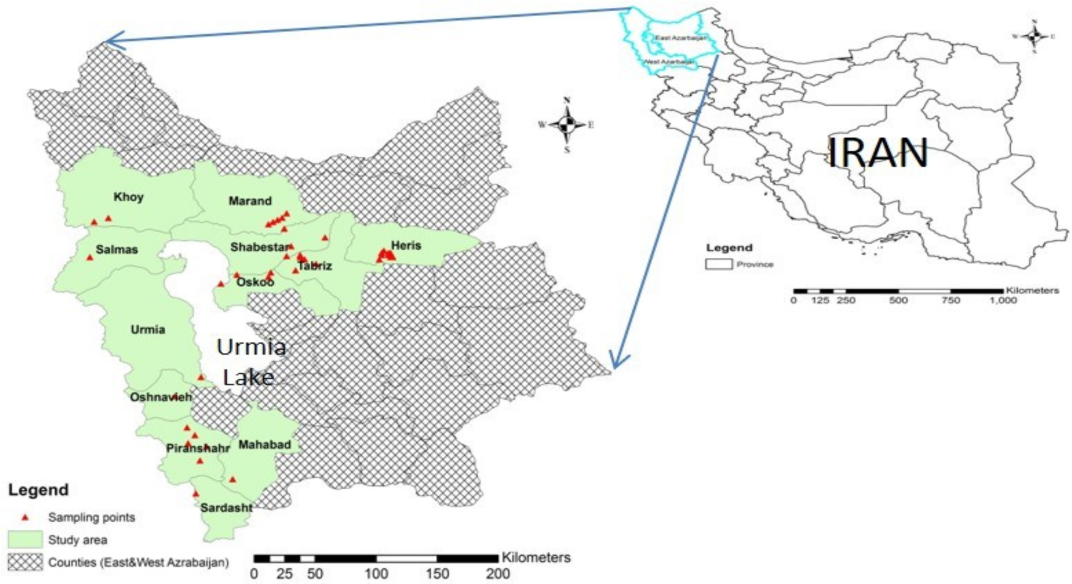

Figure 1. Scheme of study area and sampling sites

Their altitude varies from 1100 m to 1700 m and marl, gypsum, lime, metamorphosed limestones, sandstone tuff, shale and soluble salts are the main parent materials. Based on previous studies 40 profiles were selected and described according to the “Field Book for Describing and Sampling Soils” (Schoeneberger et al., 2012) and then sampled.

After sampling and soil preparation, properties such as texture (Gee and Or, 2002), calcium carbonate equivalent (CCE) (Allison and Moodie, 1965), cation exchange capacity (CEC) (Chapman, 1965), gypsum content and pH_p (Richards, 1954) and EC_e (Rhoades, 1982), exchangeable sodium percentage (ESP) (Jones, 2001) were determined. In addition, semi-quantitative clay mineralogical analysis was carried out in B-horizons of each profile with the highest clay content. Oriented clay slides were prepared according to the standard methods (Kittrick and Hope, 1971, Kunze and Dixon, 1996) and the characteristic peak areas in the diffractograms to identify and estimate the main components of clay minerals were determined using OriginPro 9.4 software (Origin Lab Corporation, Northampton, Massachusetts, 2017). By applying the appropriate weighting factors to the relative area of each peak, the percentage of each mineral was realized. The peaks and respective weighting factors were the weight of the area of the 18 angstrom glycerol peak for montmorillonite; four times (4x) the weight of the 10 angstrom peak on the glycerol pattern for illite; and twice (2x) the weight of the 7 angstrom peak for chlorite and kaolinite (USGS). After data gathering and analyzing the morphological and physicochemical properties of the studied profiles, soil classification was performed using ST and WRB systems (Soil Survey Staff, 2014, IUSS Working Group WRB, 2015). Taxonomic distance was used to obtain the similarities and differences or general relationships between reference soil groups and suborders in two systems. The foundation of this distance was Mahalanobis or Euclidean equation that is calculated by concept and centroid-based approach methods (Minasny et al., 2009 and Lang et al., 2013) and numerical Taxonomy and using the hierarchical clustering method. The conceptual method was based on the dominant identifiers such as soil-forming factors and processes, diagnostic horizons, morphological properties of calcareous, gypsiferous and saline soils and calculated using the matrix table with the common dominant characteristics of the salt-affected soils in both classification systems and related codes of 0, 0.5 and 1. When the identifiers cannot be present (code: 0), or is likely to be present (code: 0.5) or must be present (code: 1), have used and determined based on ST and WRB systems, personal experiences and experts' opinions or knoladge. On the basis of this matrix, the taxonomic distances between the selected ST and WRB groups were calculated using the Mahalanobis equation (Equation.1) by R software (Development Core Team, R, 2009).

$$d_{ij} = \sqrt{\left(x_i - x_j\right)^T \left(x_i - x_j\right)} \qquad (1)$$

where, dij is the element of distance matrix D with size (c×c), c is the number of soils. The value of dij represents the taxonomic distance between soils group i and group j, and X refers to a vector of indicators of the soil identifiers (Minasny et al., 2009).

The centroid-based approach is based on the physicochemical characteristics which are measured in the laboratory and calculated by selected quantitative properties. According to researchers finding in the past (Minasny et al., 2009 and Lang et al., 2013) and expert opinions, a number of 15 important physicochemical characteristics of the studied soils were selected. The correlation between the WRB and the ST was obtained by the R software and the Mahalanobis distance matrix applied for taking into account the covariance (Equation. 2):

$$d_{ij} = \sqrt{\left(x_i - x_j\right)^T S^{-1} \left(x_i - x_j\right)} \qquad (2)$$

where, S represents the covariance matrix. Other elements have been described before.

The foundation of both methods was Mahalanobis or Euclidean distance that is calculated by statistical software including SPSS (Version 24, 2016) and The Algorithms for Quantitative Pedology (*AQP*) and Statistical Analysis Tools for High Dimension Molecular Data (HDMD) packages of R software (Development Core Team, R, 2009).
In addition to taxonomic distance calculations and determining the proximity and similarity between soils, a principal coordinate analysis was performed to visualize the relative position of each soil with the R "cluster" and Flexible Procedures for Clustering (FPC) packages.

Results and Discussion

The obtained morphological, physical, chemical and mineralogical results and classification of 38 profiles in the selected regions revealed Salids, Calcids, Gypsids, Xerolls, Aquolls, Xerepts, xerrerts and Argids suborders or Solonchaks, Solonetzs, Calcisols, Gypsisols, Kastanozems, Glysols, Vertisols and Luvisols reference soil groups with different family and qualifiers in the ST and WRB classification systems, respectively.
The taxonomic distance and numerical Taxonomy between the Specified suborders and reference soil groups of calcareous, gypsiferous and saline soils in the studied area were carried out using concept and centroid-based approaches in different soil classification systems. Based on matching and coding of above named 8 ST suborders and 9 WRB reference soil groups matrix with the final selected dominant identifiers (Table1) in the conceptual method, the taxonomic distance between soil units were calculated using the Mahalanobis equation by R software and the results are reported in Table 2.

Table1. The matrix of suborders and reference soil groups matched and coded with the selected dominant identifiers

Dominant identifiers	**Salids**	**Calcids**	**Argids**	**Gypsids**	**Xerolls**	**Aqolls**	**Xerepts**	**Xer-rert**
Slickensides 0-125	0	0.5	0.5	0.5	0.5	0.5	0.5	1
Moisture regim Aridic	1	1	1	1	0.5	0	0	0
Calcic H.	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5
Gypsic H.	0.5	0	0.5	1	0.5	0.5	0.5	0
Salic H.	1	0	0	0	0	0	0	0.5
Mollic H.	0	0	0	0	1	1	0	0
Duric H.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Natric H.	0	0	1	0.5	0.5	0.5	0	0.5
Argilic H.	0	0	1	0.5	0.5	0.5	0	0
Cambic H.	0	0	0	0	0.5	0	0.5	0
Albic H.	0	0.5	0.5	0	0.5	0.5	0.5	0
Ochric E.	0	0	0	0	0	0	0.5	0
Umbric E.	0	0	0	0	0	0	0.5	0
Litic cantact	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5
abrupt textural change <100	0	0.5	0.5	0	0.5	0.5	0	0
aquic coundi-tion*	0.5	0	0.5	0	0.5	1	0.5	0.5
anthraquic coundition	0.5	0.5	0.5	0	0	0	0	0

Continuation of table 1

Dominant identifiers	**Solon-chaks**	**Solo-netzs**	**Cal-cisols**	**Gyp-sisols**	**Kastano-zems**	**Glysols**	**Vertisols**	**Luvi-sols**
Slicken-sides 0-125	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5
Moisture regim Aridic	0	0	0.5	0.5	0	0	0	0.5
Calcic H.	0.5	0.5	1	0.5	1	0.5	0.5	0.5
Gypsic H.	0.5	0.5	0.5	1	0.5	0.5	0.5	0
Salic H.	1	0.5	0	0	0	0.5	0.5	0
Mollic H.	0.5	0.5	0	0	1	1	0.5	0
Duric H.	0.5	0.5	0	0	0.5	0	0.5	0
Natric H.	0	1	0	0	0	0	0	0
Argilic H.	0	0	0.5	0.5	0.5	0	0	1
Cambic H.	0	0	0.5	0	0.5	0	0	0
Albic H.	0	0.5	0.5	0.5	0	0	0.5	0.5
Ochric E.	0.5	0.5	0.5	0.5	0	0	0	0.5
Umbric E.	0	0	0	0	0.5	1	0	0
Litic can-tact	0	0	0.5	0.5	0.5	0	0.5	0.5
abrupt textural change <100	0	0.5	0	0	0	0.5	0	0.5
aquic coundi-tion*	0.5	0.5	0.5	0.5	0.5	1	0.5	0.5
anthraquic coundition	0	0	0	0	0	0.5	0.5	0.5

Table 2. Calculated distances between the ST suborders and the WRB RSGs, according to the concept-based approach

RSGs/ Suborders	**Solon-chaks**	**Solo-netzs**	**Cal-cisols**	**Gyp-sisols**	**Kastano-zems**	**Gly-sols**	**Ver-tisols**	**Luvi-sols**
Salids	0.0000	0.0882	0.0588	0.0294	0.0882	0.0882	0.0588	0.0588
Calcids	0.0882	0.0000	0.0294	0.0588	0.0000	0.0000	0.0294	0.0294
Gypsids	0.0294	0.0588	0.0294	0.0000	0.0588	0.0588	0.0294	0.0294
Argids	0.1765	0.0882	0.1176	0.1471	0.0882	0.0882	0.1176	0.1176
Xerolls	0.1471	0.0588	0.0882	0.1176	0.0588	0.0588	0.0882	0.0882
Aquolls	0.1176	0.0294	0.0588	0.0882	0.0294	0.0294	0.0588	0.0588
Xerepts	0.0294	0.0588	0.0294	0.0000	0.0588	0.0588	0.0294	0.0294
Xererts	0.0294	0.1176	0.0882	0.0588	0.1176	0.1176	0.0882	0.0882

Also in the centroid-based approach, after analyzing of studied soil samples and selection of fifteen important physicochemical characteristics, their mean values calculated and weighted based on the thickness of the horizon for each soil group and the matrix of mean values of the dominant quantitative properties and soil groups were created (Table 3).

Table 3. Mean values of dominant quantitative properties for ST and WRB soil groups

Proper-ties/ Subor-ders and RSGs	Clay % 0-25	Clay% 25-100	Sand % 0-100	CEC in clay max	OC% 0-25	CaCO3 % 25-100	CaSO4 % 25-100	EC (dS/m) 0-25	EC(dS/m) 25-100
Calcids	36	39.25	39	17.56	0.747	30.77	0	2.25	3.6
Xerepts	26.05	26.5	43.2	18.8	0.976	21.63	0	0.79	0.637
Xerolls	46.25	46.25	24.62	32.12	1.975	25.27	0	0.542	0.457
Aquolls	60	56	11.66	30	1.8	19	0	0.69	0.69
Xerrert	49	50.5	13	35	1.1	21.5	0	0.4	0.2
Gypsids	40.1	34.09	39.47	17.81	0.439	14.09	21.68	3.849	7.3
Salids	45.86	43.78	18.04	18.08	0.517	17.79	5.35	48.05	44.64
Calcisols	28.13	29.16	40.06	18.83	1.027	21.71	0	1.301	1.586
Luvisols	18	25.2	51.6	21	0.46	26.5	0	0.6	0.4
Kastano-zems	46.25	46.25	24.62	32.12	1.975	25.27	0	0.542	0.457
Gleysols	60	56	11.66	30	1.8	19	0	0.69	0.69
Vertisols	49	50.5	13	35	1.1	21.5	0	0.4	0.2
Gypsisols	39.97	33.24	41.03	16.96	0.444	13.48	21.57	3.931	7.114
Solonetz	48.1	45.5	25.6	19.35	0.303	14.93	8.067	30.69	25.03
Solon-chaks	44.578	42.79	16.7	18.29	0.575	18.81	1	48.87	47.17
Argids	18	25.2	51.6	21	0.46	26.5	0	0.6	0.4

Continuation of table 3

Properties/ Suborders and RSGs	pH 25-100	ESP 0-25	ESP 25-100	Smec-tite%	Illite%	(Kaolin-ite+Clorite)%
Calcids	7.395	2.112	4.52	2.113	77.273	20.61
Xerepts	7.72	2.88	1.79	15.49	61.784	22.709
Xerolls	7.5	1.52	1.32	7.3	72.7	20
Aquolls	7.6	1.53	1.44	8.25	72.9	18.84
Xerrert	7.5	3.8	4.48	16.7	35.35	47.95
Gypsids	7.745	8.8	8.58	12.41	65.71	21.881
Salids	7.7364	38.52	40.36	8.67	70.236	21.079
Calcisols	7.6531	2.77	2.81	9.9	64.579	25.511
Luvisols	8	3.15	1.12	10.92	76.48	12.6
Kastano-zems	7.5	1.52	1.32	7.3	72.7	20
Gleysols	7.6	1.53	1.44	8.25	72.9	18.84
Vertisols	7.5	3.8	4.48	16.7	35.35	47.95
Gypsisols	7.7371	8.8	8.58	13.81	64.383	21.807
Solonetz	8.1167	34.61	36.37	3.97	73.77	22.257
Solonchaks	7.6167	39.87	41.98	10.97	70.795	18.215
Argids	8	3.15	1.12	10.92	76.48	12.6

After collecting and determining the weighted average of the quantitative data (Table 3), the centroid taxonomic distance were calculated using R software. The results are reported in the table 4.

Table 4. Calculated distances between the ST suborders and the WRB RSGs, according to the centroid-based approach

RSGs	Solon-chaks	Solo-netzs	Cal-cisols	Gyp-sisols	Kastano-zems	Glysols	Ver-tisols	Luvi-sols
Salids	0.0347	2.1365	11.5795	8.3927	9.3920	9.2193	9.4807	11.5107
Calcids	9.6653	7.5635	1.8795	1.3073	0.3080	0.4807	0.2193	1.8107
Gypsids	8.2827	6.1809	3.2622	0.0753	1.0747	0.9020	1.1633	3.1933
Argids	11.4760	9.3742	0.0689	3.1180	2.1187	2.2913	2.0300	0.0000
Xerolls	9.3565	7.2547	2.1883	0.9985	0.0008	0.1719	0.0895	2.1195
Aquolls	9.1847	7.0829	2.3602	0.8267	0.1727	0.0000	0.2613	2.2913
Xerepts	11.8813	9.7795	0.3365	3.5233	2.5240	2.6967	2.4353	0.4053
Xererts	9.4460	7.3442	2.0989	1.0880	0.0887	0.2613	0.0000	2.0300

Finally, based on the results of both methods and expert's opinion or knowledge, soil groups association or similarity were checked. With regard to taxonomic distance calculations of the applied methods and the expert's knowledge, the closest WRB RSGs for each suborder in the ST classification system were determined and are reported in Table 5.

Table 5. Possible correlation of ST suborders to related WRB RSGs according to the results of the applied methods compared with expert knowledge

ST suborders	Closest RSGs based on expert knowledge	closest WRB RSG according to the concept based approach	closest WRB RSG according to the centroid based approach
Salids	Solonchaks	**Solonchaks**, Gypsisols	Solonchaks, Solonetzs
Calcids	Calcisols	**Kastanozem, Gleysols, Solonetzs** Calcisols, Vertisols, Luvisols	**Vertisols, Gleysols, Kastanozems**, Gypsisols, Calcisols, Luvisol
Gypsids	Gypsisols	**Gypsisols,** Calcisols, Solonchaks, Vertisols, Luvisols	**Gypsisols** Gleysols
Argids	Luvisols	Kastanozem, Glysols, Solonetz	**Luvisols** Calcisols
Xerolls	Kastanozem	Kastanozem, Glysols, Solonetzs	**Kastanozems** , Vertisols
Aqolls	Kastanozem, Gleysols	Kastanozems, Gleysols, Solonetzs	**Gleysols** , Vertisols
Xerepts	Cambisols	**Gypsisols,** Calcisols, Vertisols, Luvisols	Calcisols, Luvisols
Xererts	Vertisols	Solonchaks	**Vertisols** , Kastanozems

After the proximity and similarity determination and calculation of taxonomic distance, all of them clustered and a principal coordinate analysis was performed to visualize the relative position of each soil. According to obtained results from R software, in the first stage clusters were determined and 3 clusters for clustering of this soils had optimum condition (Figure 2).

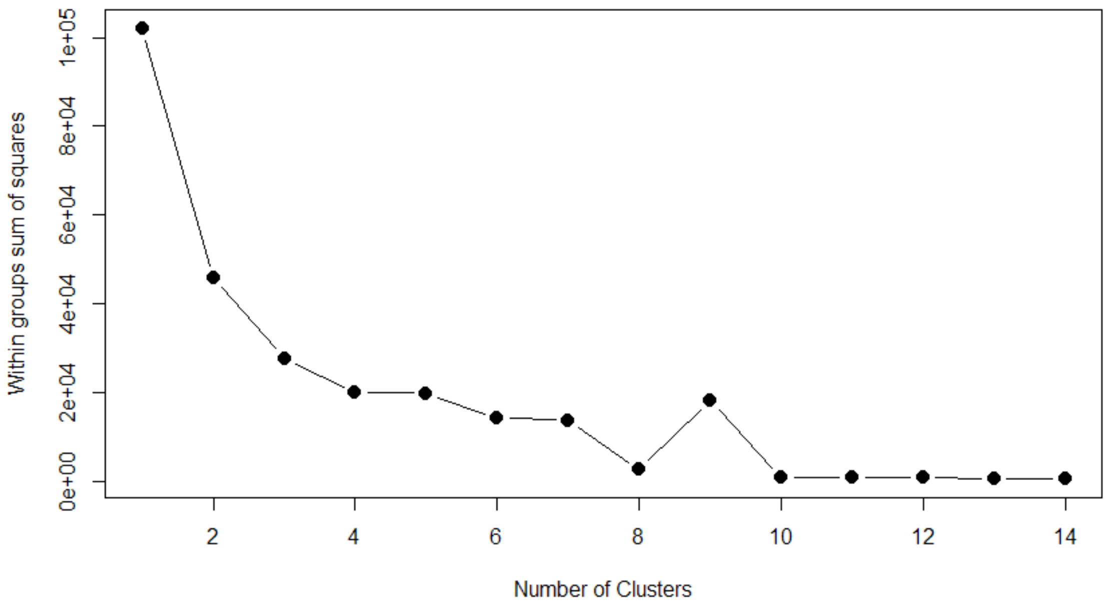

Figure 2. Determine the number of clusters

Analysis of main components (Figure 3) revealed, that clustering can be done by two main components, which 64.7 percent of the total variation explained by clusters of 1 and 2 despite the soils were classified into three clusters (**Cluster1:** salids(1), Solonchaks(7), Solonetz(8), **Cluster2:** Calcids(2), Gypsids(3), xerepts(6), calcisols(9), gypsisols(10), luvisols (14), argids(16) and **Cluter 3:** xerolls(4), aquolls(5), kastanozems(11), gleysols(12), vertisols(13), xerrerts(15)).

The concept and centroid-based approach, numerical Taxonomy and the hierarchical clustering methods results were almost identical and similar with each other, but use of each one had their limits and skills.

The calculated distances between the salids suborder and WRB RSGs by the concept-based approach (Table 2) refers to Solonchaks as a closest reference soil group to the Salids, and Gypsisols in the second level. Because both soils are salt affected in aridic soil moisture regimes and with similar morphological characteristics and similarities based on the lower category of ST. For example, Gypsic Haplosalids that have a gypsic horizon within 100 cm of the soil surface that could be similar to Gypsisols. The expert opinion and the centroid based taxonomic distances confirm the same and the closest RSGs Solonchaks, though the centroid -based method, also describe Solonetzs in Table 4, which it can be reasonable according to their characteristics and 2nd closest RSGs (Solonetzs) based on Foroughifar findings in 2011 (Natrisalids). Also analysis of main components (Figure 3) group this soils in the same cluster (Cluster1).

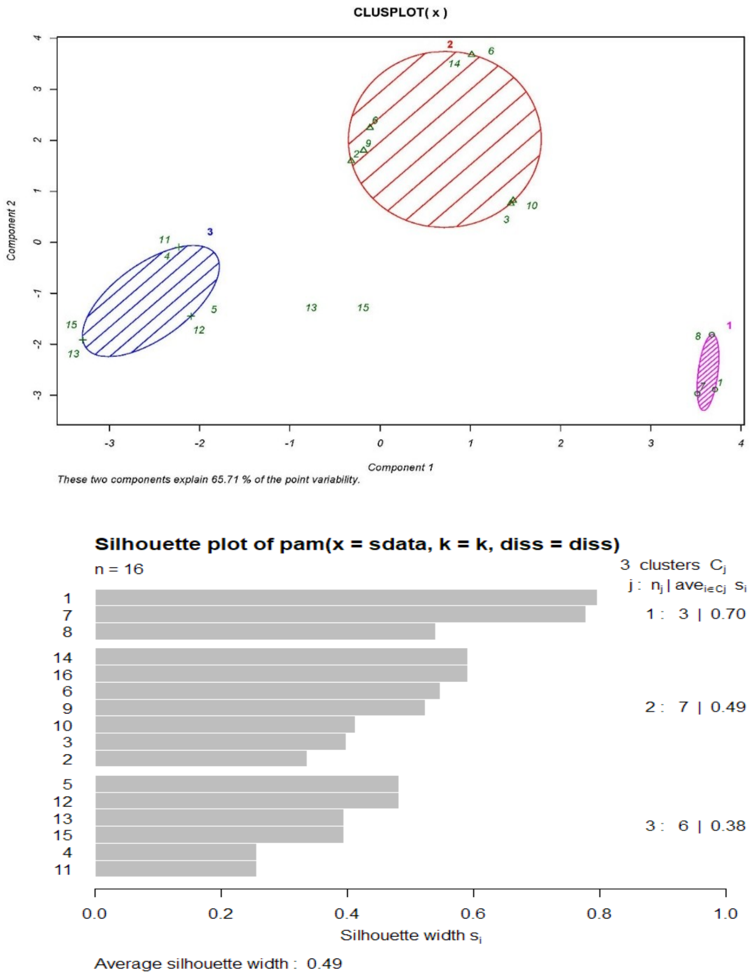

Figure 3. The soils plotted along the two principal coordinates based on the centroid values of quantitative properties

Despite it was expected that calcisols is the nearest group to Calcids, the concept and centroid-based results (Tables 2 and 4) showed that Kastanozem, Gleysols, Solonetzs and Vertisols are closest groups to Calcids and at the second level Calcisols is the close groups, while closest RSGs based on expert knowledge is Calcisols (Table 5), that calcic horizon and carbonates with high pH in these groups have caused similarity and close relationship. On the other hand, in the lower category of Calcids such as Vertic haplocalcids could be similar to Vertisols, Sodic Haplocalcids and Natric Petrocalcids look like Solonetz and Aquic Haplocalcids could be similar to Gleysols. Also the analysis of main components (Figure 3) group this soils in the same cluster with other suborders and RSGs (Cluster 2). The concept and the centroid based methods and expert knowledge describes Gypsisols as first closest group to Gypsids and the second level closest groups in the concept -based approach were Solonchaks, Calcisols, Vertisols and Luvisols (Table 2 and 5). This result can be explained by the fact that mostly this kind of soils (Solonchaks, Calcisols and Gypsisols) are in relation to arid and salt-affected soils with similar morphological characteristics. The few distance and relationship between Vertisols and Luvisols to this type of soil can be related to the amount and type of clay and morphologic characteristics associated with clay that is common in this soils and also in lower category of Gypsids like Vertic Natrigypsids and Argigypsids similar to them. Gypsic Gleysols with gypsic horizon could be similar to Gypsids that revealed the se-

cond level closest groups in the centroid based methods. Analysis of main components (Figure 3) almost showed the same trend (Cluster 2). Kastanozem, Glysols, Solonetz are the closest groups to Argids according to the concept based method. This similarity and relationship probably related to Aquic Calciargids, natriargids and Calciargids sub categorize of Argids. By the centroid-based method, Luvisols as a close group to Argids is in good agreement with the expert knowledge. But the results are different with the main components analysis. By the presence of calcareous materials and mollic epipedon, it is expected that closest group to Xerolls can be Kastanozem, which have confirmed by the concept and centroid based methods. Gleysols, Solonetzs and Vertisols are closest groups too, their similarities can be explained with some sub categories of Aquic Argixerolls, Natrixerolls and Vertic Argixerolls and also the Aquoll is almost like this suborder and main components analysis (Figure 3) almost showed the same trend (Cluster 3). The weakly developed Xerepts suborder have very common morphological characteristic of other suborders and the results of taxonomic distance calculation showed that Gypsisols, Calcisols, Vertisols, Luvisols are the closest groups, which it can be explained by sub categories like; Calcixerepts, Gypsic Haploxerepts, Vertic Calcixerepts, Lamellic Haploxerepts and this results can be confirmed by the main components analysis (Cluster 2). The closest groups for Xererts, were Vertisols and Solonchaks based on concept and the centroid-based methods and expert knowledge, because this suborder has characterized with slickensides, cracks and high amount of clay and xerert sub category (Halic Durixerert) may be have some similarity with Solonchaks that just Xererts and Vertisols have reported in the same cluster (Cluster 3) by components analysis.
Generally, it can be concluded that the expert knowledge, the concept and the centroid based results are not always identical. The concept based method much better reflects the descriptive soil parameters, while the centroid based approach is much more focused on actual data, so if we do not correct the dominant identifier, we couldn't get accurate results of concept based method. By centroid based method, the results were more reasonable, because of using more accurate quantitative data to calculate the taxonomic distance and similarity. Also Lang et al., 2013 achieved to similar results and concluded that the use of quantitative and numerical data is better than coding and qualitative characteristic. The clustering is a general classification of soils that similar soils were placed in a cluster, this approach is simple but taxonomic distance metrics is quantitative procedure to evaluate the similarities between the soils in comparing the ST and WRB systems. Four different approaches and their result complement each other and each method has its own restrictions (limitations). In general the results of this study showed that there is a good correlation between salids and salonchaks and salonetz, gypsids and gypsisols, argids and luvisols, xerolls and kastanozems, aquolls and gleysols, xerepts and calsisols and gypsisols, xerrerts and vertisols.
Finally, it can be suggested that by adding several sub-groups to ST and several qualifiers to WRB, and by harmonizing some of the definitions proposed for the diagnostic horizons and characteristics, increase the correlation and relationship between two systems.

Acknowledgements (Optional)

This study was supported by the University of Tabriz and we thank for this support.

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Identification of suitable micro catchments for organic agriculture using GIS and remote sensing in east part of the Black Sea region

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Abstract

In recent decades, degradation of environmental quality and decreasing food safety concerns due to excess use of fertilizers and pollutions promoted the organic farming. In addition, organic agriculture has developed rapidly in the world and global organic food market has been growing. Organic farming has a great scope in the Artvin Province because of its climatic and other environmental conditions. The main crops are hazelnut and tea plant cultivation in Artvin province. The purpose of this study was to determine suitable micro catchments for organic farming by using GIS and Remote sensing techniques in Artvin Province located at the east part of the Black Sea of Turkey. Remote sensing and GIS can play an important role in the identification of the suitable zones for the development of organic farming in more facile manner. Total 142 micro catchments were determined in Artvin Province using DEM by means of Hydrology Tools. After removing forest, pasture, bare lands and, also artificial areas such as settlement, road, industrial area and so on, 18 micro catchments were selected by taking into consideration of their arable land size. From arable lands located in selected catchments, total 242 soil samples were collected from surface (0-20 cm) and subsurface (20-40 cm) depths to determine their physical, chemical, nutrient element status and heavy metal content. According to results, micro catchments coded as 1, 6, 7, 12 located around Ardanuç, Şavşat and Arhavi Districts were determined nickel concentration which is over the threshold in both depths due to volcanic parent material. In addition to that, high cupper heavy metal content was found in some micro catchments coded as 4 and 5 located around Borçka District due to strong acid condition. On the other hand, other micro catchments located around Arhavi, Yusufeli and Şavşat such as 2, 3, 10, 11, 13, 14, 15, 16, 17 and 18 were detected as suitable micro catchments for organic agriculture activity.

Key words: Organic agriculture, micro catchment, GIS and RS, Artvin.

Introduction

In recent decades, degradation of environmental quality and decreasing food safety concerns due to excess use of fertilizers and pollutions promoted the organic farming. In addition, Organic farming can play an important role for socio economic development and to make rural people self-sustainable. Thus, organic agriculture has developed rapidly in the world and global organic food market has been growing.

Avoidance of the external inputs such as conventional fertilizers, pesticides and staying far chemical contamination makes its environmentally friendly. Leifeld (2012) indicated that organic farming also lowers the nitrogen losses from soil and enhances soil carbon sequestration. In order to gain optimum production suitable land, local environmental and geological conditions are mainly necessity. Identification of suitable lands for organic farming or agriculture requires consideration of various topological environments, climatic and geophysical limitations (Kamkar et al., 2014). Therefore, accurate and recent land use and land cover (LULC) and other geophysical data should be taken into consideration for evaluation environmental concerns (Deep and Saklani, 2014). Geographical Information System (GIS) and Remote Sensing (RS) techniques can be used for the detection of the appropriate sites for the organic farming on different criteria such as, geology, soil quality, stay far from artificial areas (settlements, highway, industrial zone etc.), drainage, topography of the place. In addition these tools can also help to identify and prioritize the potential sites for the organic farming. Mishra et al (2015) performed research about identification of suitable sites for organic farming using GIS and RS in Uttarakhand covering with 64.76% of its area under Himalayan forest providing the exquisite biodiversity and differences in climate with a miscellany of flora and fauna. According to their study, 1212.7 km^2 was determined the most suitable site for organic farming whereas, 2816.4 km^2 of the total study area was determined as not suitable for organic farming.

Recent advances in space and computer technologies have provided us with the opportunity to process for huge areas associated with large amounts of data (multi-source), not only spectral data but spatial data such as relief, aspect, slope, and elevation (Bayramin 1998). Burrough (1986) introduced the principles of GIS tools for collecting, storing, manipulating, and displaying spatial data, and Eedy (1995) reported the advantages of using GIS in environmental assessment. In this context, GIS represents a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world. RS also provides valuable data for LULC, environmental monitoring and disaster management. Hereby, the integration of GIS and RS technologies has applied to detect micro catchments which are suitable for organic farming

Organic farming has a great scope in the Artvin Province because of its biodiversity climatic and other environmental conditions. Therefore Artvin province has great potential for the development of organic farming. Management of organic farming is necessary for the conservation and protection of natural treasures with economic improvement of the local people. That's why, it is a strong reason for the applicability of this study. Consequently, in this current research, a methodology was proposed to determine suitable micro catchments for organic farming by using GIS and RS techniques based on some natural criteria in order to boost and contribute rural economies to make self-sustainable villages in Artvin Province located at the east part of the Black Sea of Turkey.

Materials and Methods

Field description

This study was carried out in Artvin province in the Eastern Black Sea region of Turkey. The Province of Artvin is coordinated between 4500000-4600000 North and 180000-300000 East (UTM- 38 Zone m) (Figure 1). Total area of the Artvin is about 7623.8 km^2. However, arable land selected for this study covers approximately 12% of the total area. On the other hand, 68.9% of the study area is covered by forest and pasture lands.

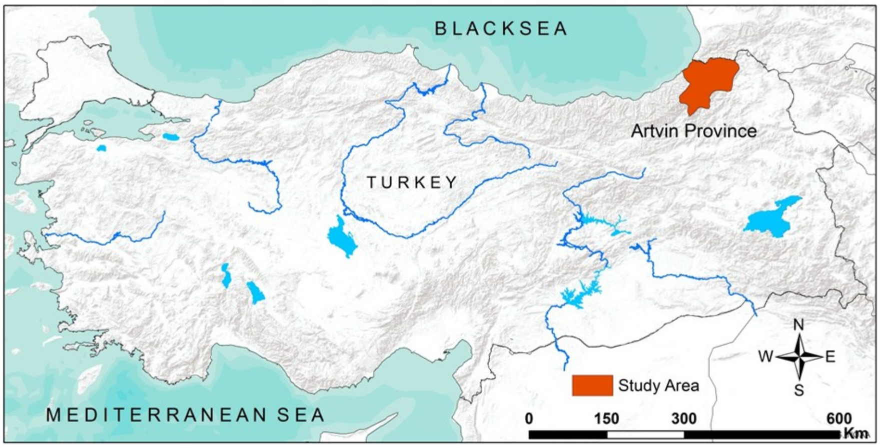

Figure 1. Location map of the study area

The climate can be described as sub-humid and according to long term meteorological data (1974-2017), average annual precipitation and temperature of the study area are 809 mm and 10.2 ºC, respectively. The study area lies at an elevation above the sea level from 0 to 3929 m. The region has topographically very heterogeneous topographic features such as hilly, rolling, flat, etc., but particularly hilly and rolling physiographic units are common in the study area, only 2.7% of the total area is almost flat and gentle slope (Figure 2). Most of the total area corresponding with 681417.6 ha has more than 20% slope degree. These steep slopes play an important role in growing hazelnut and tea which are main agricultural products of the region.

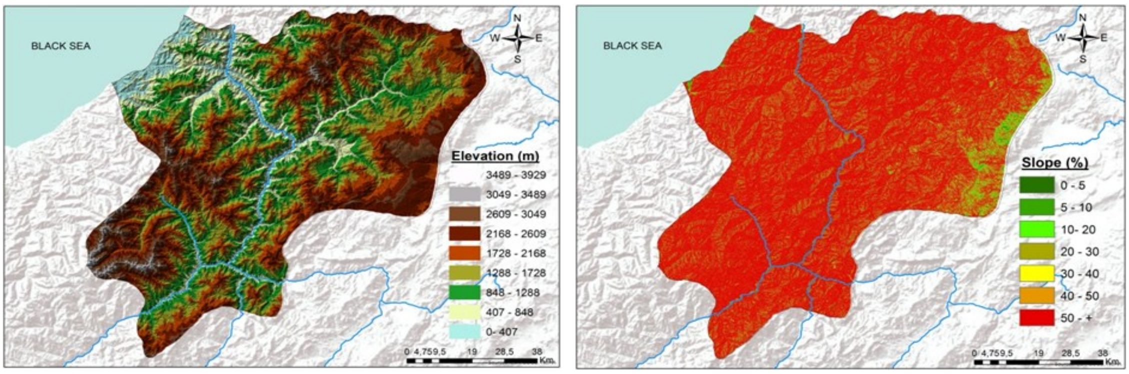

Figure 2. Elevation and slope maps of the Artvin Province

Determination of micro catchments

In order to determine micro catchments for organic farming in the Artvin province, it was performed in three main steps which were i-collection of spatial and non-spatial data, ii-determination of all micro catchments in the study area, iii- identification of which catchments suitable for organic farming based on some criteria such as topography, land use-land cover (LULC), geology, soil data etc. Schematic representation of the methodology was given in Figure 3.

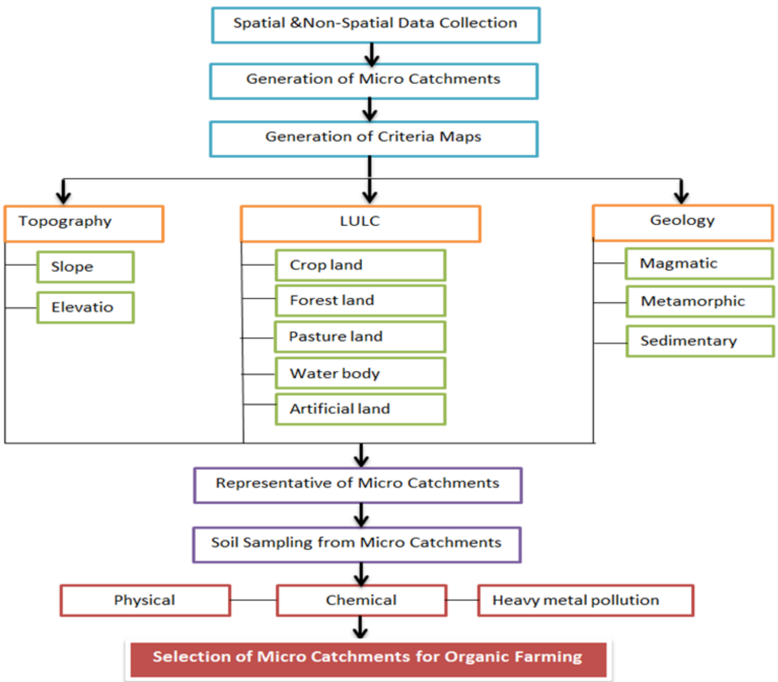

Figure 3. Schematic representation of the methodology

In first step, to produce all micro catchments, topographic map scaled 1:25:000 was digitized for generating of Digital Elevation Model (DEM) then, some watershed processes (fill skins, flow direction, flow accumulation, stream definition, stream segmentation, catchment grid delineation and catchment polygon process) were performed using DEM in Hydrology tool of ArcGIS program. In second step, it was formed also some topographic features such as elevation, slope, aspect, hill shade layers. In addition, in order to determine land use and land cover pattern of the study area, CORINE LULC classification system was taken into consideration of satellite image to separate water body, forest, pasture and artificial lands in micro catchments. In this context, it was also determined soil pysico-chemical and heavy metal concentration in representative micro catchments selected previous process.

Soil Sampling and analysis

Field study was conducted in 2017. In total 242 soil samples from mostly Leptosol and Lixisol-Alisols-Acrisols soil units (FAO/WRB, 2014) were taken on agricultural lands. The sampling was carried out after harvest in the autumn and before start of the next cropping season in order to avoid the influence of agricultural practices during the crop growing season, i.e. fertilization. 129 soil samples were taken from soil surface layer (0–20 cm), while 113 soil samples were collected from sub surface (20-40 cm). In addition, their coordinates were recorded using global positioning system (GPS) tool. Samples were air-dried and sieved through a 2 mm sieve to be prepared for analyses. Soil requirements for organic farming including soil physico-chemical properties, nutrient elements and heavy metal concentration were determined based on literature (Lindsay and Norvell, 1978; Kloke, 1980). Table 1 shows the selected analytical protocols.

Table 1. Protocol measurements for some soil physical and chemical properties

Parameters	Unit	Protocol	Reference
Texture (Clay, Silt and Sand)	%	hydrometer method	Bouyoucos (1951)
pH	1:1	(w:v) soil-water suspension	Soil Survey Laboratory (1992)
EC	dSm^{-1}	(w:v) soil-water suspension	Soil Survey Laboratory (1992)
Ca2CO3 (CaCO3)	%	Scheibler calcimeter	Soil Survey Staff (1993)
Organic Matter	%	Soil organic carbon by a modified Walkley-Black method	Soil Survey Laboratory (1992)
$NaHCO_3$–P	mg kg^{-1}	Bray-Kurtz and Olsen	Kacar, 1994
Total N	%	Kjeldahl	Bremner and Mulvaney (1982)
NH4OAC–K, Ca, Mg, Na	mg kg^{-1}	Ammonium acetate extraction, flame spectrometry detection	Soil Survey Laboratory 1992
DTPA–Cu, Fe, Mn, Zn	mg kg^{-1}	DTPA extraction, AAS detection	Lindsay and Norvell (1978)
Total heavy metal (Cu,Cd,Cr,Pb,Co,Ni,Zn)	mg kg^{-1}	According to EPA 3051 sing ICP-OES detection	Kloke (1980)

Some physico-chemical characteristics of soil such as the organic matter, pH, and lime contents, and the particle size fractions are of great importance in the heavy metal toxicity of soils. The calculation of the enrichment factors (EF) for the heavy metals was made using an equation suggested by Sposito (1989) and Agbenin (2002)

$EF = (HM_{soil}) / (HM_{earth})$

where HM_{soil} is the total heavy metal concentration in the soil sample, and HM_{earth} is the mean heavy metal concentration in the earth's crust, which is 0.11 mg kg^{-1} for Cd, 50 for Cu, 100 for Cr, 20 for Co, 80 for Ni, 14 for Pb, and 75 mg kg^{-1} for Zn (Sposito, 1989).

Based on the EF value, five categories of pollution were distinguished by Sutherland (2000): the absence of enrichment (<2), moderate enrichment (2–5), high enrichment (5-20), very high enrichment (20–40), and extremely high enrichment (>40).

Results and Discussions

Representative micro catchments

According to TUİK (2015), almost 56% of population of province depending on agriculture has a great potential for organic farming. The implementation of organic farming in the Artvin province will not only encourage the rural economy but also promote the rural tourism and diversification of farmers and thus, prevent the migration of people from hilly region. The cost of the productivity, net profit and the total labor cost are key factors in adaptation of new technologies like organic farming (Thapa and Rattanasuteerakul, 2011). So selection of appropriate land which is having the maximum productivity, maximum net profit on lesser input is expected. For that reason, after watershed operation in ArcGIS, total 142 micro catchments were detected in Artvin province using DEM and presented in Figure 4.

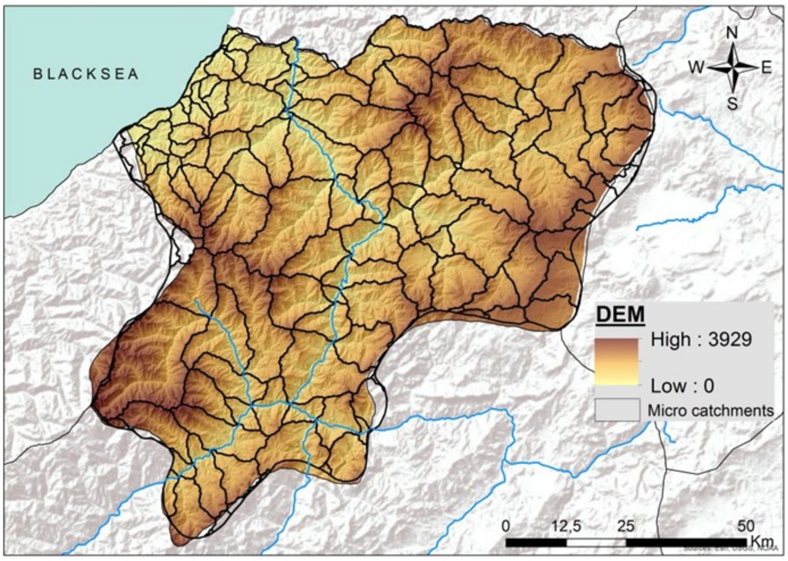

Figure 4. Micro catchments used DEM in Artvin province

In order to fulfil organic farming activity in the study area, it should be chosen suitable sites in 142 micro catchments based on some criteria. Firstly, some topographic properties (slope and elevation) were combined with micro catchments. Demirağ (2017) indicated that more than 12% slope lands are not appropriate for cultivation due to soil erosion risk. In the study area more than half of the study area has steep slope position. In addition to that, about more than 2000 m elevation is also not suitable for agricultural activities in the study area. Secondly, forest, rocky, pasture and crop lands were extracted from LULC map based on CORINE-LULC classification system in the study area and given Figure 5.

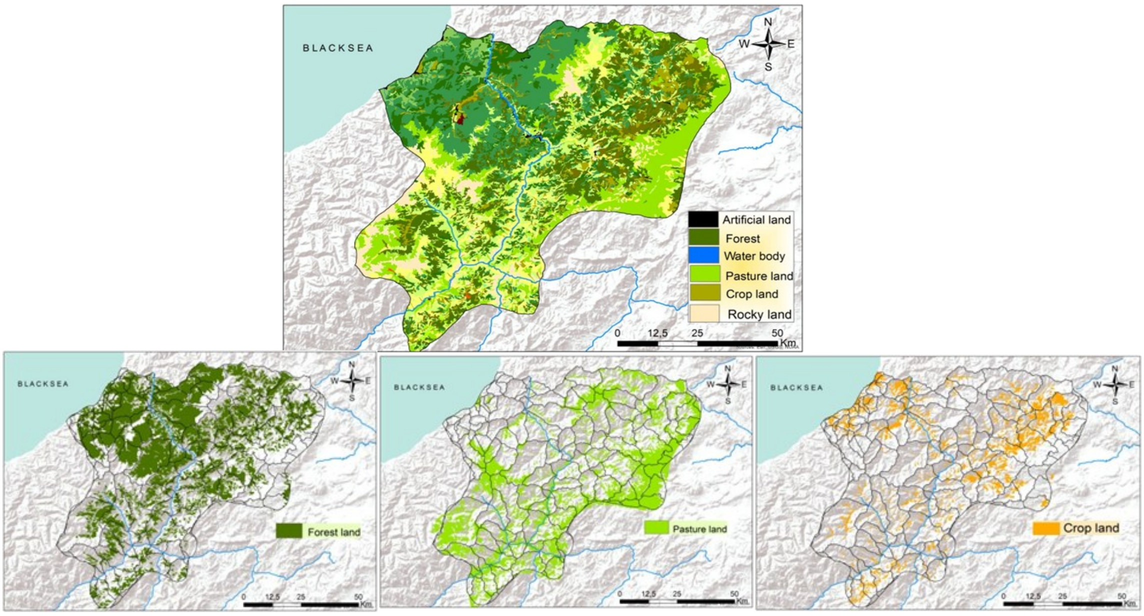

Figure 5. Extraction of forest, pasture and crop lands from LULC map of the study area

In addition to that processes, some artificial areas (harbour, settlement, industrial zone etc) were extracted from LULC map of the study area and buffer zone process was applied 1 km for highways and 500 m for sub-secondary road to escape for heavy metal pollution of traffic (Figure 6).

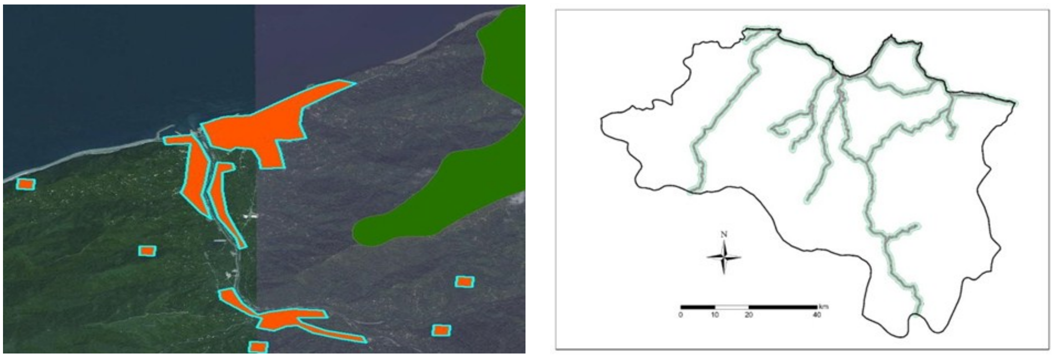

Figure 6. Extraction and buffer zones for settlement and roads in the study area

Finally after all process, representative 18 micro catchments which include dominantly agricultural land were selected to take soil samples (Figure 7).

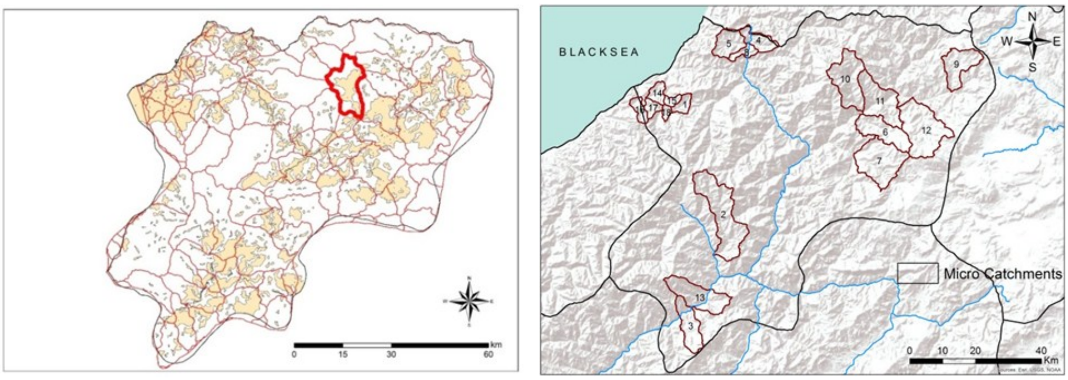

Figure 7. Selection of representative micro catchments from total micro catchments

Soil physico-chemical properties

The physico-chemical characteristic selected in this study showed changefulness as a result of dynamic interactions among natural environmental factors, including the degree of soil formation, leaching process, and agricultural activities such as tillage systems or fertilization (Dengiz et al. 2015). The descriptive statistical parameters such as mean, maximum, minimum, and coefficients of variation (CV) of the some basic physico-chemical properties and macro-micro nutrient elements related to 242 soil samples taken from surface (0-20 cm) and subsurface (20-40 cm) of the crop lands in 18 micro catchments of the Artvin province were given in Table 2. In order to determine variability of some physico-chemical soil properties, many researchers offer to investigate coefficient of variation (CV). According to CV values, it was classified as low (<15%), medium (15-35%) and moderate (> 35%) (Mallants et al. 1996). In this case, variables of sand, silt and pH have moderate CV. On the other hand, the variables of clay, EC, CaCO3 content and OM of soils had a high level of variability. In addition to that, variability of all nutrient elements was found as high CV in surface soil samples. The values of pH in soil samples ranged from strong acid to slightly alkaline (3.56 and 7.89), whereas electrical conductivity had a minimum value of 0.02 dS m^{-1} and a maximum value of 1.20 dS m^{-1}. The mean values of organic matter and $CaCO_3$ content (%) were 3.52 and 2.53. Table 2 shows also macronutrient status of the soil samples available P and exchangeable K showed high variation between minimum and maximum values. Total N varied between 0.02 and 0.58 and the average value of total N was 0.22. Moreover, according to limit values reported by Lindsay and Norvell (1969, 1978) and FAO (1990) for micro nutrient elements, only available Zn was found insufficient amounts in most of the soil samples (about 46.5%) and their mean values are 1.24 mg kg^{-1}.

As for subsurface soil samples in Table 2, while variables of sand, silt and pH have medium CV, the variables of other parameters of soils have a high level of variability. Range of the soil reaction and EC values showed similarity with surface soils' values. This case can be said for OM and CaCO3 content; the mean values of OM and $CaCO_3$ content (%) were 2.30 and 3.42. In addition, micro and macro nutrient elements showed similar variability when compared to surface soil samples.

Table 2. Descriptive statistical analysis of physico-chemical properties and nutrient elements of soil samples

Parameters	Mean	SD	*CV	Varians	Min.	Max.	**Skewness	Kurto-sis
1	2	3	4	5	6	7	8	9
Surface (0-20 cm, *n:129*)								
Sand (%)	51.13	12.25	23.95	149.95	24.6 0	82.59	0.27	-0.26
Clay(%)	24.21	10.13	41.85	102.63	6.97	48.45	0.29	-0.78
Silt (%)	24.66	5.80	23.53	33.66	9.76	42.97	0.09	0.45
pH (1:1)	5.94	1.12	18.90	1.26	3.56	7.89	-0.32	-1.01
EC (dS m^{-1})	0.43	0.26	60.72	0.07	0.02	1.20	0.50	-0.67
CaCO3(%)	2.53	6.04	238.93	36.50	0.00	32.34	2.85	8.38
OM (%)	3.52	1.82	51.62	3.31	0.10	9.08	0.75	0.47
AvP (mg kg^{-1})	12.60	18.11	143.73	327.90	0.29	133.25	16.97	3.56
exNa(mq100g^{-1})	0.09	0.09	108.91	0.01	0.00	0.71	23.82	4.46
exK (mq100g^{-1})	0.46	0.30	65.59	0.09	0.03	1.30	0.02	0.91

Continuation of table 2

1	2	3	4	5	6	7	8	9
exCa (mq100g^{-1})	21.85	16.25	74.35	263.91	0.00	62.35	-0.87	0.37
exMg(mq100g^{-1})	2.94	2.26	77.07	5.12	0.09	9.88	0.50	0.96
TN (%)	0.22	0.11	48.57	0.01	0.02	0.58	0.87	0.86
B (mg kg^{-1})	2.12	0.86	40.51	0.74	0.78	4.77	-0.03	0.63
AvFe (mg kg^{-1})	12.17	12.54	103.01	157.18	1.44	64.12	5.88	2.34
AvCu (mg kg^{-1})	5.80	13.94	240.49	194.23	0.19	100.24	34.25	5.70
AvZn (mg kg^{-1})	1.24	1.60	129.39	2.56	0.12	11.55	19.54	4.04
AvMn (mg kg^{-1})	26.97	19.45	72.11	378.32	0.42	83.15	-0.06	0.87
Subsurface (20-40 cm, *n:113*)								
Sand (%)	47.26	12.47	26.39	155.50	20.45	82.02	-0.31	0.11
Clay(%)	27.63	10.69	38.67	114.21	9.79	53.86	-0.72	0.30
Silt (%)	25.11	5.67	22.56	32.09	8.16	43.58	1.43	0.09
pH (1:1)	5.96	1.17	19.72	1.38	3.50	7.93	-1.20	-0.25
EC (dS m^{-1})	0.39	0.25	64.87	0.06	0.04	1.05	-0.86	0.46
CaCO3(%)	3.42	7.12	208.14	50.73	0.00	30.85	4.25	2.26
OM (%)	2.30	1.11	48.49	1.24	0.15	5.64	0.04	0.64
AvP (mg kg^{-1})	8.90	13.80	155.04	190.33	0.14	80.30	10.68	3.07
exNa (mq100g^{-1})	0.10	0.10	100.54	0.01	0.00	0.75	20.97	3.96
exK (mq100g^{-1})	0.39	0.28	71.76	0.08	0.01	1.41	0.97	1.12
exCa (mq100g^{-1})	22.69	17.40	76.69	302.88	0.00	68.81	-0.42	0.48
exMg (mq100g^{-1})	3.05	2.55	83.57	6.50	0.09	10.75	0.72	1.05
TN (%)	0.16	0.07	41.97	0.00	0.01	0.36	1.42	0.86
B (mg kg^{-1})	2.01	0.95	47.12	0.89	0.47	5.79	2.54	1.21
AvFe (mg kg^{-1})	10.81	12.67	117.22	160.65	1.44	75.99	8.65	2.75
AvCu (mg kg^{-1})	4.04	6.58	162.69	43.27	0.14	64.27	64.09	7.30
AvZn (mg kg^{-1})	0.92	1.33	144.20	1.77	0.12	9.37	20.17	4.18
AvMn(mg kg^{-1})	22.53	16.95	75.23	287.40	0.63	82.32	2.04	1.36

SD: Standard deviation, Min.: Minimum, Max.: Maximum, n: sample number, *CV (Coefficient of Variation**)**, **skewness:< │±0.5 │= Normal distribution, 0.5- 1.0 = Application of character changing for dataset, and > 1,0 → application of Logarithmic change

The concentrations of heavy metals in the soils

As for the concentrations of heavy metals in the surface and subsurface soils given in Table 3, it was determined that variables of heavy metal concentration of soils had a high level of variability. In the soils studied, the concentrations of Cu amounted to 14.84–198.69; Cr, 3.75-

124.05; Pb, 4.83-115.50; Co, 5.47-52.79; and Ni, 17.19-136.27 mg kg^{-1}. In all the cases, the heavy metal contents were higher than those given in Table 3. Only, Cd and Zn concentration not exceeded their permissible threshold level in all of the soil samples. While 17% of the soil samples was found Ni concentration exceeded its maximum permissible value and illustrated its grouping in representative micro catchments, Cu concentration passed maximum level of permission in 6% of soil samples. Furthermore, only in one sample an elevated Cr and Pb content was found.

Table 3. Some statistical characteristics for the total heavy metal contents and maximum permissible concentration in the soils studied, mg kg^{-1}

Heavy Metals	Mean	SD	*CV	Varians	Min.	Max.	**Skewness	Kurto-sis	MPC
Surface (0-20 cm, *n:129*)									
Cu	54.27	27.30	50.31	745.53	14.84	198.69	4.77	1.58	100
Cd	0.49	0.44	90.33	0.20	0.00	2.50	2.74	1.47	3
Cr	28.82	18.74	65.04	351.26	3.75	124.05	6.71	2.12	100
Pb	16.09	351.26	94.61	231.65	4.83	115.50	21.22	4.18	100
Co	7.67	6.71	76.45	34.38	5.47	52.79	26.50	3.76	50
Ni	28.86	2.12	76.65	489.44	17.19	136.27	7.09	2.21	50
Zn	50.44	65.04	41.75	443.36	24.15	131.62	3.37	1.83	300
Subsurface (20-40 cm, *n:113*)									
Cu	52.76	26.85	50.89	720.88	1.62	190.83	5.28	1.68	100
Cd	0.46	0.45	98.22	0.20	0.00	2.73	6.28	2.08	3
Cr	28.68	18.80	65.57	353.59	1.74	148.66	13.87	2.71	100
Pb	14.85	15.99	107.70	255.81	2.75	127.56	27.93	4.90	100
Co	7.70	5.95	77.24	35.36	0.00	52.71	28.55	4.01	50
Ni	28.83	22.30	77.35	497.41	0.31	162.39	10.97	2.53	50
Zn	47.43	20.27	42.73	410.79	1.74	157.49	9.12	2.40	300

SD: Standard deviation, Min.: Minimum, Max.: Maximum, MPC: Maximum permissible concentration, n: sample number, *CV (Coefficient of Variation), **skewness:< $|\pm 0.5|$ = Normal distribution, 0.5-1.0= Application of character changing for dataset, and > 1,0 → application of Logarithmic change

According to results, micro catchments coded as 1, 6, 7, 12 located around Ardanuç, Arhavi and Şavşat Districts were determined accumulation of Ni concentration which exceeded maximum permissible concentration (MPC) in the both soil depths of the east and northern parts of the Artvin province area. This relatively high Ni concentration level is not related with industrial or other anthropogenic pollution. It can be said natural case namely; it appears to be associated with the properties of the parent (volcanic) rock. As Chen et al. (2005) and Kızılkaya (2011) reported, the Ni concentration in volcanic rocks is 20–40 times greater as compared to other ones. All the heavy metal concentrations determined in the soils of the test plots were lower than the threshold ones. In addition to that, high Cu heavy metal content was found in some micro catchments coded as 4 and 5 located around Borçka District due to strong acid condition of soil samples. The second reason, an elevated Cu concentration (>100 mg kg^{-1}) was recorded in the north western parts of the territory. This fact is likely related to the wide application of pesticides containing copper. On the other hand, the other micro catchments codded as 2, 3, 10, 11, 14, 15, 16, 17, 18 and located around Arhavi, Yusufeli and

Şavşat Districts were detected as suitable micro catchments for organic agriculture activity due to no contamination of heavy metal (Figure 8). Moreover, Pb and Cu have (105.97 and 115.5 mg kg^{-1}) over threshold level in each one soil sample in micro catchments coded as 9 and 13. This case can be assessed no potential risk in terms of heavy metal concentration. Moreover, Pb and Cu have (105.97 and 115.5 mg kg^{-1}) over threshold level in each one soil sample in micro catchments coded as 9 and 13. This case can be assessed no potential risk in terms of heavy metal concentration. Because, these heavy metals don't show grouping of samples as Ni or Cu in Figure 8. A correlation analysis was done for the determination of the relationships between the physico-chemical properties of the soils and heavy metals and given in Table 4.

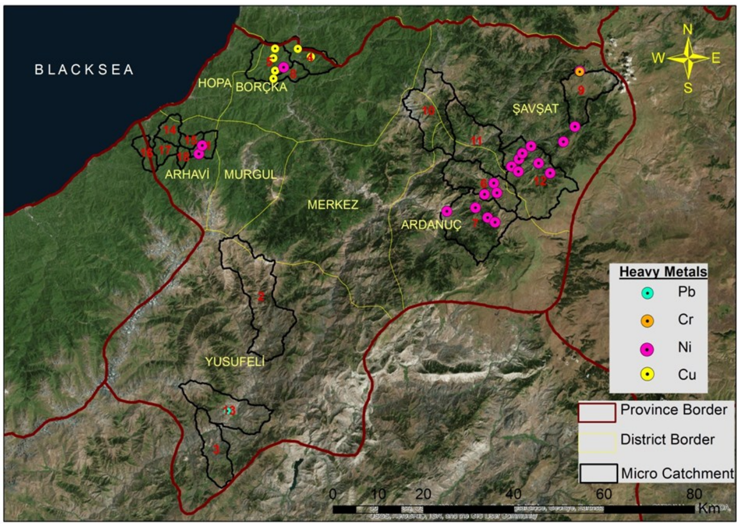

Figure 8. Exceeded heavy metals their maximum permissible concentration in representative micro catchments

Table 4. Relationships between some physico-chemical properties of the soils and the heavy metals in the surface and subsurface soils

Heavy Metals (mg kg^{-1})	Sand (%)	Clay (%)	Silt (%)	pH	EC (dS m^{-1})	$CaCO_3$ (%)	OM (%)
Surface (0-20 cm, *n:129*)							
Cu	-0.243**	0.351**	0.099^{ns}	-0.274**	-0.271**	-0.321**	0.013^{ns}
Cd	-0.244**	0.290**	-0.009^{ns}	-0.279**	-0.255**	-0.214*	0.156^{ns}
Cr	-0.196*	0.193*	-0.076^{ns}	-0.226**	-0.136^{ns}	-0.249*	0.155^{ns}
Pb	-0.242**	0.251**	-0.074^{ns}	-0.295**	-0.260**	-0.155^{ns}	0.049^{ns}
Co	-0.296**	0.262**	-0.167^{ns}	-0.108	-0.114^{ns}	-0.073^{ns}	-0.041^{ns}
Ni	0.000^{ns}	0.003^{ns}	0.004^{ns}	0.148^{ns}	0.158^{ns}	-0.335**	0.006^{ns}
Zn	-0.269**	0.351**	0.045^{ns}	-0.246**	-0.160^{ns}	-0.223*	0.206*
Subsurface (20-40 cm, *n:113*)							
Cu	-0.306**	0.345**	-0.023^{ns}	-0.240*	-0.269**	-0.271**	-0.105^{ns}
Cd	-0.287**	0.283**	-0.098^{ns}	-0.340**	-0.268**	-0.095^{ns}	0.140^{ns}
Cr	-0.144^{ns}	0.207*	0.074^{ns}	-0.231*	-0.221*	0.004^{ns}	0.148^{ns}
Pb	-0.204*	0.181^{ns}	-0.107^{ns}	-0.280**	-0.194*	-0.107^{ns}	0.102^{ns}
Co	-0.272**	0.244**	-0.139^{ns}	-0.172^{ns}	-0.208*	-0.117^{ns}	-0.046^{ns}
Ni	-0.091^{ns}	0.027^{ns}	0.149^{ns}	0.158^{ns}	0.113^{ns}	-0.312**	0.033^{ns}
Zn	-0.248**	0.254**	-0.065^{ns}	-0.292**	-0.219*	-0.198*	0.191*

Note: ns—insignificant, *—$P < 0.05$, **—$P < 0.01$, EC—electric conductivity, OM—organic matter.

Puschenreiter and Horak (2000) stated that the basic soil characteristics, such as the pH and texture, are of great importance in the availability of heavy metals in the soils. It was found that a significant negative correlation was revealed between the content of sand and the Co, Cd, Cu, Zn, and Pb concentrations, whereas a positive correlation was determined between the clay content and the heavy metal content. This result confirmed the data of Temmerman et al. (2003). No significant relation was found between the content of silt and the heavy metals. The soil's pH and the $CaCO_3$ content have significant role related to the heavy metals accumulation in the soils. Negative linear correlations were found between these soil properties and heavy metals in both depths.

In addition to obtain real heavy metals' values, all the elements were additionally grouped into five levels by Sutherland (2000) in order to estimate their relative accumulation according to the enrichment factors (EF) values for surface and subsurface soil samples. Some statistical characteristics of the EF for the surface and subsurface soils are given in Table 5. In surface soil samples, the EF value for Cd attests that the soil was enriched with this element as compared to its mean background value. The EF values for the other elements were<2. The maximal EF value for Cd (4.46) points to the enrichment of the soil with this element; the EF values <2 for Pb, Ni, Co, Zn, Cu and Cr pointed to the absence of the soil's enrichment with these elements. Similar results were also detected in subsurface soil samples (Table 5).

Table 5. Some statistical characteristics of the enrichment factors (EF) for the surface and subsurface soils, mg kg^{-1}

Heavy Metals	Mean	SD	*CV	Varians	Min.	Max.	**Skewness	Kurtosis
Surface (0-20 cm, *n:129*)								
Cu	1.09	0.55	50.31	0.30	0.30	3.97	4.77	1.58
Cd	4.46	4.02	90.33	16.20	0.01	22.73	2.74	1.47
Cr	0.29	0.19	65.04	0.04	0.04	1.24	6.71	2.12
Pb	1.15	1.09	94.61	1.18	0.25	8.25	21.22	4.18
Co	0.38	0.29	76.45	0.09	0.00	2.64	26.50	3.76
Ni	0.36	0.28	76.65	0.08	0.04	1.70	7.09	2.21
Zn	0.67	0.28	41.75	0.08	0.26	1.75	3.37	1.83
Subsurface (20-40 cm, *n:113*)								
Cu	1.06	0.54	50.89	0.29	0.03	3.82	5.28	1.68
Cd	4.16	4.09	98.22	16.70	0.01	24.84	6.28	2.08
Cr	0.29	0.19	65.57	0.04	0.02	1.49	13.87	2.71
Pb	1.06	1.14	107.70	1.31	0.20	9.11	27.93	4.90
Co	0.38	0.30	77.24	0.09	0.00	2.64	28.55	4.01
Ni	0.36	0.28	77.35	0.08	0.00	2.03	10.97	2.53
Zn	0.63	0.27	42.73	0.07	0.02	2.10	9.12	2.40

SD: Standard deviation, Min.: Minimum, Max.: Maximum, n: sample number, *CV (Coefficient of Variation), **skewness:< │±0.5 │= Normal distribution, 0.5- 1.0 = Application of character changing for dataset, and > 1,0 → application of Logarithmic change

Conclusion

In this current study, it was investigated to determine site suitability for organic farming activity in micro catchments of the Artvin province by taking into consideration of topographic, soil, land use-land cover and heavy metal pollution criteria by means of GIS and RS techniques. These technologies were also very effective at providing and processing large amounts of spatial and spectral data and provided more accurate, accessible and actual information.

In the study area, less area located in representative micro catchments is available for organic farming mainly because of some limitations such as natural resources (land cover, soil and parent material) and high elevation variations. The final result can be adopted for the decision making process of the organic farming in the study area, as it gives insight in finding the suitable areas. In addition, the results can be more refined by critically analysing the techniques used. The study contains the physico-chemical and topographic parameters only and need to associate with the socio-economic factors. Moreover, the study can also be adopted for rest of zones and also incorporating other domains of ecotourism than organic farming, which can flourish in that area.

Acknowledgement

The authors gratefully acknowledge the scientific research grant from Eastern Black Sea Region Development Agency (DOKAP) which supported to this project

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A study on the positional accuracies of gps measurements in terms of GIS spatial data precision

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Abstract

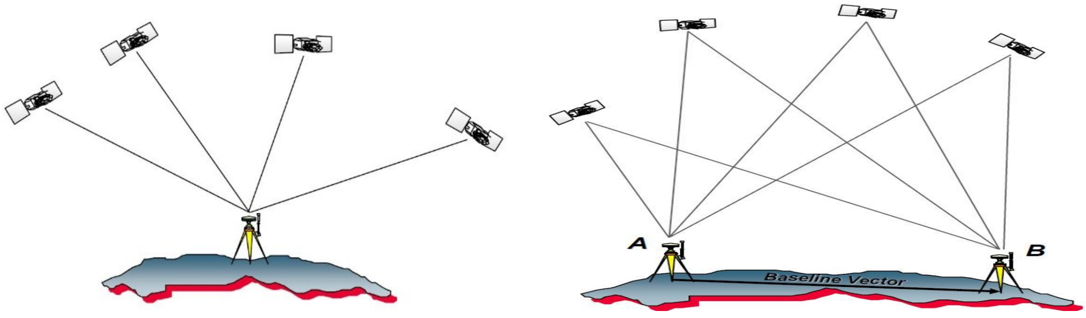
The most fundamental requirement for Geographical Information Systems (GIS) is spatial data. There are various different methods to obtain spatial data and, of these, GPS technique is the most essential data collection means. It is possible to obtain spatial data of varying accuracies using different techniques in the GPS technique. This study aimed to investigate positional accuracies of different GPS measurement methods. To this end, a test network was created in the Bosna Hersek neighborhood of Konya province in Turkey. Of the GPS measurement techniques, absolute point positioning through code measurements and of the relative point positioning techniques, static point positioning and Real Time Kinematic (RTK) point positioning technique were used. The coordinates obtained as a result of static observations made at the same points and of the code measurements, the coordinates obtained from absolute point positioning and RTK measurements were compared and contrasted. The findings were assessed within the scope of the accuracies expected of the GIS positional purposive measurements. Spatial data and measurement methods were compared and contrasted in terms of durations of measurements, repeatability and accuracies. Usability of the obtained results for GIS applications of different purposes was interpreted.

Key words: GIS, GPS, spatial data, absolute point positioning, relative point positioning.

Introduction

GNSS technology is becoming the most effective positioning method for all types of engineering projects (Bonnor, 2012). GNSS techniques are among the most important data collection tools for positional data for GIS. Accuracy of positional data to be obtained is directly related to the objectives of the GIS project to be implemented. For purposes of satellite-based ground positioning, the countries below have developed the following satellite programs: the USA: GPS, Russia: GLONASS, European Union: GALILEO, China: Beidou/ Compass, India: GAGAN and Japan: QZSS. Thus, all of the existing satellite systems and all differential systems (WASS, EGNOS, SBAAS etc.) were named Global Satellite Navigation Systems (GNSS). In these systems, the possibility for users to make use of real time kinematic applications has increased enormously (Kahveci, M., 2017). There are two types of ground positioning methods in GNSS (Figure 1).

Absolute/Point Positioning; In absolute point positioning, code observations are made via four or five satellite normally with a single receiver and thus the coordinates of point on which a receiver is installed are determined. The method is based on satellite receiver distances calculated by multiplying the time passing between the exit of the signal from the satellite to its arrival at the receiver by the speed of light and back azimuth in space via the known coordinates of the satellites. Receiver coordinates can be determined instantaneously and an absolute sense depending on code information used (P code, C/A code) and satellite geometry. This method is defined as static point positioning if the receiver is fixed and as kinematic point positioning if the receiver is mobile (Hofmann-Wellenhof-Lichtenegger-Collins, 1997). The absolute point positioning method is divided within itself into different techniques such as Single Point Positioning (SPP) and Precise Point Positioning (PPP) as in the relative point positioning method (Gürtürk, 2016). Point positioning for practical navigation is conducted in accordance with this method using code measurement.



a) Absolute Point Positioning b) Relative Point Positioning

Figure 1. GNSS point positioning methods (Ayers, 2011)

Relative Positioning: This method involves determination of coordinates of a point or points relative to a point whose coordinates are known. The base vector between two points is determined using the relative positioning method (Kahveci and Yıldız, 2017). The measurement methods used in positioning with GNSS can be divided into two groups, namely static and kinematic, depending on whether the point to be measured is mobile or static, duration of measurement, the desired accuracy (precision) and the receiver used. In the kinematic measurement method, if the positioning information is obtained via instantaneous assessment of measurements, it is called Real Time Kinematic (RTK).

Materials & Methods

In this study, a test network was created in the vicinity of Selcuk University campus in order to investigate the positional accuracy of different GNSS methods (Figure 2). The study area is Bosna Hersek neighborhood in the Selcuklu District of Konya province within the borders of Turkey whose datum is between ITRF96 38^0 01′ 14.92″ - 38^0 00′ 02.73″N latitudes and 32^0 31′ 07.69″ E - 32^0 31′ 35.32″E longitudes.

Three higher degree geodetic network points having TUTGA, C1, C2 degrees were obtained while creating the geodetic network design. In addition to the 3 existing points, 25 new points were determined (created/established) (Figure 2). As the coordinate of the points, ITRF96 datum, Transversal Mercator (TM) projection, horizontal coordinates according to 33^0 East central meridian, ellipsoidal heights according to GRS80 elipsoid were used.

The coordinates of the newly established 25 points were measured using three different GNSS observation methods, namely static, Real Time Kinematic and Code observations.

In static measurements, GNSS receivers with the brand name of JAVAD TRIUMPH-1 belonging to Selcuk University were used. The data collected from the area were converted into the RINEX format and then assessed using the LEICA GEO OFFICE software. During the assessment, the three already existing points were taken as reference points, and thus the coordinates of the 25 new points were calculated.

In RTK measurements, again JAVAD TRIUMPH-1 GNSS receivers belonging to Selcuk University were used. In the field, the point with number L29-G002 on Selcuk University campus was taken as the reference point and it was established (mounted) on a fixed GNSS receiver. Measurements were taken twice according to the RTK method for a period of 5 seconds on 25 new points using mobile receivers. Means of two measurements taken at each point were determined and thus coordinates were calculated for the 25 points using the RTK method.

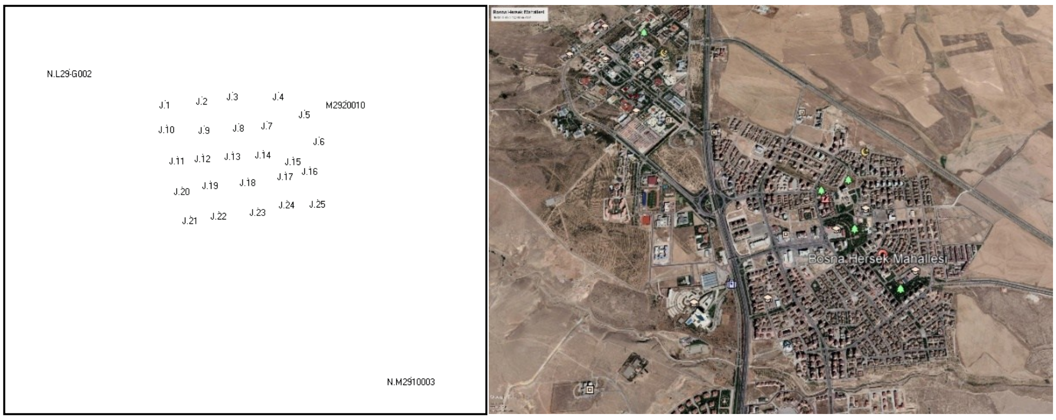


Figure 2. Study area and test points

In Code measurements, measurements taken using the ground positioning feature of mobile phones and the KOCAMAN application were used. Measurements were taken twice at each point at different times and then their means were taken. Thus, coordinates of the 25 points were calculated through code observations.

Results & Discussion

Of the results obtained from the three methods, the static method was taken as the reference point and it was compared and contrasted with the mean coordinates obtained from RTK and code observations. Static-RTK differences can be seen in Table 1. When Table 1 was examined, it was seen that the differences were smaller than 10 cm on the horizontal and 16 cm on the vertical.

Table 1. Differences between static RTK measurements at 25 points

	DE (m)	DN (m)	Dh (m)
Mean	-0.039	-0.083	-0.049
Minimum	-0.052	-0.106	-0.142
Maximum	-0.017	-0.040	0.168
Standard deviation	0.008	0.013	0.053

Static-code differences can be seen in Table 2.When Table 2 was examined, it was seen that the differences were smaller than 8 meters on the horizontal and 10 meters on the vertical.

Table 2. Difference between static-code measurements at 25 points

	DE (m)	DN (m)	Dh (m)
Mean	1.008	0.023	-1.553
Minimum	-2.555	-6.977	-9.013
Maximum	6.604	7.738	8.626
Standard deviation	2.168	3.467	3.742

Conclusions

In GNSS techniques, the coordinates obtained using RTK have shown that positional accuracies similar to static observations could be obtained. As a result, thanks to RTK GNSS, it will be possible to quickly and accurately establish points, which lead to much time and costs in many applications. The tests conducted using RTK GNSS have shown that the RTK GNSS method has a great advantage over classical geodetic methods in terms of speed, time and feasibility when applications such as collection of data for Land and Urban Information System, making of topographic maps are taken into consideration.

Code measurements obtained via mobile application can be readily used in practices such as navigation that does not require much precision (accuracy), determination of forest borders, agricultural work etc. It is a method that is faster than static and RTK GNSS applications, does not require fixed points, is cheaper, more useful and easier to carry.

Implementation of the GNSS observations of the network designed for the application lasted for about 12 to 13 hours including the time spent on goings and comings between the points. On the other hand, only the time spent to reach the points was effective in measurements of the same network taken using RTK GNS and Code methods, because measurement of a point in RTK GNSS and Code methods lasted only a few minutes including the installation of the tool. Therefore, positions of all network points were determined at a mere 5 to 6 hours in total using RTK GNSS. Since it is generally used in dense urban areas, it has been observed that RTK GNSS is more appropriate for work requiring urgent (rapid) and sensitive application.

Acknowledgement

The data used in this study were obtained within the scope of undergraduate thesis studies conducted by İsmail Aktas, Nurullah Adiguzel and Ugur Kutat, with Prof. Dr. EkremTusat as adviser, at Selcuk University Department of Map and Cadastral Engineering. The presentation of this study at the International Soil Congress 2018 to be organized in Almaty-Kazakhstan is supported by Selcuk University BAP Coordinationship within the scope of project number 18701499.

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Biomarkers as paleoecological indicators in mountain soils of Eurasia

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Abstract

It has been shown by the methods of biochemistry, nuclear magnetic resonance, and isotope geochemistry that the proportions of lignin phenols, n-alkanes, amino sugars may be used as molecular traces of paleovegetation and paleobiota. The information role of biomarker has been tested at the reconstruction of paleovegetation in the Caucasus and Tien Shan, an upward shift of the forest boundary has been recorded on the Northern Caucasus; the hypothesis about the steppe period of landscape development in the Tien Shan mountain valleys during the middle Holocene has been confirmed, and molecular traces of tropical flora have been revealed in the buried soils of Pleistocene age in Crimea, the earliest stage of the allochthonous carbonate accumulation in the area dated to approximately 20 ka cal BP was established in the Lesser Caucasus. The representativeness of information has been increased using the isotope analysis (δ13C); a new parameteres - the composition of lignin phenols and n-alkanes - have been introduced in the existed system of biomarkers.

Key words: paleosoils, biomarkers, mountain soils, carbon isotope composition.
Financial Support: RSF №17-14-01120.

Biomarkers are organic molecules of the known structure and origin. In contrast to humic acids, whose formulas and chemical structures are still unknown, separate molecules of phenols, aminoacids, aminosugars, and lipids can be reliably detected in living organisms, their residues, and waste, as well as in complex associates of humic substances in the soil. Many biomarkers are resistant to degradation and mineralization in soils under specific conditions because of their specific structure and biochemical functions; therefore, they serve as molecular traces of paleobiota and land vegetation and as indicators of the rates of recent and past biochemical processes occurring in the biosphere. Individual organic compounds are well preserved not only in the normal profiles of postlithogenic soils, but also in their redeposition products, soilcolluvial and soilalluvial complexes, pedosediments, pedoliths, derivatives of separate horizons, bottom sediments of water bodies, etc. The information role of biomarkers is important when the pool of molecular products of organic matter decomposition in soils is not identical to the sum of individual waste components because of the masking effect of the mineral matrix. The organomineral soil particles or soil neoformations favor the preservation of indi the paleoconditions of their formation. The information role of biomarkers extracted from soils can be increased due to the determination of their structurally specific isotopes.
The diagnostics of the structural elements of individual nonspecific compounds in associates of humic substances, e.g., by NMR spectroscopy, in combination with the radiocarbon dating of soil humus increases more the representativeness of the obtained information. The biomarkers include *n*_alkanes from plant waxes, L- and D-enantiomers of amino acids, and glycerol dialkyl glycerol tetraethers [4, 7], lignin phenols, n-alkanes, aminosugers . A unique methodological basis for the interpretation of biochemical information from soil archives includes the studies of organic matter from buried soils. The most informative paleolandscape indicators in the paleosoils and soillike bodies are the magnetic susceptibility, calcium carbonate, the content of inorganic phosphorus, as well as the carbon isotopic composition of organic matter.
The objects of research were located in the Lesser Caucasus (Lori and Verkhneakhuryan depressions of northern Armenia), in the Northern Caucasus (Dagestan, Russia), in the Crimea

mountain, in the Kirgizskiy Range of Northern Tien-Shan (Kyrgyzstan).The objects of study included different dated paleosols detected in polygenetic profiles of recent soils and thoroughly studied by a set of physicochemical methods. The following soils were studied: mountain chernozems, chernozem_like soils, and mountain-meadow soils of intermountain valleys and chestnut soils of Tien Shan; brown forest and mountain-meadow soils of Caucasus and brown forest, mountain-meadow soils and crasnozem of Crimea.
The isotope composition of carbon in soil organic matter was determined on a Thermo V Plus isotoperatio mass spectrometer and a Thermo Flash 1112 elemental analyzer. The soil was purified from carbonates by the HCl fumigation method of Harris et al. [9]. The age of soils was determined by the radiocarbon dating of humus. The magnetic susceptibility of soils measured by kappameter KT-5. 13C NMR spectra were recorded for 25 HA preparations. The preparations were isolated from the studied soils, including iron–manganese nodules, by triple extraction with a 0.1 M NaOH + 0.4 M NaF mixture from the samples decalcified with 0.05 N H2SO4. After the separation from colloids by centrifugation (Beckman Model J_6 centrifuge, 2500 g, 15 min), the HA preparations were purified from mineral salts by electrodialysis (MWCO 12000–14 000). The dialyzed and frozen out HA preparations (50 mg) were dissolved in 0.6 mL of 0.3 M NaOD/D2O. Spectra were recorded on a Bruker Avance DRX 500 NMR spectrometer at 25.18 MHz and 290 K. The content of lignin phenols was determined in ten HA preparations. Lignin phenols were isolated in triplicate from soil and HA preparations using Amelung's version [1] of the Ertel–Hedges procedure [2]. The determination of lignin in the soils included the alkaline oxidation of the sample with copper oxide at 170°C under pressure in a nitrogen atmosphere. The phenol components of lignin were derivatized into trimethylsilyl ethers and separated on a gas-liquid chromatograph. They were determined on a gas chromatograph–mass spectrometer (Hewlett_Packard, Palo Alto, CA, USA) with a flame ionization detector and a capillary column. Nitrogen was used as the main and marking gas. The injector temperature was 250°C; the detector temperature was 300°C. Individual reaction products (vanillin, syringic aldehyde, syringic acid, *p*-coumaric acid, and ferulic acid) were identified by comparing the retention times and peaks with those of the known components and amounts used as external standards. Qualitative and quantitative determination of n-alkanes was carried out by capillary gas-liquid chromatography. The extraction was carried out with chloroform using an automatic extractor ASE 200 at a temperature of 100°C. Separation of the nonpolar fraction of hydrocarbons was carried out on aluminum oxide Al_2O_3 (Brokman activity level - II). The analysis was carried out on an Agilent 6890 gas chromatograph with a flame ionization detector and a column DB-1ms (length - 30m, diameter - 0.25mm, phase thickness - 0.25 μm). For calibration with individual alkanes, a standard mixture of n-alkanes C_{12}-C_{36} was used.
The soils of herbaceous ecosystems in mountain landscapes contain similar proportions of vanillyl, syringyl, and cinnamyl structural units in both steppe (1 : 1 : 1) and meadow (2 : 1 : 1) ecosystems; a regular predominance of vanillyls is observed in the soils of coniferous forests (S/V < 0.5), and equal amounts of syringyls and vanillyls are found in the organic matter of deciduous forests (S/V = 0.96). The molecular traces of an upward shift of the forest boundary were recorded in the Northern Caucasus from the proportions of lignin phenols typical for the forest soils (4 : 2 : 1) in the lower part of the humus horizons of mountain-meadow soils. The composition of lignin phenols in the humus horizon of mountain-meadow soil formed about 3600 years ago coincides with the heaving of δ13C (to –25.69‰), which indicates the shift of all zonal boundaries to the ecosystems in the upper zones. This was the time of distribution of burozem soils (with the predominance of vanillyl structures in the lignin composition) on slopes and the advance of meadow-steppe herb-grass associations (with the equal proportions of vanillyls and syringyls) on chernozems (2 : 2 : 1) upward in the mountain valleys. In the recent humus horizons of burozem and mountain chernozem, the

proportions of lignin phenols are typical for the forest and meadow_steppe soils (5 : 2 : 1 and 3 : 3: 1, respectively). The isotope ratios typical for the woody and herbaceous plants of the temperate zone (–26.91 and –26.07‰, respectively) also agree with them. This period of climatic optimum with an isotope ratio of –24.7‰ typical for the dry and warm climate – 1300 years ago according to archeological dating – coincides with the development of Alanian urban settlements in the low and middle mountains of the Northern Caucasus. The proportions of lignin phenols inherent of herbaceous meadow associations (3 : 1 : 1) are established after the end of the medieval climatic optimum (Arkhyz interval of Alp glaciation) 500–300 years ago, which is also confirmed by the lightening of isotope ratios in the recent humus horizons of the studied soils (–25.70 to –26.91‰). The NMR spectra of HA preparations show characteristic signals of vanillyl, syringyl, and coumaryl structures accumulated in the molecules of specific soil organic matter under Alpine meadows with the equal proportions of syringyl and cinnamyl structures [5].

The composition of lignin phenols with the predominance of cereal cinnamyls in the buried horizons of chernozem-like Tien Shan subalpine soils (2 : 1 : 1) confirmed the supposition about the chernozem stage of pedogenesis in the middle Holocene (about 5500 years ago) and revealed the forest genesis of illuvial horizons about 7000 years old. Their proportions of the vanillyl, syringyl, and cinnamyl phenols is typical for the woody plants with the predominance of vanillyls: 5 : 2 : 1. The lightening of isotope ratios δ13C to −28.8‰ in the studied horizon confirms the hypothesis about the distribution of coniferous forest in mountain valleys during the early Holocene. On the contrary, the accumulation of cinnamyl phenols in the second humus horizons of the late Holocene (3 : 1 : 3) and the absence of vanillyl structures in the NMR spectra of their HAs well agree with the existence of the steppe period of landscape formation in mountain valleys that we proved earlier [5]. The molecular traces of the upward shift of vegetation zones are also preserved in the isotope composition of humus from subalpine chernozem-like soils (δ13C –25 to –24‰) typical for mountain chernozem.

Of special interest is the composition of lignin in the horizons of Pleistocene soils buried in loess deposits. The ratio V : S : C = 8 : 4 : 1 is similar to that in plants of tropical forest and close to the proportions of lignin phenols in redcolored soils under current juniper forest. In combination with the anomalously heavy $\delta^{13}C$ (–8 to –12‰), the presence of molecular traces of the Pleistocene tropical flora in the studied soils, which corresponds to the soil fauna described in terra_rossa by Gilyarov [9], can be supposed. It is known that all woody plants and most of the shrubs and herbs of the cold and moderate climate are classified among the C3 plants, and their $\delta^{13}C$ values are about −28‰. The C4 plants with isotope ratios of about −14‰, including the herbs of tropical savannas, are adapted to a drier climate, high temperatures, and low CO2 concentrations in the atmosphere. The detection of heavy isotope ratios $\delta^{13}C$ = –14‰ in the deposits of a mountain lake in Kenya at a height of 2350 m was also reported by Zech and Glaser [10]. As shown earlier [5], the structure of HA molecules from these old soils, in contrast to their Holocene analogues, contains the maximum amount of bonds of lignin fragments in the peripheral region of the spectrum (56 ppm), rather than in its nuclear region (147 ppm).

Early Pleistocene palaeosols and pedolithic sediments were discovered in the Paleolithic sites and quarries in tephro-soil and lagoon-marine series of plateau-like surfaces of the Lesser and Northern Caucasus. In the Lesser In the Early Paleolithic site Karakhach (1800 m above sea level), dated by the subchron Olduvai, a tephro-soil sequence with two palaeosols is described. The cultural layers and buried soils are covered with powerful (4 m) ash-volcanic sediments with low acidic pH values (pH_{KCl} 4.9-5.1; pH_{H2O} 5.6-6.0). The upper palaeosol (layers 1-3), formed on the pebbled deposits, lies at a depth of 6.2-7.4 m and has a reddish brown color. Lower pebbly and sandy sediments (layers 4-10) have signs of hydromorphism (blue-gray shades of color, Fe-Mn plots, washed ash layer). The second buried soil (layer 11,

at a depth of 10.8 m) has a brown color, relative increase in the content of organic carbon and nitrogen. The values of magnetic susceptibility (χ= up to 643,4*10^{-6} cm^3/g, CGS). and is the content of inorganic phosphorus are diagnose the presence of two stages of volcanic activity. Minimum values of magnetic susceptibility are fixed in paleosols and are an indicator of stable soil formation conditions when sedimentation is slowed down. $\delta^{13}C_{org}$ in palaeosols diagnoses a humid climate with a predominance of C3 type vegetation (-25.9-26.4 and -26.8 ‰). Similar hydromorphic soil on gravels was found in the Early Pleistocene deposits of the Upper Akhuryan basin. Pedolitic sediments of low salinity hydromorphic soils were found in excavations in the territory of Dagestan (Russia) at altitude of 1629 m above sea level in Early Paleolithic site Muhkai IIa. $\delta^{13}C_{org}$ is -25,1-26,4‰. Low values of magnetic susceptibility and abundance of Fe-Mn ortstein indicate the hydromorphic coastal landscape in the past. Preliminary data on the content of n-alkanes confirm the isotopic composition data on the prevalence of woody vegetation at the paleolithic sites.
The laminae-like carbonates were accumulated in the Kurtan I and Muradovo sections (Lesser Caucasus) due to strong erosion cycle(s) in the Late Pleistocene interglacial period(s) that led to the limestone scour in the region by ground and surface water. They reflect the earliest stage of the allochthonous carbonate accumulation in the area dated by radiocarbon method to approximately 20 ka cal BP [3]. Therefore, all the CFs cannot be regarded as indicative of Early and Middle Pleistocene environmental changes, as they appeared in the uppermost layers of the studied sections much later than the time of formation for the surrounding groundmass.

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Transformation of microstructure of soils with different genesis in the composition of soil constructions with different structure in the conditions of Moscow

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Abstract

The transformation of soil microstructure in soil constructions was reviewed in this work. The studies were conducted during a 4-year experiment on the territory of Lomonosov Moscow State University (from 2012 to 2016). The method of rheology and scanning electron microscopy were used in this investigation. The object of the study were three variants of soil constructions with different structure of the profiles: 1) variant 1 (control) – its upper part is consisted of a homogenized A arable horizon; 2) variant 2 – layered construction, consisted of a series of layers: A arable horizon, peat, sand, A arable horizon; 3) variant 3 – a mixture of the above mentioned horizons. Scanning electron microscopy revealed an increase in the differentiation of the pore space of the upper A arable horizons of variants 1 and 2, the appearance of large associated microstructures in the peat layer of variant 2 and the microstructuring of the upper layer of variant 3. Changes in the spatial organization of the solid phase of soils are reflected in their rheological behavior. Gradual increase of the stability of structural relationships in the A arable horizon (variant 1) was discovered during investigation. The influence of the underlying layer of peat on the shape of the rheological curves of the A arable horizon in variant 2 and the transformation of the strength properties of the mixture with the formation of the characteristic rheological behavior of flowing bodies, which is typical for arable humus horizons, also were discovered.
This research was financially supported by Russian Foundation of Basic Research (the project No. 16-04-01851).
Key words: soil constructions, physical properties of soils, soil structure, scanning electron microscopy, pore space of soils, rheological characteristics of soils, solid phase of soils.

Introduction

The soil structure is one of the most important characteristics of the soil. It causes features of soil's functioning and represents the space organization of a solid phase of soils, complexity and differentiation of a pore space of the soil. Soils constructions, which are artificially created from various soil horizons, are an interesting object for investigation from positions of destruction, formation or reorganization of soil structure. However, researches of transformation of structure of soil constructions at the microlevel are not enough, though questions of its reorganization and degradation are very important. The rheological behavior of soils is one of characteristics of stability of the soil's microstructure. It reflects dispersion, a form of particles and various types of communications between them. Also it is very sensitive to changes of properties of a solid phase of soils. The aim of this work was researching of a microstructure of soil samples of different genesis and its transformation during the 4-year period as a part of different soil constructions in the conditions of Moscow.

Materials and Methods

The object of investigation was a complex of experimental model soil constructions with different structure, created on the territory of Lomonosov Moscow State University in 2012 year. There were formed 3 variants of experimental sites with follow profiles structure: 1) horizon Aarable 0-30 cm (var. 1 - control); 2) Aarable (0-6cm) - lowland peat (6-12cm) – sand (12-18 cm) – Aarable (18-30 cm) (var. 2); 3) construction mixed from 3 components

(Aarable, peat, sand, mixed in the same proportions as in the layered construction) (var. 3). The same external conditions were maintained at all sites: they were planted a lawn grass mixture (0.05 g seeds/cm^2): Festuca rubra and Lolium perenne. The method of rheology (determination of viscosity in the viscometer "RHEOTEST 2") and scanning electron microscopy (SEM) for investigation of microstructure of soils were used in this research.

Results and Discussion

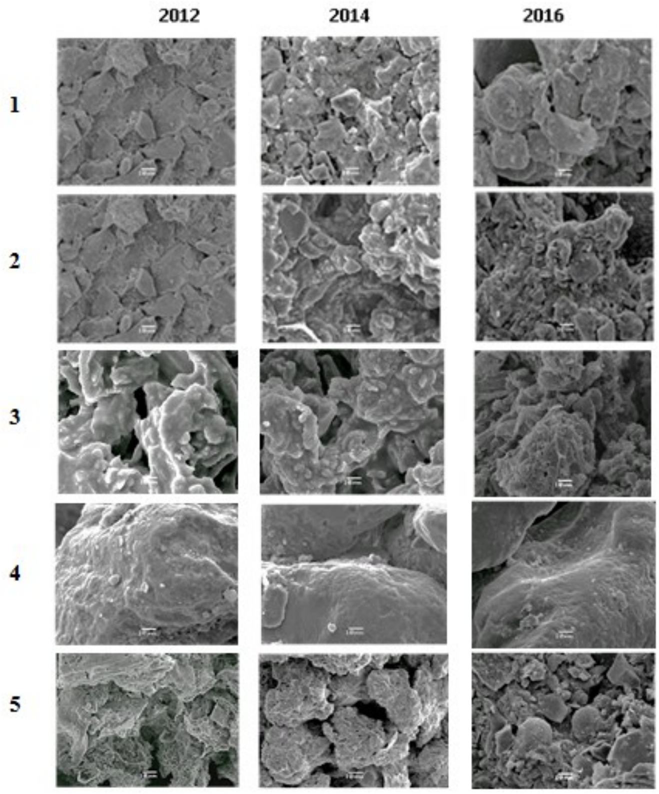

Figure 1. SEM-image of different horizons of soil constructions at magnification x1000:
1 – var.1 (A arable, 0–6 cm), 2 – var. 2 (A arable, 0–6 cm), 3 – var. 2 (Peat 6-12 cm), 4 – var.2 (Sand 12-18 cm), 5 – var. 3 (Mix 0-6 cm)

The conducted researches of microstructure of soil layers of soil constructions during 4-year's functioning showed: (1) the transformation of their microstructure was fixed by SEM method. More complex organization of a pore space appeared in the surface horizons A arable of var.1 (control) and var.2, the number of large associated microstructures increased in the peat layer of var. 2 and the microstructuring of the upper layer of variant 3 appeared; (2) arrangement of horizon A arable in constructions with different structure leads to various transformation of its microstructure during the functioning of soils. More expressed microstructure of horizon A arable was observed in variant 2. (3) The interrelation between microstructuring of soils and its transformation and changes of rheological behavior was found. Gradual increase of the stability of structural relationships in the A arable horizon (variant 1) was discovered during investigation. The influence of the underlying layer of peat on the shape of the rheological curves of the A arable horizon in variant 2 and the transformation of the strength properties of the mixture with the formation of the characteristic rheological behavior of flowing bodies, which is typical for arable humus horizons, also were discovered.

This research was financially supported by Russian Foundation of Basic Research (the project No. 16-04-01851).

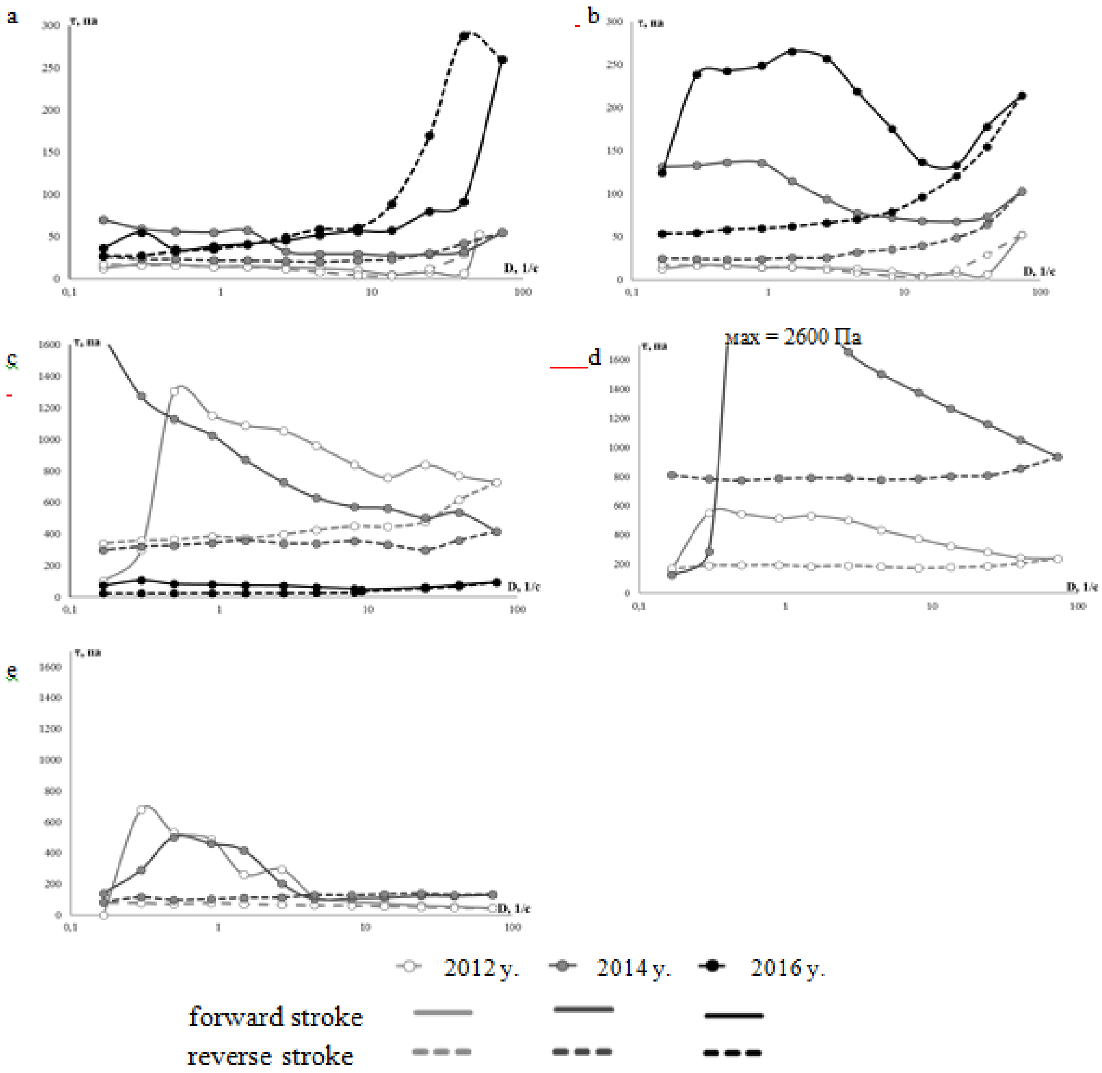

Figure 2. Main rheological curve of soil samples: a – var.1 (A arable 0-6 cm), b – var.2 (A arable 0-6 cm), c – var.3 (Mix 0-6 cm), d – var.2 (Peat 6-12 cm), e – var.2 (Sand 12-18 cm)

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Information assessment of contemporary evolution alterations of soils at the south of Western Siberia

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Abstract

Contemporary evolution of soil (CES) is considered as the process of changes of conditions of soil with time intervals from ten to hundred years. Assessment of changes of soil properties at fields is important for drawing conclusions about the CES happening in soils caused by anthropogenic influence and climate changes. When carrying out spatial soil monitoring, points of approbation in space don't coincide at different time, so it is necessary to use probabilistic models for assessment of states and changes of soils. The set of probabilistic-statistical distribution (PSD) of *n* soil properties in *k* soil horizons within the studied object is the model of a condition of the soil cover. We have offered to use probabilistic and information indicators for assessment of condition of soils and their changes. For condition of soil, besides the PSD functions of soil properties the information entropy is used. Values of information divergence of soil properties are used for assessment of changes of soils. The entered characteristics allow estimating extent of influence for the soil forming factors and anthropogenic impacts on probabilistic structure of values of soil properties and its stability. The case studies have been conducted in the big territory at the south of Western Siberia. It has been shown that CES occurs under the anthropogenic influences and natural processes caused by climatic trend of warming and by cycles on moistening. It is revealed by changes of probabilistic structure of values of properties of the soil. On data of archive records the probabilistic and information assessment of changes of soils during 60-90 years of the 20th century has been executed. In fact, the received models and estimates are statistical standards of condition of soils which should be used for comparison with the current and future results in the explored and neighboring territories.
Key words: soil processes; probabilistic models; information evaluation, statistical standard.

Introduction

Land degradation under intensive anthropogenous influence is the widespread phenomenon in the different countries. Therefore the scientific community faces important problems – studying, generalizations, and understanding of this negative process. Degradation of soils leads to infringement of soil functions in biosphere, both on local, and at regional and global level of consideration that puts mankind before challenges in sustainable soil management. The most objective exact knowledge of soils properties is necessary for this purpose. It is especially important that properties of soils to a great extent define ecological risks, both probability of occurrence of ecological dangers, and degree of their possible negative consequences. All aforesaid leads to a conclusion that for the decision of the big number both scientific, and essential applied problems, it is necessary to develop mathematical models for an estimation and modeling of behavior of soils in various adverse conditions.
Global climate changes lead to ambiguous regional climatic changes in different parts of the planet. It is important authentically assess risks of desertification of steppe ecosystems on reliable information about dynamics of their parameters, accordingly of land use and conservation. It concerns also steppe ecosystems in internal Eurasia, like Kulunda steppe located in the south of Western Siberia at adjacent territory of Russia and Kazakhstan, which was object of investigation. The greatest interest represents change of humus contents not only from point of view of agricultural properties, but global carbon cycle too.
Realization of integrated quantitative estimations demands more differential approach to local changes, differently to not avoid gross mistakes owing to overestimation or underestima-

tion of the contributions of various natural objects to global changes. So, according to DPSIR framework we have tried identifying indicators and methods for land degradation assessment, which help overcome problem of statistically proved quantitative estimation of transformations of soils as a result of natural and anthropogenic processes, caused by high natural variability of soils.

Materials and Methods

Research methods. Initial data. In this work were used contemporary records of studying of soils by standard methods at large-scale mapping and monitoring of soils, laboratory methods of determination of soil properties (All-union Guidelines, 1973). Initial data were materials of the large-scale (1:25000) soil investigations conducted in the studied territory at different times by standard techniques (Materials of monitoring, 1995). Data bases have been created in which every information line is characteristic of soil parameters like depth of layer, humus content, pH, texture fractions content and other, were inputted. The first obligatory stage of the data processing was grouping these data according to soil-genetic principle. Every group refers to one time moment and one soil variety; namely, given data belong to soil of one taxonomical type and one class of texture. Volumes of the received statistical samples were n = 40-130, depending on abundance of this or that soil group. Truthful of this grouping were proved by unimodality of receiving distributions and high level of significance. They were enough for carrying out the probabilistic analysis. We carried out main stages of data processing: formation of databases, grouping and the analysis of data.
Probabilistic indicators. Visual analysis of PSD alterations is very useful for assessment of change of probability structure of soil properties in soil objects under anthropogenous or natural processes. But it is important to have some numerical convoluted assessments of distinction of these functions in different time or under various external conditions. Taking mentioned above into account we have introduced probabilistic and information indicators for characterization of soil status and soil alterations (Mikheeva, 2011). For soil status they are array of pdf of soil properties, which could be defined from the list of usable functions by applying statistical procedure to factual data. These functions have one, two, three or four parameters (table 1). We considered such probability distribution functions as probabilistic-statistical models of soil properties and used for calculation of statistical (information) entropy and information divergence. Moreover it seems that values of these indicators are instrument for assessment and modeling of soil evolution (Table 1).

Table 1. Probabilistic and information indicators of status and changes of soil objects

Category	Indicator	Calculation
State of soil in time points *t1*, *t2*	Probability-statistical distributions $W_t(x)$ of soil property at time points *t1* , *t2*	$W_{t1}(x) = W_{t1}(x, \theta_0^{t1}, \theta_1^{t1}, \theta_2^{t1}, \theta_3^{t1})$ $W_{t2}(x) = W_{t2}(x, \theta_0^{t2}, \theta_1^{t2}, \theta_2^{t2}, \theta_3^{t2})$
	Information (statistical entropy), *h* at *t1* , *t2*	$h_{t1} = -k\int_A W_{t1}(x)\ln W_{t1}(x)dx + h_0$ $h_{t2} = -k\int_A W_{t2}(x)\ln W_{t2}(x)dx + h_0$
Change of soil during period $\Delta t = (t2 - t1)$	Increment of informational entropy, Δh during period $\Delta t = (t2 - t1)$	$\Delta h = h_{t2} - h_{t1}$
	Informational divergence $d = \Delta W(x)$ during period $\Delta t = (t2 - t1)$	$d = \int_A (W_{t1}(x) - W_{t2}(x))\ln\left(\frac{W_{t1}(x)}{W_{t2}(x)}\right)dx$

Results and Discussion

Exact knowledge of a condition of soils and their changes is necessary for the solution of important state problems, including food and ecological security of Russia, and neighboring states as Kazakhstan. Carrying out repeated monitoring researches of soils of agricultural territories is for this purpose important. On the basis of the data obtained at the same time statistical standards of soils in concrete territories in certain time points (table 2) have to be defined.

Results have shown (fig. 1) that when weighting particle size distribution and zone change of a climatic factor in the south of Western Siberia is observed revealed by us before (Mikheeva, 2001) regularity of "wave" of PSD of the content of a humus (CH). At this PSD are displaced on an axis OX towards increase in CH to the right, however in relatives on soil formation factors soils of PSD CH are significantly crossed. In chestnut more lungs on particle size distribution are closer than loamy soils of PSD CH to an analog of chernozem soils, than to chestnut soils. Changes of PSD CH under the influence of deflation and also long agricultural use, against the background of the climatic changes which have begun in 80-90 years of the 20th century don't lead to considerable shifts of PSD. Changes happen owing to reorganization of frequencies of occurrence of values most often in almost invariable intervals of variation that leads to change of PSD CH.

Table 2. Probability-statistical functions of soil organic matter (humus) content in topsoil of Chestnut Soil and Chernozem Southern

Year	Soil variety	Kind of probability function	Parameters of function θ_0 ; θ_1 ; θ_2 ; θ_3	α*	h	d
Chestnut soil (Kulunda steppe)						
1965	Light loamy sand, defl.	Double power	3.94; 84.56	0.6	-0.02	
1965	-"- , none-defl.	Su- Jonson's	-3.34; 3.21; 0.48; 0.59	0.7	0.2	0.1
1975	Light loamy sand, , none-defl.	Max value	0.23;1.18	0.8	0.74	0.1
1965	Heavy loamy sand, defl.,	Logistic	1.42; 0.3	0.4	0.17	
1965	-"- , none-defl.	Su- Jonson's	- 0.42; 1.64; 0.4; 1.42	0.5	0.16	0.2
1975	, none-defl.	Nakagami	0.63; 0.89; 0.98	0.5	0.15	0.1
1965	Sandy loam, defl.,	Normal	1.66; 0.38	0.7	0.1	
1965	-"- , none-defl.	Su- Jonson's	- 1.43; 1.76; 0.48;1.40	0.5	0.53	0.6
1975	Sandy loam none-defl.	Max value	0.38; 1.83	0.6	0.85	0.1
1965	Loam, none-defl.	Su- Jonson's	- 0.61; 0.99; 0.38;2.25	0.8		
Chernozem southern (Priirtishsky uval)						
1989	Loamy sand	Logistic	1.54; 0.12	0.6	-0.72	
1965	Sandy loam	Ln-normal	0.85; 0.22	0.8	0.8	
1989	-"-	Double exponent	1.25; 0.34; 2.24	0.6	0.34	0.45
1965	Loam	Ln-normal	1.02; 0.21	0.5	0.75	
1989	-"-	Ln-normal	0.98; 0.15	0.2	0.48	0.18
1989	Heavy loam	Beta 1-th kind	0.4; 0.4; 2.64; 1.29	0.3		

* α - level of reached statistical significance (average on 6 criteria's);
h - information entropy; d - information divergence.

Our researches have shown that transformation of soils and a soil cover under the influence of natural and anthropogenic processes leads to change of probabilistic structure of values of soil properties. Therefore for assessment of states and changes of soils it is necessary to use the probabilistic and information indicators offered by us for state assessment – probabilistic and statistical distributions and information entropy of soil properties; and changes – transformation of probabilistic distributions, an increment of entropy and information divergence. The conducted researches convinces that these characteristics are natural and have sensitivity even under quite close conditions and small time intervals therefore are a well-tried remedy of assessment of distinctions. It allows to carry out earlier and exact diagnostics of undesirable processes and more differentiated assessment of their results.

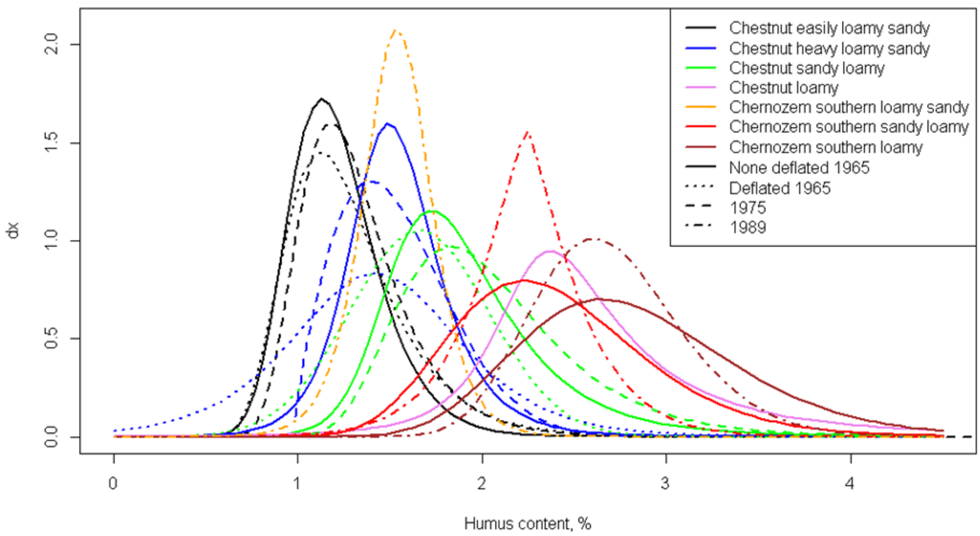

Figure 1. Probability-statistical functions of soil organic matter (humus) content in topsoil

Conclusion

Exact knowledge of a condition of soils and their changes is necessary for the solution of important state problems, including food and ecological security of Russia and neighboring countries. Carrying out repeated monitoring researches of soils of agricultural territories is for this purpose important. On the basis of the obtained data statistical standards of soils in concrete territories in certain timepoints have to be defined. Researches have shown that transformation of soils and a soil cover under the influence of natural and anthropogenic processes leads to change of probabilistic structure of values of soil properties. Therefore for assessment of states and changes of soils it is necessary to use the probabilistic and information indicators.

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Creation of a Cartographic Model of the Terrain for Planning Soil Treatment Technologies in Field Cultivation

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Abstract

One of the most important factors of rational land management is the nature of the terrain, especially its relief. It must be taken into account when choosing the field configuration and the tillage way. The object of the research was selected part of the territory, located in the foothill plain of Altai. The relief of the investigated territory is characterized by a considerable dissection with a predominance of surfaces with an inclination angle of 1.0 ... 3.0. The area of the plot is 1920 hectares. Coordinates are from 50.9 to 50.95 ° N and from 81.55 to 81.63 ° E. The research method included a survey of the terrain using a Supercam-250 unmanned aerial vehicle equipped with a Sony Alpha 6000 24.3 mP camera, a high-precision on-board receiver JAVAD TRE-G3TAJT, creating a relief map and, after that a field soil survey, creating a soil map and an integrate map of agro-ecological land types. The specified cartographic model allows to calculate and visualize such characteristics as surface slope in degrees, direction of surface runoff and erosion, describe relief elements, indicating slope and exposure of the slope, create longitudinal and transverse profiles of surface areas, etc. A rational method of using land, choosing crops and types of soil conservation treatment is determined based on the results of soil surveys and integrated map of agro-ecological land types.
Key words: digital elevation model, soil survey, digital model of the land.

Introduction

The difficulty of rational land management in agriculture is due to the complexity of the natural-production system. The manager must take into account a variety of information on the soils and environmental resources in order to adopt a cost-effective and environmentally friendly solution. Traditional soil maps are very important source of information about fundamental soil properties, but these don't reflect current trends of soil formation due to agricultural use. Beside this traditional soil maps contain an element of subjectivity because of the author's views on the soil cover. There are known research works on digital soil mapping and the use of statistical methods based on the establishment of quantitative relationships of field observations in combination with environmental data (Boettinger et al., 2010; McBratney et al., 2007). At the same time as Robert J. Ahrens considers "we should not be enamored solely on technology without an appreciation and understanding of soil-landscape relationships, which provide the predictive tools and foundations of soil survey" (2006).
One of the most important factors of the nature systems and soil cover formation are the relief of the terrain. It must be taken into account when choosing the field configuration and the tillage way. But "there is almost always a shortage of data in soil research and its applications. That may lead to unsupported statements, sloppy statistics, misrepresentations and ultimately bad resource management" (Hartemink et al., 2006). Krenke A.N. offers remote sensing of the surface using a space satellite and digital terrain models as one of the possible methods of quantitative correction of traditional maps (2012). However, he considers, the problem is absent of digital elevation models with a resolution less of 1 km for many territories.
This problem can be solved for small areas in our eyes with the help of unmanned aerial vehicles. Our research was focused on creating of the complex model of the terrain, including the

digital elevation model (DEM), the soil cover map and the map of agroecological types of the land. Such model is an objective information basis for the design of farming systems, the choice of adapted crops, soil protection methods of soil treatment, etc.

Materials and Methods

The object of the research was selected part of the territory, located in the foothill plain of Altai (Altai region, from 50.90 to 50.95° N and from 81.55 to 81.63° E). The relief of the investigated territory is characterized by a considerable dissection with a predominance of surfaces with an inclination angle of 1.0 ... 3.0 °. The area of the plot is 1920 hectares. The research methodology included several stages. Firstly, survey of the terrain using a Supercam -250 unmanned aerial vehicle (UAV) equipped with a Sony Alpha 6000 24.3 mP camera and a high-precision on-board receiver JAVAD TRE-G3TAJT was conducted. Then the Digital Elevation Model (DEM) and Digital Topographic Plan (DTP) were created. In this work, DEM was created using digital aerial photography with a resolution of 9 cm per pixel, using marked reference and control points. The accuracy of the DEM was about 25 cm in height, which corresponds to the requirements for the height of the relief section of 1 m. The construction of the DTM and DTP was carried out using the programs Photoscan (Agisoft, Russia) and GIS Panorama. After that, soil survey was conducted and a soil map was created. Then agroecological grouping of soil combinations was carried out and the integrate map of agroecological land types was created.

Results and Discussion

DEM was presented in two versions: 1) the altitude part of the DTP scale 1: 2000 in the form of pickets and horizontals through 1 meter, superimposed on the orthophoto. In this variant, the basic forms of the mesorelief are presented, 2) the matrix of heights, in which each pixel corresponds to a square on a surface measuring 0.5 x 0.5 m. This version of DEM allows you to detail the features of the surface, including the level of microrelief - surface shapes and elements of a size of one to tens meters, even with slight variations in heights.

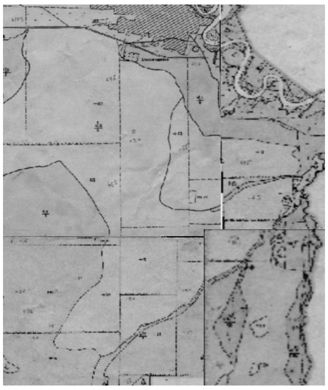
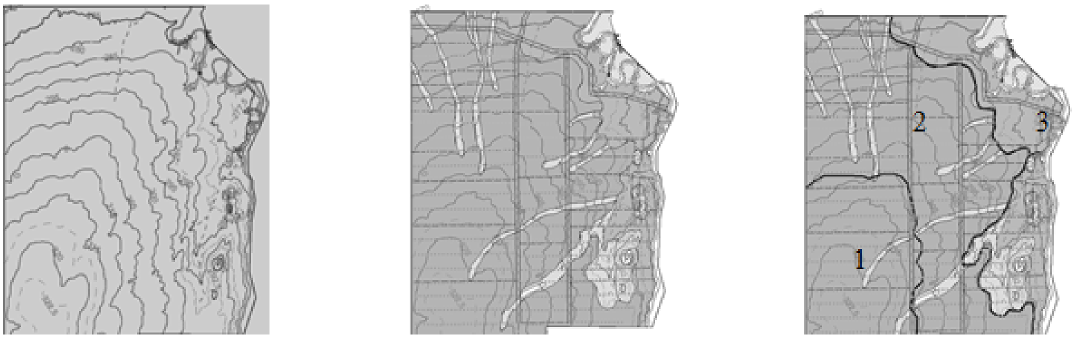


Figure 1. The fragment of the "Altair" farm soil map

The accuracy of the soil survey significantly increases when using the Digital Elevation Model. On fig.1 you can see the fragment of the soil map of the "Altair" farm, created by the Zapsibgiprozem (West Siberian Institute of Land Management Design) in the 80-s of the last century. The territory has slope to east and north-east to the small river Solonovka. The soil combination consists of chernozem odinary and chernozem solonetsic. The map is made in the "patchwork" technique and therefore does not reflect the relief and microrelief features sufficiently.

In 2016 a digital relief model (DEM) was created (fig 2A). The height of the relief section is every 5 meters, the overall slope of the terrain is 1.0 -1.5 degrees. Specific characteristics of the relief are the slopes of a complex shape - the so-called corrugated slopes. Such slopes especially contribute to development linear erosion process. Deep narrows and gullies appear in a short time. It is easily to calculate the length of the slope on the DEM. This characteristic is very important for forecasting of a water stream speed and possible quantity of the soil carried away by the spring melted waters.



A B C

Figure 2. The map of the relief (A), map of the soil cover with the plan of farm fields (B), map of agroecological land types (C)

The chernozem soils are dominant in the soil cover of this plot, but the low- and medium-eroded soils with the thickness of humus horizon less 30 cm were found in shallow and long troughs. On the fig. 2B you can see rectilinear boundaries of agricultural fields, separated from each other by forest belts, against the background of the soil map. In center and east part of the plot the direction of the troughs coincides with the direction of the long side of the production field. It means, that tillage along the long side of the field really contributes to the development of erosion processes. Based on the results of soil surveys and on the basis of the relief map data, the extent and area of the catchment troughs that could not previously be fully identified were determined, and the boundaries of elementary soil areas and complexes are more accurately determined.

In the eastern part of the object a number of local rounded elevations (hills) with a height of about 7-8 meters were found without any soil cover. The surface of the hills is formed by large stones and gravel. The hills separate the large thalweg of the northern direction from the river bed. The soil cover of the thalweg is characterized by constant overmoistening. Here, meadow solonetsic soils with pH above 8.0 were formed (table 1). The alkaline pH of the soil solution is due to the enrichment of the soil absorbing complex by magnesium ions, which are liberated upon weathering of rock carbonate magnesium.

Table 1. The main properties of the soils on the investigated object

Name of the soil	Thickness of humus horizon, sm	SOM,%	Clay,%	CTC, cmolc/kg	pH in H_2O
Chernozem ordinary	45-60	2,7-4,7	44,7-49,9	15-20	7,0-7,8
Chernozem eroded	20-30	2,8-3,0	35,8-38,9	17-18	7,0-8,0
Chernozem solonetsic	40-50	3,0-4,7	47,0-54,8	18-22	7,6-8,5
Meadow chernozem solonetsic soil	18-25	1,8-3,4	41,0-51,2	18-21	7,8-8,4
Complex meadow solonetsic + saline-alkali	2-5	1,8-2,7	38,7-44,2	17-19	7,8-8,2

Thus, we see that the real soil cover of the studied area is more complex than that shown in Fig.2A. There are 2 factors limiting the cultivation of crops: erosion processes in the central part of the site and waterlogging and solonetzicity and soil salinization in the eastern part. New differentiated technologies in agriculture and plant growing, new agricultural machinery equipped with navigational equipment allow switching to precise fertilizer application technologies, crop treatment with chemical plant protection products for more effective and environmentally friendly land use. The task of soil scientists is to adjust the soil map with the obligatory use of the digital terrain model and create a new map of agroecological land types. For this purpose, we previously developed a landscape-ecological classification of lands in the forest-steppe zone of Western Siberia, based on an analysis of the factors that limit crop production (Vlasenko et al., 2011). This allowed us to develop a map of agro-ecological land types for the “Altair” farm (Fig. 2C) and give recommendations on their use (Table 2).

Table 2. The agro-ecological land types in “Altair” farm and recommendations on their use

№№ on the map (fig.2C)	Name of the land types	Soil types	Production recommendations
1	Plakor earth	Chernozem ordinary, chernozem leached	Any zoned cultures, intensive technologies are permissible
2	Erosion-hazardous lands	Chernozem eroded, meadow chernozem eroded	Necessarily anti-erosion systems of agriculture only
3	Waterlogged saline-alkali lands	Meadow chernozem solonetsic soil, complex meadow solonetsic + saline-alkali soils	Perennial grasses, meadow formation

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Cadastral valuation of lands of Irkutsk region transferred from agriculture category: theoretical and methodological aspects

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Abstract

This file provides a template for writing papers for the congress. The congress proceedings will be published in an congress book and also it will be published electronic format only and abstracts in congress web page will also be printed to hand outs. The full paper in MS Word file shall be written in compliance with these instructions. Later on it will be converted into Portable Document Format (PDF). An abstract not exceeding 300 words should appear on the top of the first page, after the title of the paper in chapter titled "Abstract" (without chapter number), after the names of the authors and the contact information of the corresponding author.
Key words: land's cadastral evaluation, agricultural lands, land turnover.

Introduction

The issue of cadastral evaluation of agricultural land in the modern conditions of Russia's transition to a market economy is the most relevant. Land transformations, carried out in the Irkutsk region since the beginning of the agrarian reform have led to a change in the area of agricultural lands, but have not improved their quality. There are abandoned arable lands at the most agricultural and developed municipal areas of the region. In the valuation there are problems associated with the lack of formed market of agricultural lands.
In the Irkutsk region, the cadastral value of agricultural lands has increased significantly. In some cases it is much higher than the market value. Inadequate cadastral valuation complicates the process of land management and contributes to unsustainable land use. There is a need of land' cadastral value revising and soil-economic justification when transferring land from one category to another or entering abandoned arable land in agricultural turnover.
The purpose of the work is analysis of the cadastral value of agricultural land in Irkutsk region, of dynamics of the structure of agricultural land and justification for the introduction of unused arable land in agricultural turnover.

Materials and Methods

The subject and object of the study is the cadastral value of agricultural land within boundaries of the land Fund of the Irkutsk region. The information base of this study was the materials of the Federal state statistics service of the Russian Federation, of the Ministry of agriculture of the Irkutsk region, the data of the annual cadastral reports, legislative and regulatory acts of Russian Federation and of the government of the Irkutsk region on land reform and land use regulation, also periodic literature on research topic, materials of scientific and practical conferences and personal observations of author.
Overview of the state and structure of the land fund of the study area
In accordance with the Land code of the Russian Federation, the lands of the Irkutsk region are distributed into 7 categories according to their purposes (Land code of the Russian Federation, 2009). As of 01.01.2018, most of the territory is occupied by forest lands ─ 89.52% (69365.4 thousand hectares). The remaining 6 categories account for only 10.52%, of them with the share of agricultural land of only 3.73% (2882.8 thousand hectares).

The Irkutsk region is one of the largest regions of the Russian Federation. By area it occupies the 5th place among 83 subjects of the Russian Federation and the 2nd - in the Siberian Federal district. Meanwhile, the region has one of the lowest indicators of population' security of arable lands. If on average in Russia it is accounts for 0.89 hectares of arable land per inhabitant, in the Irkutsk region – it's only 0.46 hectares. The state of more than 20% of agricultural lands of the region is assessed as unsatisfactory. Intensive and indiscriminate land' using leads to lower fertility and productivity of them (Husnetdinov S. K., etc., 2017).
The natural conditions of the region and strongly continental climate of the region are the limiting factor in the development of agricultural production. The peculiar features of the relief, which are characterise for the foothill foothill valley of two intersecting mountain areas (East Sayan and pre-Baikal), the presence of spots of stable and degraded permafrost, the proximity of semi-deserts are created here a kind of special natural conditions for agricultural production. In addition, the main area of agricultural lands are located at areas with close occurrence of late Pleistocene deposits, which form of hilly-zapalenie landforms, that contributes to disastrous proper moisture drain, to reduction of humus layer horizon and – to plowing of Sartan ancient sediments (Dergacheva M. I., 2000; Granina N.I., 2010).

Results and Discussion

In the process of agrarian reform of Russian Federation of 1990 in the Irkutsk region there was a significant reduction of land's area including agricultural land due to the expansion of industrial, hydraulic and transport construction, create Ust'-Ilimsk, Boguchany hydroelectric power plants, for extraction of coal in Alara, Cheremkhovo regions (Vinokurov M. A., 1999; Regional report, 2017) as well as for expansion of territories of settlements of region' municipalities in Cheremhovo, Nizhneudinsk districts.
In addition, for agricultural enterprises there was a widespread voluntary abandonment of previously granted land, associated with their poor economic condition, with reduction of lands' fertility.
At the same time, the question about future of land' plots was remained unresolved. As a result, the information of such land plots, which has been included into cadastral documents, continued to consider as agricultural land (State (national) report, 2011). The dynamics of the agricultural land area of Irkutsk region is presented at table 1.

Table 1.The dynamics of the farmlands' area of the territory of Irkutsk region 1999-2017 (Ivanyo Y. M., 2017 with the additions of the author)

Agricultural land	Land's area, thousand hectares / per year							
	1990	1995	2000	2005	2010	2015	2016	2017
	5248,4	4361,7	4145,1	2901,6	2892,2	2888,5	2885,1	2882,8
The decrease of the area		886,7	216,6	1243,5	9,4	3,7	3,4	2,3

Abandoned arable lands are increasing everywhere. In 2006, their area was of 315 thousand hectares; in .2016 ─ 706,35 thousand hectares (Road map, 2017). The whole taiga areas, which once have been unrooted with cleared works today are overgrown with pines and birches. The reason is that the region is located at zone of risky agriculture. And in order to get a decent return from the land, the worthy finances funds need to invest to seed production, fertilizers and technologies. Only large agricultural holdings can afford it. In addition, the proximity of China is influenced as an additional supplier of agricultural products. Over the past decade Irkutsk agricultural producers have losted of many markets in Central Asia and at other regions (Ivanyo Y. M., 2017).

353,85 thousand hectares (50,09%) out of 706,35 thousand hectares of unused arable land are estimated currently as suitable for development and are planned for introduction into agricultural turnover. The remaining 49.91% (352.5 thousand hectares) will be transferred to the redistribution Fund (Road map, 2017). In accordance with Federal law No. 101-FZ, land plots, which are incoming into the lands' redistribution Fund, can be transferred to citizens and legal entities for lease or ownership.

Herewith, the legal regime of the Fund' lands is not yet regulated by special regulation documents on the procedure for crediting, granting and excluding land from the redistribution Fund. Therefore, the areas of agricultural land granted by the Fund for urgent using are not included into compilations of statistical indicators (Federal law, 2002). Today, agricultural lands are entered into all categories of the land Fund of the region (see Fig. 1)

The most arable lands of the Irkutsk region are located at the forest-steppe and steppe zones, which are favorable for agriculture. In almost all municipal districts of the region the land is cultivated by large agricultural enterprises. A significant share of arable land is owned by peasant (farm) farms.

Today, according to 01.01.2018 year, a significant part of the agricultural lands of the region's territory is owned by the citizens and consist of 1563,1 thousand hectares (or 54.2 per cent). In the ownership of legal entities is 110.7 thousand ha (3.8 per cent). The state and municipal ownership is of 1209.0 thousand hectares (42.0 %). Thus, 93.9% of the total lands area of the Irkutsk region, which have been privately owned, are agricultural lands (1673.8 thousand hectares) (Regional report, 2017).

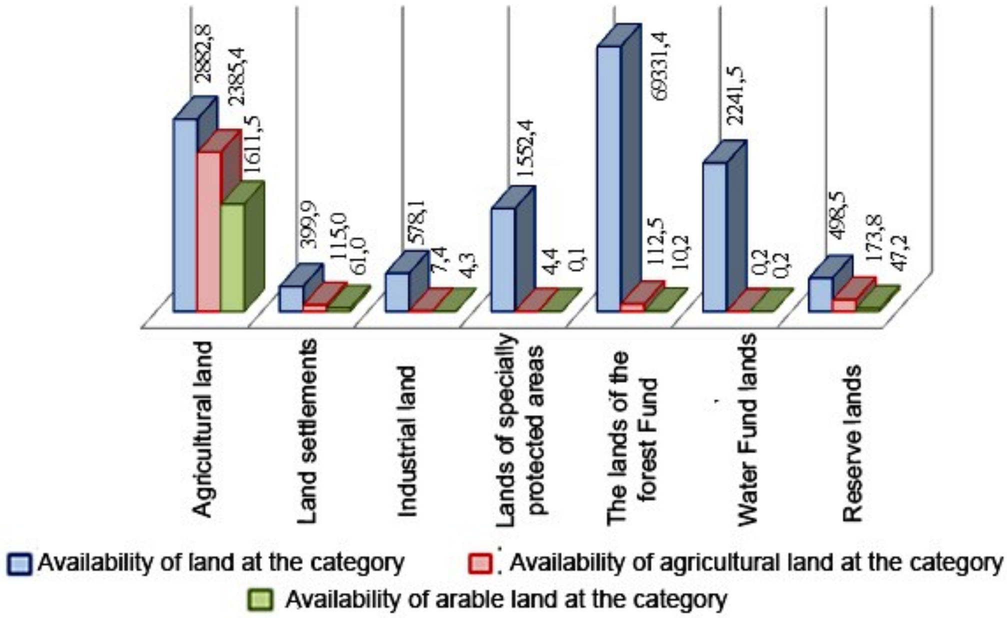

Figure 1. The structure of agricultural land in the Irkutsk region (Regional report, 2017)

At the present stage of land' reform in Russia, the most actual issue is the conducting a land' cost valuation, which connect with establishment of payment for the land use. The basis for determining of the lands' value were the results of mass on-farm land valuation, which have been carried out in 1989-1991 for all existing at that time agricultural enterprises. Agricultural lands were assessed according to their productivity, to the value of gross output, cost recovery, differential revenue, cost price, laboriousness and Fund capacity of production output (Sapozhnikov, P. M., 2011).

For the cadastral value of land in the first two rounds of the state cadastral evaluation of agricultural land (2001 – 2002; 2006 – 2007) were developed. The basic standards on the level of subjects of the Russian Federation have been determined In determining of the cadastral lands' value during first two rounds of the state cadastral evaluation of agricultural lands (2001 – 2002; 2006 – 2007). So the indicators of land rent and cadastral value were logically reflected the natural and economic conditions of land use. The cost of the lands was determined by multiplying of the data's of mass on-farm land assessment by the corresponding coefficient.

Thus, in 2004, the cadastral value of agricultural lands has been determined for 340 agricultural enterprises of the Irkutsk region within of cost and comparative approaches. That is, the cadastral value has been calculated by the cost' determining of agricultural production and multiplying of the land plots' area by the Specific Indicator of the Cadastral Value (SICV) for the reference land plot, as well as by indexing the past results of the on - farm lands valuation. Average cadastral value of the lands of Irkutsk region amounted to 6361 RUB/ha (0,64 RUB/sq m); maximum cadastral value consist of 11122 (RUB / ha (or 1.11 RUB / sq m) (for Usolskiy district).

The minimal cadastral value, which acting as absolute rent and is amount to 396 rubles/ha (or 0,04 RUB/sq. m), has been determined for seven agricultural districts of Irkutsk region: Bodaybinskiy, Zhigalovsky, Kazachinsko-Lensky, Katangsky, Mamsko-Chuyskiy and Olkhonsky, Ust-Kutskiy (Resolution of the Governor of the Irkutsk region, 2004).

Guidelines (2010) on the state cadastral evaluation of agricultural land have been adopted by the order of the Ministry of economic development of Russia № 445 of 20.09.2010, which had significant differences. For example, in the organizational and methodological plan, 1-stage organization of works (at level of land plot) has been proposed instead of 2-stage (at level of the subject of the Russian Federation and the land plot), which was included the evaluation of only the land plot.

Instead of analyzing of statistical data's in recent years on crop yields and the cost of their cultivation, the using of indicators of normative productivity and standard costs have been proposed on the basis of technological maps. There is lack accounting of absolute land rent and, as a result, there is no minimum cadastral lands' value. It was provided to take into account of crop rotation without taking into account and assessing of the location of land plots. In addition, the technology of lands' valuation works has been changed.

At the third round of evaluation the performers of the lands' evaluation works are not provided with centrally developed Technical instructions, special software, by a standard report structure and other necessary scientific and methodological materials. They are obliged to develop them on its own (Sapozhnikov p. I., 2011)

As a result of the third round of evaluation the Specific Indicator of the Cadastral Value (SICV) for the first group of agricultural lands was amounted to 1.13 RUB/.sq.m. at the Irkutsk region and to 1.01 RUB/ sq. m - at Siberian Federal district. (State (national) report, 2010) (see table 2)

The works having the state status are carried out by organizations of appraisers at the tender of the executor on the auction basis, therefore, each appraiser at his own risk redistributed the level of cost between the subjects (Makht V. A. et al., 2007).

Table 2. Specific indicator of cadastral value of agricultural lands of the Siberian Federal district, 2010 (State (national) report, 2010)

№	The districts	The Specific Indicator of the Cadastral Value at land's groups, RUB/sq. m.				
		I group	II group	III group	IV group	V group
1	Altai republic	0,91	0,90	0,09	0,09	0,29
2	Republic of Buryatia	0,59	*no	*no	*no	*no
3	Republic of Tuva	0,29	0,25	0,25	*no	*no
4	Republic Of Khakassia	0,70	0,62	0,54	0,09	0,09
5	Altai territory	1,09	1,14	1,05	0,04	0,25
6	Krasnoyarsk region	1,10	1,23	1,36	0,09	0,09
7	Irkutsk region	1,13	1,55	0,59	0,09	0,09
8	Kemerovo region	1,27	2,15	1,41	0,09	0,09
9	Novosibirsk region	1,40	1,40	1,53	0,04	0,21
10	Omsk region	2,27	2,62	2,80	0,09	0,09
11	Tomsk region	0,78	0,68	0,51	0,09	0,13
12	Zabaikalsky Krai	0,56	0,62	*no	0,09	0,10
The average cost for the district		1,01	1,20	1,01	0,08	0,14

* no information; no objects of evaluation for group 6

So, in the Irkutsk region the value of the second group of agricultural lands (1.55 RUB/sq. m.) became higher than the cost of lands of the first group (see table.3). In 2018, the cadastral value of 1 sq. m. of agricultural land in Irkutsk region increased on average by 4 %, from 1.46 to 1.52 RUB/ sq. m., for lands of another agricultural purposes ─ by 37 %, from 5.5 to 7.56 RUB /sq.m (Resolution of the government of the Irkutsk region, 2017).

At present time, instead of the previously existing methods, the new ones have been developed separately for the valuation of each category of lands. The unified methodology for all categories of lands has been developed and approved by the Ministry of economic development of the Russian Federation, which taking into account a variety of facts affecting to the lands' value in a market economy (FZ "on cadastral valuation", 2018). The question arises: what place in it will be occupy by agricultural lands?

Conclusion

The tendency of decrease in productivity of agricultural lands becomes threatening and causes the necessity of decision - making for preservation of reserves of ensuring stability of agricultural production of the region. In modern conditions of land using the cadastral value of agricultural lands becomes one of the main economic lever of land management of the Irkutsk region. In determining of land's value assessment, the needless of carrying out of soil-ecological and economic assessment or examination of agricultural lands had became obvious with justification of the possibility or admissibility of their transfer from one category to another and carrying out of their reclamation.

Unfortunately, the works of soil scientists on soil bonitation have been suspended for a long time because of the needless for an inventory of land resources. The bonitation of soils is a logical continuation of comprehensive lands surveys and precedes of their economic assessment (cadastral and market). When performing a lands' valuation In Irkutsk region there was a problem with the lack of bonitation data's of soil and lands.

At the present stage, it is extremely important to create such a motivational mechanism of management, so that the owner / tenant of the land was interested in the involvement of lands into economic turnover and their effective use. It is necessary to consider the land not only as an attractive object of real estate, property, purchase and sale, but also as the main means of production and a unique natural resource.

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Mapping and evaluation based on modelling of soil fertility using GIS and interpolation methods

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Abstract

This study, The Ilıcak and Kum Stream, which covers an area of 16.64 km2 in the Gediz Basin of the Aegean Region, was conducted in two adjacent micro basins by taking into consideration of different land uses. Soil fertility changes of land resources were investigated and distributed maps were created by using the soil fertility model by means of interpolation models and Geographic Information System techniques in the study area. In the study, 15 parameters (physical, chemical and productivity soil properties) in the Soil Fertility Index (SFI) model were determined surface (0-30 cm) to estimate soil fertility. The study area was divided into 700 x 700 m grid squares. A total of 319 soil samples were collected from the surface (0-30 cm) of each grid intersection point. The proportional values of all the factors considered for determining the soil fertility index (SFI) value of each soil sampling point were used and the soil fertility was calculated through a parametric approach. After this step, soil fertility distributions and mapping processes were carried out using interpolation methods and Geographic Information System (GIS) techniques. 58% of the total area has good (S1) and moderately fertile (S2) soil and 30.70 % (S3) of the study area's soil is poor fertile soil when the soil fertility of the surface area of the study area is evaluated. Only a very small area (11.30 %) has non fertile (N) soil. In addition, CORINE land use and land cover classification were performed in order to determine land use-land cover distribution of the study area.

Key words: Soil fertility index, geographic information systems, land use, alluvial areas.

Introduction

Soil fertility is a complex process that involves the constant cycling of nutrients between organic and inorganic forms and land use patterns play a major role in influencing nutrient availability and cycling (Lu et al. 2002). Soil fertility degradation by nutrient depletion, mostly caused by erosion, but also by removal of nutrients in crops, is one of the major threats to agricultural systems. Soil erosion is the most visible and sometimes most destructive form; about 85% of land degradation worldwide is due to soil erosion by wind and water (Mukashema 2007). This threat, in addition to causing on-site loss of topsoil and reducing the productivity of soils, brings about major off-site environmental effects such as pollution and sedimentation in streams and rivers, clogging these waterways and causing declines in fish and other species. As well as those risks, lands degraded by erosion are also often less able to retain water, which can worsen flooding.

In order to use sustainable land resources and improve their productivity, it is necessary to determine the current status and monitored whether degradation can be explained by use of land in local condition. For this reasons, in the last few decades advanced computer programs such as a geographic information system (GIS), geoststistical program and simulations models contribute to the speed and efficiency of the overall planning process and allow access to large amounts of information quickly.

The main purpose of the present study was to investigate and create map of soil fertility changes in two adjacent micro basins covering area of 16.64 km2 in the Gediz Basin of the Aegean Region by taking into consideration of different land uses by means of a soil fertility model developed with the geostatistical programme and GIS techniques.

Materials and Methods

The study field description

This study was carried out in two adjacent micro catchments which is located at the Gediz Basin (Figure 1). This study area which consists of two adjacent micro catchments in the Gediz Basin is about 16647 ha and its elevation changes between 70 m and 760 m from sea level. General land cover and land uses of the study area are irrigated agriculture (cotton, grape, maize, tomato, potato, water melon etc), rainfed agriculture (olive, tobacco, wheat, barley etc.), makii, shrub land, forest, settlement and bare and dune lands.

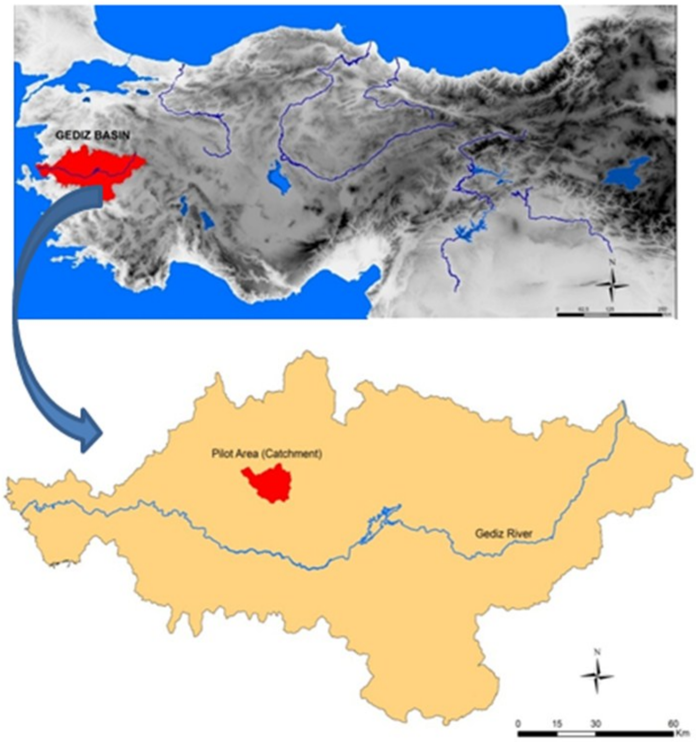

Figure 1. Location map of the selected catchment area of the Gediz Basin in Turkey

Most of the flat and gently slope area are located on west parts while; east part of the watershed is hilly and mountainous. Slope is undoubtedly one of the most important determinants of soil erosion. Erosion only occurs when slope exceeds a critical angle and it increases with the absence of vegetation cover. Almost half of the study area has moderate, high and very high erosion levels. Particularly hilly and mountainous areas covered by generally forest or pasture have been used for olive cultivation leading to exacerbate soil erosion process.

Method

Soil Sampling

The study site was divided into 700m x 700m grid squares (Figure 2). The total of 320 grid points was obtained and while 319 soil samples were collected from surface soil (0-30 cm), depth of each grid centre. Soil samples also represent for different topographic positions and land use/land cover types. The soil samples were transported to the laboratory where they were crumbled gently by hand after the root material was removed. These samples were used to determine the physicochemical and fertility status of soils.

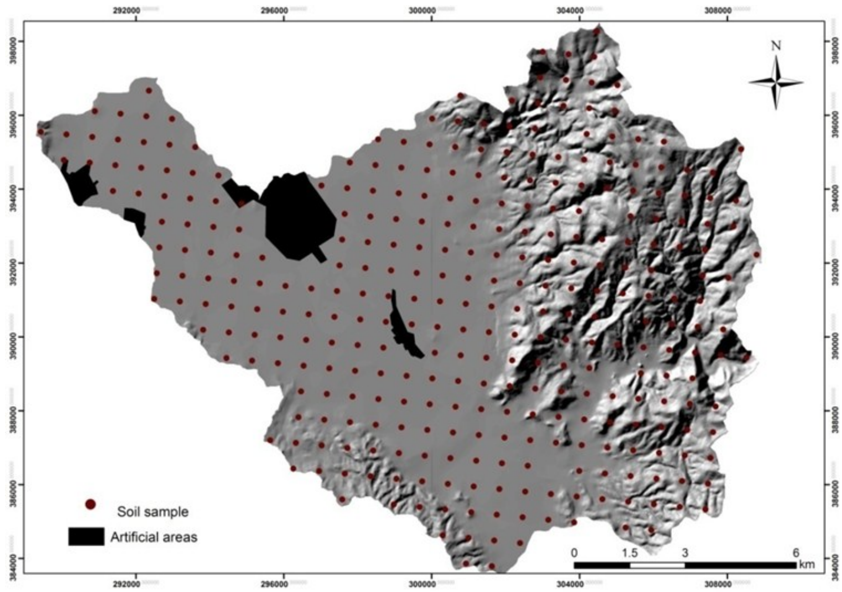

Figure 2. Maps of soil sampling sites in the study area

Soil Physicochemical Analyses

Physicochemical analyses of soil were conducted on air-dried samples stored at room temperature and from which crop residues, root fragments and stones larger than 2 mm in diameter had been removed. Soil properties were determined with the following methods: soil particle size distribution by the hydrometer method; pH and electrical conductivity (EC) in 1:2.5 (w/v) in soil: water suspension by pH-meter and EC-meter, respectively; CaCO3 content by the volumetric method; total nitrogen (Ntotal) by the Kjeldahl method; available phosphorus (Pav) by the 0.5 M NaHCO3 extraction method; and exchangeable potassium (Kexc), calcium (Caexc), sodium (Naexc) and magnesium (Mgexc) by the 1 N ammonium acetate extraction method (Soil Survey Staff, 1992). All soil samples were sieved through a 150 μm mesh before determination of the total organic matter content with the wet oxidation (Walkley-Black) method with K2Cr2O7 (Nelson and Sommers 1982). Soil micronutrient availability (Feav, Cuav, Znav, Mnav) was determined for each sample (Lindsay and Norvell 1978). Micronutrient levels (Feav, Cuav, Znav, Mnav) were determined for each soil sample by using atomic absorption spectrophotometry (Perkin Elmer 1990).

Computation of Soil Fertility Index

Over the years, there are many different soil testing procedures or methods that provide the most reliable prediction of crop yield response to evaluate soil fertility status. Soil fertility status can be evaluated directly or indirectly. Direct evaluations are carried out in the field, greenhouses or laboratory by means of some experiments under given climatic and management conditions. Indirect evaluations consist basically in developing and applying models of varying complexity. One of the most suitable models is Soil Fertility Index (SFI) model. To developed this model and determine threshold level of each SFI class, some literatures such as Lindsay and Norvell, 1978; Wolf, 1971; FAO, 1990; Soil Survey Staff, 1992; Moran et al., 2000; Lu et al., 2002; Boruvka et al., 2005; Hazelton and Murphy, 2007 were used. SFI was calculated to qualitative soil fertility by means of parametric approach using fifteen parameters for each soil sample point.

These parameters are commonly implemented in physical and chemical characteristic of soil using Table 1.

Table 1. Factor rating of each soil parameter

Diagnostic Factors	Unit	Factor rating				
		100	80	50	20	10
Available Macronutrient Elements						
A- N_{total}	%	> 0.32	0.32-0.17	0.09-0.17	0.09-0.045	<0.045
B- P_{av}	*mg kg^{-1}*	> 80	25-80	8.0-25	2.5-8.0	<2.5
C- K_{exc}	*cmol(+) kg^{-1}*	0.28-0.74	0.74-2.56	0.13-0.28	>2.56	<0.13
D- Ca_{exc}	*cmol(+) kg^{-1}*	17.5-50	5.75-17.5	1.19-5.75	>50	<1.19
E- Na_{exc}	*cmol(+) kg^{-1}*	0.0-0.20	0.21-0.30	0.31-0.70	0.71-2.0	> 2.0
F- Mg_{exc}	*cmol(+) kg^{-1}*	1.33-4.0	4.0-12.5	0.42-1.33	>12.5	<0.42
Available Micronutrient Elements						
G- Mn_{av}	*mg kg^{-1}*	14-50	4-14	50-170	>170	<4
H- Zn_{av}	*mg kg^{-1}*	0.7-2.4	2.4-8.0	0.2-0.7	>8.0	<0.2
I- Fe_{av}	*mg kg^{-1}*	2.0-4.5	1.0-2.0	1.0-0.2	>4.5	<0.2
K- Cu_{av}	*mg kg^{-1}*	> 0.2	-	-	-	<0.2
Soil Physical and Chemical Characteristics						
L- $CaCO_3$	%	5-15	1-5	15-25	>25	0-1
M- Salt or **EC**	*% / dS m^{-1}*	0-0.15 / 0-2	0.15-0.30 / 2-4	0.30-0.50 / 4-6	0.50-0.65 /6-8	>0.65 / >8
N- pH	*1:2,5 (soil/water-w/v)*	6.5-7.5	7.5-8.5	5.5-6.5	4.5-5.5	<4.5->8.5
O- SOM	%	>3	2-3	1-2	0.5-1	0-0.5
P- Texture	%	CL, SCL, SiCL,	vfSL, L, SiL, Si, <%50 C	> %50 C, SC, SiC	SL, fSL	S, LS

N_{total}: Total Nitrogen; P_{av}: Available Phosphorus; K_{exc}: Exchangeable Potassium; Ca_{exc}: Exchangeable Calcium; Na_{exc}: Exchangeable Sodium; Mg_{exc}: Exchangeable Magnesium; Mn_{av}: Available Manganese; Zn_{av}: Available Zinc, Fe_{av}: Available Iron; Cu_{av}: Available Cupper; EC: Electrical Conductivity; SOM: Soil Organic Matter; CL: Clay Loam; SCL: Sandy Clay Loam; vfSL: Very Fine Sandy Loam; L: Loam; C: Clay; SL: Sandy Loam; fSL: Fine Sandy Loam; S: Sand, LS: Loamy Sand; SiCL: Silty Clay Loam; SiL: Silty Loam; Si: Silty, SC: Sandy Clay; SiC: Silty Clay.

Each parameter or factor is evaluated ranging between 0.1 and 1.0. The least favour value of factor rating is 0.1 and the most beneficial value of factor rating is 1.0 for plant growth. In other words, the limiting nature of each SFI classes is taken into account by its effect in reducing productivity. SFI is calculated and using the value of factor rating for each factor as follows;

$$SFI = \left[Rmax * \sqrt{\frac{A}{100} * \frac{B}{100} * \ldots\ldots} \right] * 100$$

SFI: Soil Fertility Index,
Rmax: Maximum ratio (A+B+..........+P)/15
A, B...: Rating value for each diagnostic factors,
SFI of each soil sample point can be classified by taking into consideration of as indicated in Table 2.

Table 2. Classes and values of the soil fertility index (SFI)

Class	Description	SFI values
S1	Good Fertility	> 80
S2	Moderate Fertility	80-50
S3	Marginal Fertility	50-20
N	Poor Fertility	< 20

Interpolation Analyses

In this study, different interpolation methods (Inverse Distance Weighing-IDW, Radial Basis Function-RBF and Kriging) were applied for predicting the spatial distribution of SFI. Kriging is a geostatistical technique similar to IDW in that it uses a linear combination of weights at known points to estimate the value at an unknown point. Kriging uses a semivariogram, measure of spatial correlation between two points so that weights change according to the spatial arrangement of the samples. In contrast to other estimation procedures, kriging provides a measure of the error or uncertainty of the estimated surface. Several forms of kriging interpolation exist, including Ordinary Kriging (OK), Simple Kriging (SK), and Universal Kriging (UK).

In present study, Root mean square error (RMSE) was used to evaluate the interpolation techniques. The lowest RMSE indicate the most accurate prediction. Estimates are determined by using the following formulae:

$$RMSE = \sqrt{\frac{\sum(z_{i^*} - z_i)^2}{n}}$$

Where; Zi is the predicted value, Zi* is the observed value, and n is the number of observations.

Results and Discussion

Soil Physicochemical Properties

The physical and chemical properties that were considered in this study showed variability as a result of dynamic interactions among natural environmental factors, including the degree of soil development and leaching, and human activities such as fertilization. Soil chemical and physical properties considered in this study were pH, electrical conductivity, soil organic matter, lime content (CaCO3), total nitrogen, available phosphorus, exchangeable potassium, exchangeable calcium, exchangeable sodium, exchangeable magnesium, available manganese, available zinc, available iron, available copper and soil texture. The descriptive statistics, as minimum, maximum, mean, and coefficients of variation of physic-chemical properties of surface soil samples, are presented in Table 3. The values of pH for soil samples, which ranged widely between 6.55 and 8.28, indicated slightly acid to moderately alkali soils. Electrical conductivity had a minimum value of 0.22 dS m-1 and a maximum value of 1.83 dS m-1. Most sampling points had low CaCO3, with the exception of 5.4% of total soil samples which had more than 20% CaCO3. The mean values for organic matter and CaCO3 content (%) were 2.12 and 10.53. respectively. As for macronutrient element of samples, Pav and Kexc showed high variation between minimum and maximum values. Ntotal varied between 0.01 and 0.28 and the average value was 0.10. The mean values of Caexc, Mgexc, and Naexc concentration were 49.26, 25.85 and 1.22 cmol (+) kg-1, respectively. In addition, Table 3 shows the distribution of the micronutrient element (Feav, Cuav, Znav and Mnav) concentrations of samples. According to the threshold values reported by Lindsay and Norvell (1978) and FAO (1990), Cuav and Mn av were sufficient amounts in all of the soil samples for which the mean values were 1.12 and 31.55 mg kg-1, respectively. On the other hand, 14% of all samples were found deficient in terms of available Feav while, 37% of all soil samples include insufficient Znav (mean value was 0.62 mg kg-1). Additionally, the descriptive statistics of the soil fertility index (SFI) are presented in Table 3. Mean values of the SFI were between 2.08 and 829.78.

Table 3. Descriptive statistical analysis of physical and chemical properties of soil samples

Parameters	Mean	SD	*CV	Varians	Min.	Max.	**Skewness	Kurtosis
pH	70.33	0.26	1.73	0.07	6.55	8.28	0.65	1.32
EC (dS m^{-1})	0.66	0.25	1.61	0.06	0.22	1.83	1.06	2.12
Kil (%)	6.15	4.10	28.42	16.83	0.83	29.25	2.31	6.97
Silt (%)	8.46	6.32	36.37	39.99	0.48	36.85	1.81	3.78
Kum (%)	85.38	9.68	59.26	93.79	39.41	98.67	-1.94	4.50
O.M (%)	2.12	1.18	5.40	1.41	0.13	5,53	0.93	0.49
$CaCO_3$ (%)	10.53	10.61	76.35	112.75	0.59	76.94	2.04	5.45
N (%)	0.10	0.05	00.27	0.00	0.01	0.28	0.94	0.53
P (mg kg^{-1})	25.14	13.56	111.81	184.08	1.23	113.1	1.31	5.30
Fe,mg kg^{-1}	5.76	5.16	40.20	26.70	0.66	40.91	2.58	9.36
Cu,mg kg^{-1}	1.12	0.92	12.12	00.86	0.03	12.21	6.40	65.91
Zn,mg kg^{-1}	0.62	1.57	14.80	2.48	0.00	14.85	6.59	52.89
Mn,mgkg^{-1}	31.55	36.35	201.51	1321.81	1.48	203.0	2.17	4.82
Ca,cmol kg^{1}	49.26	15.69	108.41	246.10	9.55	117.9	0.42	1.18
Mg,cmol kg^{-1}	25.85	12.57	80.73	158.20	1.00	81.70	0.34	1.34
Na,cmol kg^{-1}	0.29	0.53	6.47	0.28	0.05	6.52	6.85	64.55
K,cmol kg^{-1}	1.22	0.87	7.37	0.76	0.01	7.38	2.03	8.43
SFI	104.73	118.48	827.70	14038.20	2.08	829.78	2.77	9.68

SD: HCStandard deviation, Min.: Minimum, Max.: Maximum, n: sample number (160),
*CV (Coefficient of Variation): < 15 = Low variation, 15-35 = Moderate variation, >35 = High variation
**skewness:< │+/-0.5 │= Normal distribution, 0.5- 1.0 = Application of character changing for dataset, and > 1,0 → application of Logarithmic change

Distribution of land productivity index with spatial variability

Interpolation analysis for SFI was used to identify the best predictive model from among eight different semivariogram models (Inverse Distance Weighing-IDW with the weights of 1, 2, 3 and radial basis function-RBF with thin plate spline (TPS), simple kriging with spherical, exponatial and gaussian variograms were tested and then, the variogram or function of each interpolation method yielding the best results was determined. Comparison of interpolation methods for SFI is provided in Table 3. Finally, Gaussian model of simple kriging was used to estimate or predict SFI at unsampled locations and their distribution maps were presented Figure 3.

Table 3. Cross validation according to interpolation methods

Enterpolasyon model	Pover/Semivariogram	RMSE
IDW	1	117.3
	2	118.3
	3	119.9
RBF	TSP	143.5
Simple Kriging	Spherical	114.8
	Exponential	115.1
	Gaussian	**114.5**

The distribution map of surface SFI of the study area are illustrated in Figure 3 and classified as four levels according to Table 2. As seen from the Table 4, it was determined from the distributions of SFI class for the study area. In the study area, 58% of the total area had good (S1) or moderately fertile (S2) soil, while 30.7% of the study area had marginally fertile (S3) soil. Only a small area (1881.1 ha) had poor fertility (N) soil. In addition Table 4 shows distribution of SFI's classes for different land uses. The highest land for poor fertility soil (1098.7 ha) was determined in crop land whereas, the highest coverage area for good fertility soil (4544.6 ha) was also determined in crop land. In addition, 3.5 % of the total forest area has poor fertility soil while only very small area (1.2%) of pasture land was found as poor fertility soil. These soils have some plant growth limitations in marginal or low productivity areas due to high hydraulic conductivity, high sand and coarse fragment content, low water retention capacity, low plant nutrient availability or poor drainage.

Table 4. Distribution of the soil fertility index (SFI) classes in the study area.

Land Use	SFI Class	Description	Area	
			ha	%
Forest Land	S1	Good Fertility	948.9	5.70
	S2	Moderate Fertility	732.5	4.40
	S3	Marginal Fertility	1564.8	9.40
	N	Poor Fertility	582.6	3.50
Pasture Land	S1	Good Fertility	1714.6	10.30
	S2	Moderate Fertility	416.2	2.50
	S3	Marginal Fertility	665.8	4.00
	N	Poor Fertility	199.7	1.20
Crop Land	S1	Good Fertility	4544.6	27.30
	S2	Moderate Fertility	1315.1	7.90
	S3	Marginal Fertility	2863.3	17.20
	N	Poor Fertility	1098.7	6.60
Total			16647	100

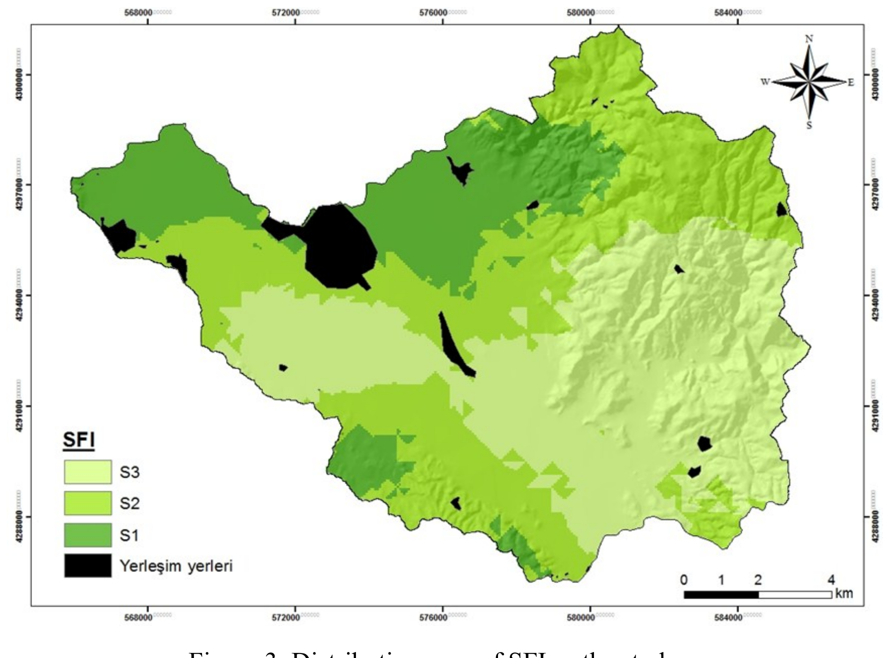

Figure 3. Distribution map of SFI or the study area

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Salt-affected soils in the Devonian Basin of Staraya Russa (Northwestern Russia): genesis, properties, classification

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Abstract

The mineral springs of Staraya Russa (Novgorodskaya oblast') and the conjugated elements of the landscape are the subject of research mostly by hydrogeologists, archaeologists and represent a unique interest in the aspect of genetic soil science as the area extent of salt-affected soils in a humid climate. While in southern regions of Russia within the semi-desert, dry steppe, steppe and forest steppe zones, salt-affected soils are widespread, in the northern regions they are locally distributed. The origin of Staraya Russa mineral water is believed to be a result of tectonic faults in the crystalline basement, which could cause the movement of sedimentary cover. As the water rises from the lower aquifers through the system of faults and joints it is saturated with salts. The soil salinization phenomenon is caused by the accumulation of saline water in zones of active groundwater seepage, and these are the places where groundwater contacts with brines of Devonian salt deposits. Soil profiles, being under the influence of mineral waters discharged, however, undergo continual changes caused by humid climate conditions.
Key words: mineral springs, Devonian brines, Novgorodskaya oblast', salt-affected soils.

Introduction

Tsaritsynsky saline spring in Staraya Russa is considered to have a resource as a potential spa resort using mineral waters for the medical treatment. In present the spring represents a high discharging well (> 73 L/s), with a depth of well intake is 246 m. Due to injecting saline waters contacted with Devonian-age salt deposits into shallow groundwater system the sites with salt expression on the soil surface were identified. Hydropedological instruments were used for studying salt migration within the local catchment with emphasis on the interactions between subsurface brines and the surface systems.

Materials and Methods

Study site

The study area is located in the southern taiga subzone within the Il'men Lowland in which surface does not exceed 50 m a.s.l. The lowland is crossed by numerous rivers flowing into the Il'men lake (Fig. 1). Staraya Russa town lies on the banks of three rivers: Porus'ya, Polist', Lovat'. Saline effluent of Tsaritsynsky spring is drained by Solyanoj spring flowing into the river Polist'. The study area was focused along Tsaritsynsky spring water flowing.

The topography at the site is a relatively flat, but includes local mounds and depressions. The area is characterized by humid climate; the mean annual rainfall is 550–650 mm/a, and evaporation of 325–375 mm/a. Late quaternary clay sediments represent the parent materials. Thus, soils in the studied area are formed under hydrological regime of waterlogging and characterized as wetland-discharge soils.

Methods

Sample site (Fig. 1) was chosen to characterize salt-affected soil types forming under the impacts associated with groundwater salinity. Sampling for artesian water of Tsaritsynsky spring, groundwater and surface water draining the local catchment was undertaken to get understanding about hydrochemical conditions across the catchment and assess salt migration. The survey was carried on during spring season 2017. Two soil profiles were excavated up to 1 m depth (Fig. 1). The concentrations of the water-soluble components in soils were determined by water extraction. Water and soil water extracts were analyzed for pH, TDS, cations, anions. Major cations were measured by atomic absorption (ICPE). Chloride ion concentration was determined by Mohr's method. Water-dissolved sulfates were determined after precipitation via 10 % $BaCl_2$. Hydrocarbonate ion was determined by titration. Total Dissolved Solids (TDS) were calculated by summing the concentrations of cations and anions.

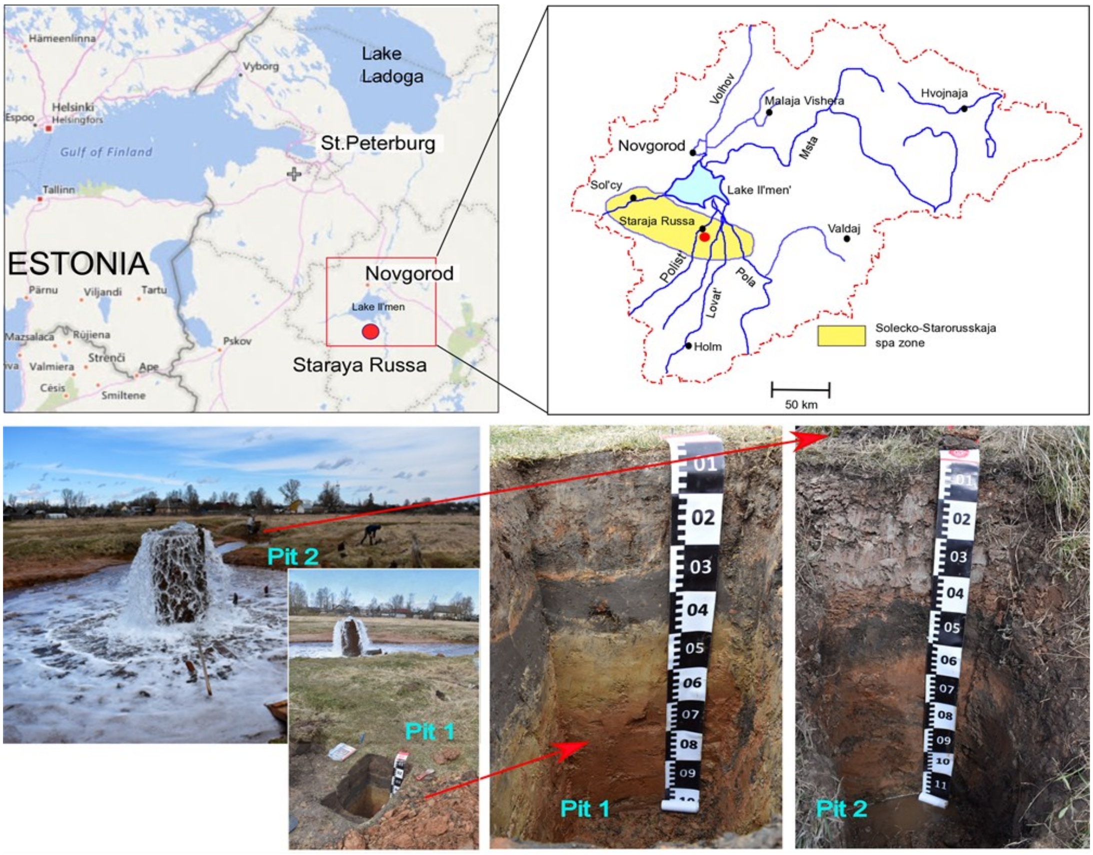

Figure 1. Study site. Tsaritsynsky saline spring in Staraya Russa. Soil profiles in the impact zone of Tsaritsynsky spring

Results and Discussion

Major ion hydrochemistry is presented in Table 1. Chemical composition of mineral water from Tsaritsynsky spring and shallow groundwater with high TDS, of the Na–Cl type reflects water–rock interaction processes leading to its present chemical composition (Tab. 1). Several authors have pointed to modern meteoric water entering the deep basin brine aquifer system along structures of the Devonian Basin, increasing in salinity through the dissolution of evaporite minerals, and mixing with paleoseawater [2]. Groundwater chemical composition may therefore be a combination of regional groundwater and the contribution from the Devonian aquifer system.

The watertable is relatively shallow (~1 m) and features of a periodically anoxic environment are observed in soil profiles. Both morphological features and analytical data indicate the influence of salt accumulation processes affecting soils. During periods of prolonged drought incrustations of salts are seen on the exposed soil surface. Halophilous vegetation occurs along the saline spring. Studied soils are slightly alkaline.

Table 1. Chemical composition of artesian, groundwater and surface water samples

Sample name	pH	TDS	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+
		mg/l							
Tsaritsynsky spring	6.9	19559	159	11000	1345	1600	540	4830	85
GW	7.3	8582	610	4396	438	293	160	2644	41
Solyanoj spring SW	6.9	26735	2135	13471	1368	1600	240	7840	81
River Polist' SW[1]	6.7	845	203	331	19	35	4	252	1
River Polist' SW[2]	6.4	976	203	425	5	50	5	286	2

SW – surface waters, GW – groundwater, [1] – down to the Solyanoj spring estuary, [2] – up to the Solyanoj spring estuary.

Base component analysis of water soil extracts revealed that in the first pit (Pit 1, Fig. 1) the dominating ions were $Ca^{2+}$and SO_4^{2-} (Fig. 2) whereas concentrations of Na^+ and Cl^- in artesian water, groundwater and surface water from Solyanoj spring were highest. Na^+ and Cl^- contents increased with depth until they reached the maximum at the base of soil profile contacting with groundwater. Surface water of River Polist' (Tab. 1) has low TDS because local rainfall is significant in maintaining standing river water levels but the Na-HCO3-Cl-type indicates inherited chemistries from both rainfall solutes and saline water dissolution along their flow path. The first soil profile (Pit 1) is located 8 m south-east of Tsaritsynsky spring and the second pit (Pit 2) excavated in the bank of Solyanoj spring is located 30 m north of Tsaritsynsky spring. The water table in Pit 2 is lower (105 cm depth) compared with Pit 1 (82 cm depth).

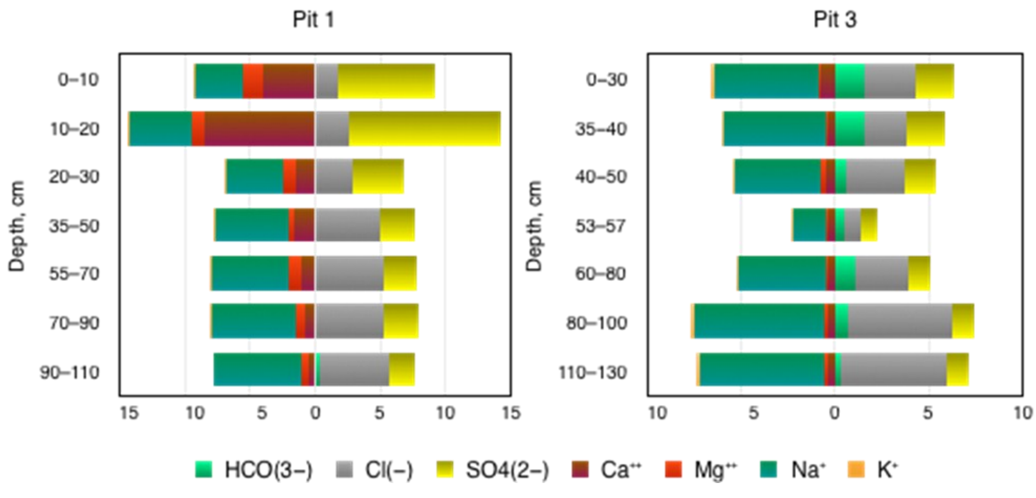

Figure 2. Diagram of vertical salt distribution in soil profiles, mmol-eq/100 g.

Soil in Pit 1 undergoes the greater salinization pressure. Soluble salt content was twice higher than in Pit 2 and the highest total salt concentration was detected in the surface horizons. In terms of chemical composition $Ca^{2+}$and SO_4^{2-} ions predominate (Fig. 2). Generally under humid conditions limiting by evapotranspiration water-soluble $Ca^{2+}$and SO_4^{2-} predominate in soils compared with Na^+ and Cl^- as they do in the first pit. In Pit 2 vertical distribution of salts demonstrates a tendency to leaching them from the profile; Na^+ and Cl^- ions predominate in water soil extract (Fig. 2). The profile variability observed in the data of salinity within both soil profiles indicates that salt concentration should be considered not only as the result of short-term fluctuations of rainfall/evapotranspiration processes but the pedogenic processes and soil properties (texture, presence of buried plowing horizons, oxidation, gleyzation, carbonate precipitation). Potential reasons for differences in the salt content, vertical salinity gradient and Cl^{-}/SO_4^{2-} ratio between these two pits are associated with the water table because over 50% of the variation in major ion concentrations occurs vertically over the top 1–2 m of the pore water/groundwater brine body [1]. Preferential flow paths control the areal distribution of saline soils.

Conclusions

The presence of high salinity in shallow groundwater is not a common feature of humid environments. Processes responsible for high groundwater salinity in this basin and the occurrence of salt-affected soils formed in the discharging saline water zone may be regarded of anthropogenic genesis as well as having natural hydrogeological basement. Analytical results covering phreatic and surface waters and two soil profiles within one local catchment show pedogenic transformation of subsurface hydrochemistry when groundwater discharging and salt transport into surface waters. Understanding the processes that regulate the spatial distribution of microsites in water and soil salinity is essential for soil and water protection in these environments.

Acknowledgements

Thanks to Chemical Analysis and Materials Research Centre of St. Petersburg University for support in laboratory analysis of water extracts (Project № 108-8100).

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Time as a factor of soil formation and evolution of soils

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Abstract

Time, as a factor of soil formation, has been poorly studied. Soil formation is the unity of two polar opposites, living and inert matter. Live plant formations and microorganisms meeting their nutritional needs destroy minerals and rocks. The driving force of this destruction is the supply of hydrogen protons to the soil environment together with active organic and inorganic compounds of acidic nature of biological origin. During the preparation of the article, the research of the Department of Soil Science of the Stavropol Agrarian University was used. Based on the study of Cuban soils on various rocks and buried soils of burial mounds in the burial grounds of the Stavropol Territory, conducted together with archaeologists. Archaeological excavations were carried out in the arid zone of the edge on chestnut soils and in a relatively humid zone on chernozems. A model of soil evolution under wet conditions is given. It can be assumed that in evolutionary development the soils consistently pass from birth on the rock to a mature state, and then aging and their natural death (neo-breed). The longest stage is the aging of the soil, the shortest stages are the beginning of soil formation and death. The increase in fertility is guaranteed by the processes of weathering of minerals and the transfer of inaccessible forms of nutrients into accessible, accumulation of organic matter, improvement of physical, physico-chemical, water, air (etc.) soil properties, and increased microbiological activity. Degradation of fertility is also caused by the weathering of minerals, but at later stages of soil formation, when significant differences between soils and rocks are observed, a decrease in the content of organic matter and nutrients, and significant acidification of the soil solution.
Key words: stages of soil formation, beginning of soil formation, maturation of soils, soil aging, fertility.

Introduction

Time, as a factor of soil formation, is given very little attention. It determines the stage of soil development, the direction of soil formation and the level of fertility. The life process is an inseparable unity of two polar opposites - ***destruction*** and ***creation***. Soil formation can be considered the result of the interaction of two mutually exclusive principles - living and inert matter. Live plant formations and microorganisms to meet their nutritional needs must destroy minerals and rocks that make up the soil. "It is destruction that is the driving, active, leading, i.e. primary in relation to creation, the side of the life process" [1] .

This is the philosophy of life, which says: in order to create something, it is necessary to destroy something. The driving force of this destruction is the supply of hydrogen protons to the soil environment, together with active chemical compounds of acidic nature, both organic and inorganic. The extracellular (holophyte) digestive cycle of phototrophs and microbial heterotrophs ensures the entering of these substances. Therefore, the soil-forming process is uniform for all corners of the earth, but its manifestation can have a different character, depending on the specific conditions of soil formation, among which the quality of the original rock and the climate are at the first place.

Materials and Methods

At the preparation of the article the research of the Soil Science Faculty of the Stavropol Agrarian University was used [2, 3]. The basis was taken to study the soil of Cuba in various rocks and buried soil of burial mounds of the Stavropol Territory, conducted together with archaeologists. Archaeological excavations were carried out in the arid zone of the region on chestnut soils and in a relatively humid zone on chernozems.

Results and Discussion

Based on these studies, it can be assumed that, in evolutionary development, the soils pass successively from birth to formation until their natural death (neo-breed).

The first stage is the beginning of soil formation. During this period, vegetation settles on the original soil-forming rock. Organic matter accumulates in the upper, forming horizon of the soil. This is the first sign that distinguishes the soil from the parent rock. The duration of this period is, presumably from 10 to 100 years, depending on climatic conditions.

The second stage is the accelerated soil formation. The formation of the upper genetic horizons begins, organic matter accumulates, microbiological activity increases, the mineral base of soils collapses, the nutrient elements accumulate in a labile form. The main soil characteristics and differentiation of the profile appear. The duration of the period is from 100 to 1 thousand years.

The third stage is delayed soil formation. All the genetic horizons of soils continue to be formed, the thickness of the profile increases, the accumulation of organic matter, labile forms of nutrition elements continues. Soil fertility is increasing. There are no differences in the mineral basis of soils and parent rocks. The duration of the period is from 1th. up to 10 th.years.

The fourth stage is a mature soil. The formation of the soil profile and all genetic horizons is nearing completion. Soil accumulates the maximum amount of organic matter and nutrients. The greatest is the microbiological activity. The physical, water, air properties of soils and soil regimes are optimal for specific conditions of soil formation. There are still no significant differences in the quality of the mineral basis of soils and soil-forming rocks. The profile of soils reaches the maximum capacity, and the fertility of the highest level. The duration of the period is presumably from 10th. up to 100 thousand years. In wet and moderately humid zones, it can begin and end sooner.

This 4th stage is inconsistent with the general ideas of the Russian theory of soil formation. It is usually called the climax and the last when the stage of equilibrium functioning comes and all the processes take place within the framework of relatively stable biochemical cycles. Many scientists believe that this period can take as long as desired. But is it possible to achieve any equilibrium and constancy in open biological systems with a constant inflow and outflow of matter and energy? The process of soil formation continues. Plants use the soil as a dining room, absorbing nutrients that are alienated from the soil along with biological products. The weathering of the mineral base continues and the depletion of soils is inevitable. Therefore, the onset of the next stage of soil formation is inevitable.

The fifth stage is soil aging. The profile of soils under unchanged weather conditions (which is difficult to imagine and rare) has no tendency to increase. Further weathering of minerals leads to a significant difference in their qualitative composition between the soil and the soil-forming rock. The number of newly formed minerals of poor chemical nature is growing. In conditions of moist climate, depending on the quality of the original rock, the processes of ferritization and ferilization develop, which lead to a gradual accumulation of sesquioxides of iron, aluminum, and among clay minerals - kaolinite. In the conditions of a moderate or arid climate, the process of sialitization proceeds with the accumulation of quartz and opal (SiO_2,SiO_2 x nH_2O).The content of labile forms of nutrients and organic matter does not increase, but decreases. Physicochemical, physical water and other soil properties are being transformed. The Ph of the soil solution becomes weakly acidic or acidic. Soil fertility declines. At the initial stages it is noticeable on the quality of the products received, and then on its quantity. The duration of this period is quite long - from 100 thousand up to several million years.

The sixth stage is the death of soils. The mineralogical composition of soils and soil-forming rocks is radically different from each other. The weathering of the minerals composing the soil reaches a level where the bulk of the newly formed soil minerals and does not remain inherited from the soil-forming rocks. In humid tropical conditions there are bauxites, siderites, kaolinite. In moderately wet and arid conditions - the minerals of the quartzalite group.Ph of the soil is acidic or strongly acidic. The amount of organic matter is catastrophically decreasing. Soil can no longer satisfy the needs of plants in the elements of mineral nutrition. It perishes, turning into a neorock, which can be represented by a whole conglomerate of minerals.

All the time of soil formation in the soil there are 2 groups of processes that guarantee, on the one hand, an increase in soil fertility, and on the other hand its degradation. Increase in fertility guarantees weathering of minerals and transfer of inaccessible forms of food elements into accessible, accumulation of organic matter, improvement of physical, physico-chemical, water, air (etc.) soil properties, increase of microbiological activity. Degradation of fertility is also caused by the weathering of minerals, but at later stages of soil formation, when significant differences between soils and rocks are observed, a decrease in the content of organic matter and nutrients, and significant acidification of the soil solution.

Evolution of soils can be compared with the evolution of a living organism, for example, a person. When he is born, he has insignificant physical and mental abilities. Soil also has a low fertility level at birth. But the human body grows and develops, accumulates mental and physical abilities, passing successively the periods of infancy, childhood, adolescence, and youth and comes to mature age. At this time, it has the highest level of abilities, as well as the soil with the highest fertility in adulthood. Then an active aging of the body begins. It should be noted that aging occurs immediately after birth. But this process is weakly expressed in comparison with development.

After a mature age, aging predominates over development. The only difference between a living organism and soil is that the last stage of aging is the longest. It can last up to several million years. The stage of aging is the death of a living organism. Death overtakes and the soil that once appeared on the rock turns into a neorock. Using the example of soil evolution, it can be concluded that there is no death; there is a transition from one state to another. Naturally, in conditions of arid or moderately wet climate of the steppes (with the exception of forests), it is impossible to expect the death of soils. The period of soil formation can be very long. During this time, geological cataclysms, land uplifts and descents, erosion processes and etc. occur. There one can observe only the accumulation of weathering products of poorer chemical composition, while the soil itself undergoes constant renewal.

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Profile-genetic soil classification of technogenic landscapes

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Currently, the level of development of the productive forces allow radically transform the natural landscape and form technogenic landscapes with new terrain and rocks. The spoil banks are formed in the open mining are the most expressive representatives of these landscapes. They can hold thousands of hectares of the earth's surface. Reclamation work far behind the rate of soil disturbance with intensive working out of deposits/ Therefore, on the surface of technogenic landscapes naturally begin to develop basic soil-forming processes that lead to the formation of underdeveloped soil [Androkhanov, 2003].
The rate of development of the young soil mainly depends on the climatic conditions of technogenic landscape location, terrain parameters and properties of the substrate placed on the surface. The specificity of soil formation in the technogenic landscape is so pronounced, that allows us to consider them as special surface layers and their soil formation, structure, properties and regimes are often resemble in the remotest degree the natural characteristics of soils [Kurachev, Androkhanov, 2002]. However, technogenic landscapes soils with all their originality perform certain environmental and geochemical features in the natural ecological situation. For this reason, despite the fact that the technogenic landscape is most often ecokline embedded in the natural landscape, its posttechnogenic development phase need to recognize as a natural process, and its anthropogenic phase – is a starting specifics genesis. Their further development is determined by the action of natural environmental factors. Accordingly, this fully applies to the soil emerging in the technogenic landscape at posttechnogenic development phase should be considered as the natural history education, but with a very short period of evolution.
Long-term studies of various technogenic landscapes revealed that the diversity of soil formation processes can be grouped into three general directions. First direction is the formation of young soils exposed soil formation same basic processes that form the profiles normally developed in the bioclimatic soil zone. Their natural position in the evolutionary scheme of soil development reflects the initial stages of the evolutionary development of the soil profile in terms of soil, prevailing in this technogenic landscapes. Second direction is that the technogenic landscapes have also soil profiles which are formed under the influence of a complex of specific soil-forming processes inherent in primitive soils. The specifics of these soils is primarily determined by unfavorable properties of substrates that are of little use to the pedogenic transformation. Third direction is the soil profiles which are formed various kinds of technological methods (reclaimed land). Representatives of this group of soils, as well as the first group of soils developed under the influence of a complex of conventional soil-forming processes, but, as shown by the results of studies, soil formation processes in them are aimed at the transformation of the created soil profile and adjustable modes of use.
Due to this specificity the formation of soil technogenic landscapes, and also taking into account the wide variety of technogenic landscapes and wide set of reclamation technologies, it is offered to separated three departments at type level: embriozem, eluviozem and tehnozem. Thus, a soil technogenic landscapes can be divided by the properties and methods of formation of soil-forming substrate at the early stages of the evolution of the soil cover.
Compared with some existing classifications, they can enter the Russian system of classification of soils [Classification ..., 2004] to the Technogenic surface education, in the WRB to Technosols, and in the Australian classification of land to Anthroposols [World ..., 2014].

However, these classifications do not take into account the further conversion of the starting substrates at the posttechnogenic period.
According to the classification and diagnosis of Russian soil, proposed in 2004 all non-soil technogenic and soil-like formation are included to the separate barrel “technogenic surface formations (TSF)”. System of taxonomic units is offered for the subsequent allocation of stands taxonomy lower level and it is consisting of only two levels: groups and subgroups. However, as shown by numerous studies and practical work in the field of land reclamation, this approach can be used only at the initial stages of the restoration of soil. Soil-forming processes that lead to the differentiation of the soil-rock stratum and to the formation of the soil profile begin to develop with the appearance of vegetation and start operation of the whole complex ecological communities on the surface of technogenic landscapes in artificial root-layers. Therefore, the approach to classification is possible from the standpoint of modern soil science.
According to the classification developed at the laboratory of soil remediation ISSA SB RAS, soil technogenic landscapes are invited to refer to the barrel – TSF, to the departments: tehnozems - reclaimed soil with artificially created rooting horizon; embriozems and elyuviozems - soil developing naturally on not reclaimed lands (Table 1).

Table 1. Taxonomic levels of the technogenic landscapes soil

<table>
<tr><td>Taxonomic levels</td><td colspan="12">Level taxonomic name</td></tr>
<tr><td>Barrel</td><td colspan="12">Technogenic surface formations</td></tr>
<tr><td>Department</td><td colspan="5">Technozems</td><td colspan="6">Embriozems</td><td>Eluviozems</td></tr>
<tr><td>Technozems types</td><td colspan="5">differentiated</td><td colspan="4">no differentiated</td><td colspan="3">modified</td></tr>
<tr><td>Technozems subtypes</td><td>typical</td><td colspan="3">potentially fertile</td><td>humuso-genic</td><td colspan="4">lithogenic</td><td colspan="2">organogenic</td><td>mineralogenic</td></tr>
<tr><td>Embriozems types</td><td colspan="2">initial</td><td colspan="4">organic-accumulative</td><td colspan="2">turfy</td><td colspan="3">humus- accumulative</td><td>gley</td></tr>
<tr><td>Eluviozems types</td><td colspan="3">initial</td><td colspan="4">organic-accumulative</td><td colspan="3">turfy</td><td colspan="2">coarse-humus</td></tr>
</table>

The types and subtypes are distinguished in structure and properties, type-diagnostic horizons. At the technozems the structure of the profile type-diagnostic horizons are created artificially in the process of reclamation, so the basis of a structure of the profile and the properties of the main root zone. In embriozems and eluviozems type-diagnostic horizons are formed naturally and characterize the level of development of biological processes, the main soil-forming process and the degree of conversion of the initial substrate. The lower taxonomic levels can be allocated on the basis of substantive-genetic soil science.
Embriozems are formed mainly on a non-phytotoxic, loose or unstable coarse clastic rocks, or mixtures thereof. Underdeveloped profile soil is mainly due to the short duration of the term of bio-pedogenic conversion breed, which is understood as a complex synthesis processes and the subsequent transformation of organic matter and its interaction with the mineral substrate. Over time, deep in the subsurface of rocks formed biocenoses and plant communities at the same time developing them syngenetic soil formation processes, which ultimately lead to the formation of the soil profile with its characteristic genetic horizons.
Eluviozems are formed on unsuitable for the development of the processes of soil substrates and are characterized by the processes aimed at preparing the substrate for soil formation. These processes are not only at technogenic landscapes, but also in natural landscapes, while soil formation on tight. Therefore, the main difference eluviozems (representatives of primi-

tive technogenic landscapes soils) from litozems (representatives of the primitive soil of natural landscapes) should be considered the age and capacity of the soil profile.

Thus, these approaches to building classification substantively-genetic basis are show the possibility of using soil parameters for the selection of different taxonomic levels in the soils of technogenic landscapes. This is due to the fact that in a period of posttechnogenic phase technogenic landscapes is the development of bio- and pedogenic processes, which leads to the transformation of the surface layers and the formation of a specific soil.

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Spatio-temporal development of deltaic landscape in the Kapchagai reservoir and methods of its study

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Abstract

The article considers the dynamics of the formation of the delta Kapchagai reservoir and the formation of hydromorphic landscapes. Based on the satellite images LANDSAT-5,7,8 period 1979-2017, the main hydrological characteristics of the reservoir and the parameters of the total water balance of the "river-reservoir" system are determined Deciphering of space images with the help of specialized software allows to determine the areas of newly formed landscapes and to diagnose the soil and vegetation of the object, which are specified by ground monitoring. The formation of new deltas of large reservoirs is considered as characteristic of the arid zone process. The formation of the delta in the Kapchagai reservoir over a 40-year period with an average speed of more than 200 hectares per year is indicative of the scale and universality of this process. Newly formed landscapes are of great ecological importance as reserves of biodiversity, as well as objects of recreational and economic development. Therefore, further cosmic and ground monitoring of such unique landscapes is an important task.
Key words: Delta, Kapchagai reservoir, landscape, space image.

Introduction

Large reservoirs are actively created all over the world for economic development, despite the opposition of the public. Their diverse impact on the environment (flooding and destruction of banks, changes in climate, vegetation , soil cover, quality of water resources) has been well studied [1, 2]. However, the process of new natural objects formation in the place of the confluence of the river into the reservoir, where unique hydromorphic landscapes with peculiar soils, vegetation and fauna are formed, has not been fully studied and evaluated. It was in the Kapchagai reservoir on the Ili River where we for the first time in the world began in 1975-1976 to investigate this process and named such an object "the new (Kapchagai) delta" of the Ili River. And later this process turned out to be a major scientific and economic problem, which is manifested globally in large reservoirs.

Materials and Methods

With the beginning of the large (23 km3) Kapchagai reservoir filling, about 11 million tons of sediments of the Ili River and the products of coast abrasion accumulated annually in its basin. These deposits formed islands, which, increasing and merging with each other, began to create a delta-like territory. In the 1990s, it became already noticeable [4], and in the first decade of the 21st century its area increased sharply, exceeding the size of the investigated part of the reservoir territory. The total area of the delta (with lakes and streams) in 2012 was more than 11 thousand hectares, and the area of hydromorphic landscapes alone (excluding the water surface) - more than 8 thousand hectares. The rate of increase in the area of these landscapes averaged about 200 hectares per year. In recent years (2013-2017) (figures 1,2), the increase in the area of hydromorphic landscapes has decreased to 175 hectares per year due to the fact that the gradual rise in the level of the new delta caused an increase in flooded areas on the periphery of the Chilik River cone. In addition, the formation of new landscapes occurs already at deeper parts of the reservoir (figure 3).

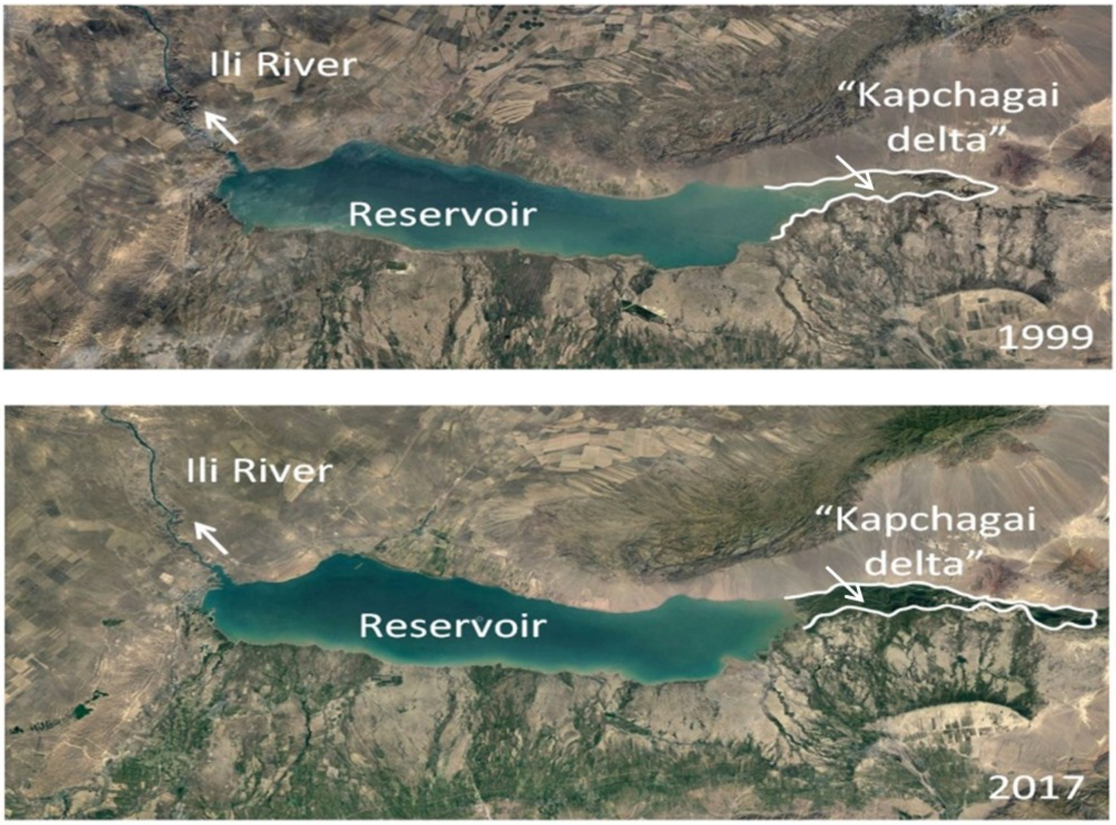

Figure 1. The Kapchagai reservoir on the Ili River (Kazakhstan)

Results and Discussion

The general features of the formation of landscapes here generally correspond to the concepts of the unity of litho-morphogenesis and soil formation in deltas, as well as changes in deltas in the process of aridization. But the cellular relief and the riverine rises ("riverine trees" or "levees") are only formed here, therefore, according to our long-term studies of ecological-genetic series of soil changes [3], bog and meadow-bog soils under the reed beds (Phragmites australis) and cattail (Typha angustifolia) prevail there. Large areas in the new delta are occupied by floating aquatic vegetation on so-called "subaquatic" soils. And only on the islands in the eastern part of the delta, which have been preserved unflooded, meadow-serozem and meadow saline soils are spread. In general, the formation of the landscapes of the Kapchagai delta also reflects the regime of fluctuations in the level of the reservoir and the active reorganization of the banks of the reservoir (both the northern and southern shores). At the same time, the increase in the delta due to the accumulation of sediments leads to an increase in the flooding and salinization of the southern coast soils in the region of the Chilik cone, which is very clearly diagnosed in space images. In this situation, conditions are created for the formation here of a salt-hydrophytic grouping of vegetation including annual saltworts, in particular seepweed (Suaeda crassifolia, S. prostrate), Climacoptera (Climacoptera brachiata, C. obtusifolia), camphor-fume (Camphorosma brachiata, C. monspeliacum), Aeluropus littoralis, and others.

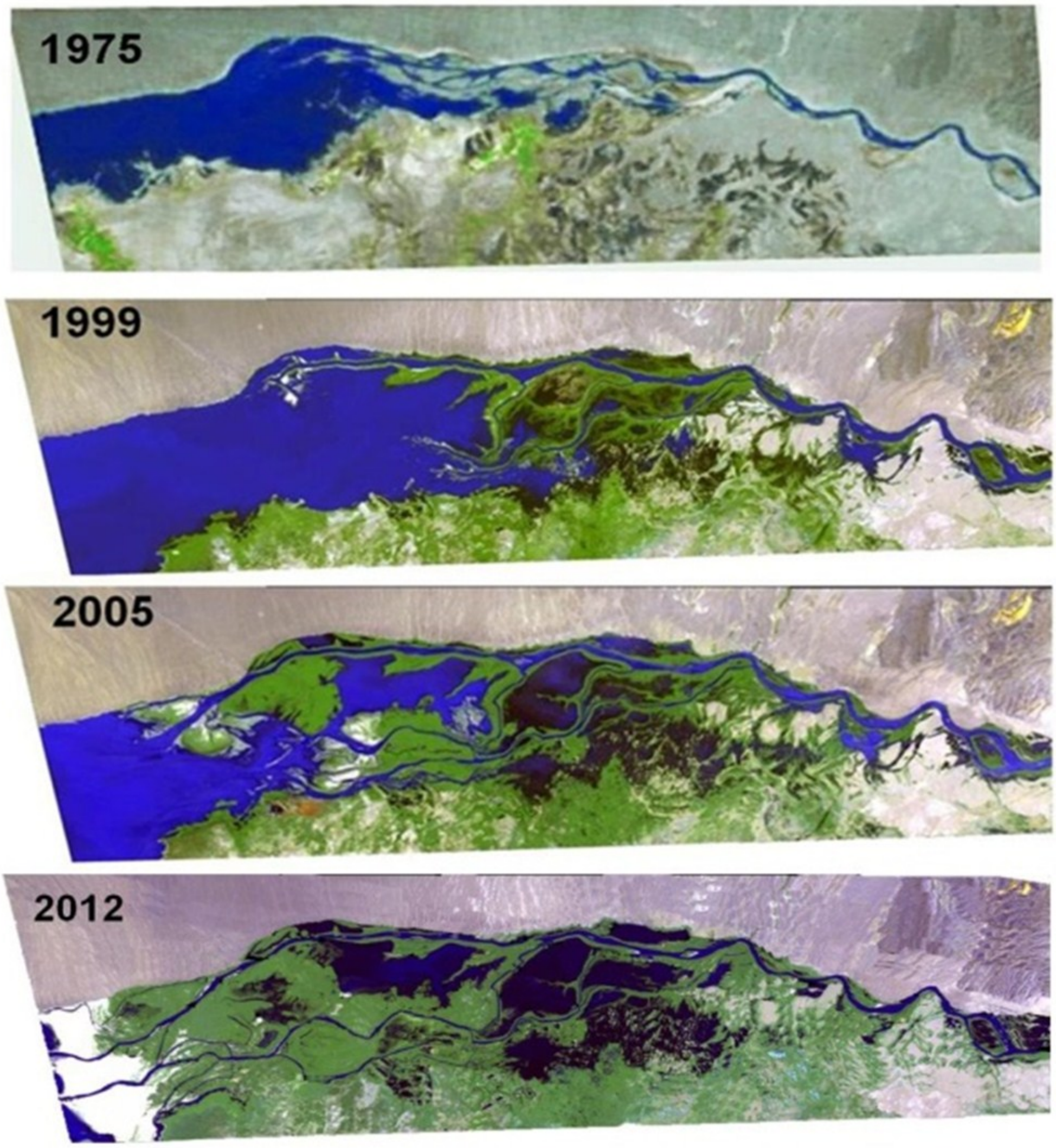

Figure 2. Increase in the area of the Kapchagai delta for the period 1975-2012 (state of the delta in 1979 is shown on the topographic map with scale 1:100000, and state in 1999, 2005, 2012 – on Landsat space images).

In general, the formation of a new delta in the Kapchagai reservoir indicates the scale and universality of this process. Newly formed landscapes are of great ecological importance as reserves of biodiversity, as well as objects of recreational and economic development. Therefore, further monitoring of such unique landscapes is an important scientific task. At the same time, a process that manifests itself upstream the river from the newly formed delta has great practical and ecological significance. The development of the river water backing-up causes increased meandering of the river, erosion of the banks, flooding and even subbmerging of coastal areas. This process was noted on the Ili River on a plot of 14.5 thousand hectares between the tributaries of Chilik and Charyn. Here, the area of new water bodies was 3.5 thousand hectares in 2017, and the increase in their area is about 100 hectares per year.

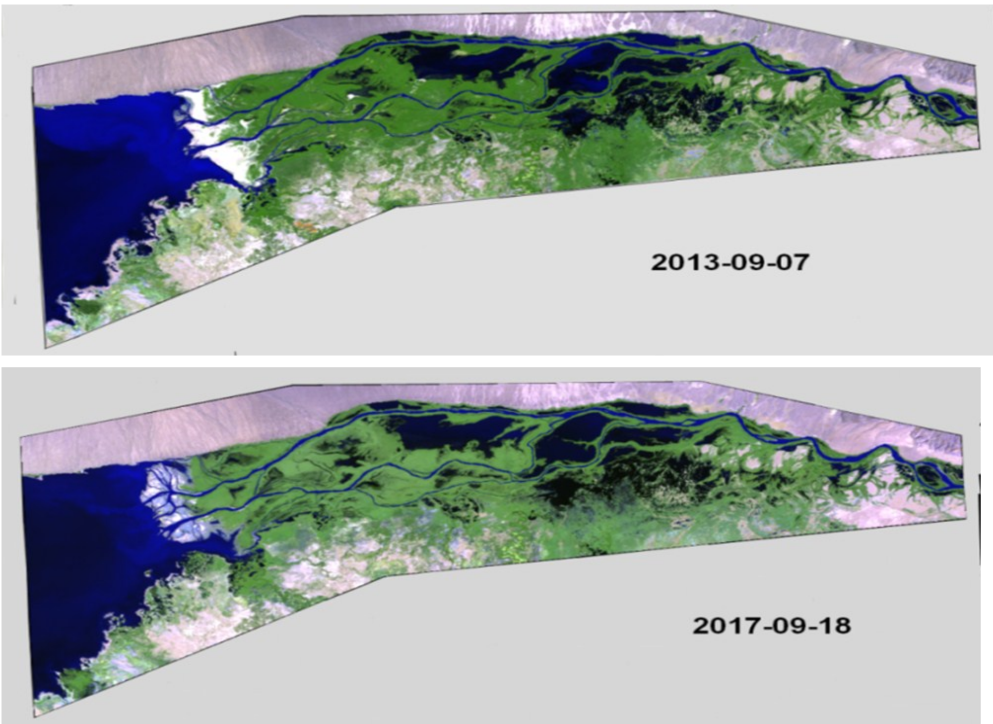

Figure 3. Kapchagai delta dynamics in 2013-2017 (the investigation area was enlarged).

The problem of methods for studying such processes deserves special attention. Initially, the formation of new deltas in the Kapchagai and other large reservoirs was observed during field hydro-morphological, botanical and soil research. Substantial information was also provided by the updated topographic maps and cartographic service of Google Earth. But a real breakthrough in the study of this problem became possible with the advent of detailed space images that allow us to evaluate such a process in time and space. In particular, the opening of access to NASA archives played a huge role, which made it possible to use Landsat images for more than 40 years for remote monitoring of such an important scientific, environmental and economic problem. And in the future, opportunities to use the latest information technologies are open monitoring the water mirror. Which will allow to remotely diagnose the overall water balance of the "river flow - reservoir" system. Such an approach is effective for hydrological monitoring of water-deficit transboundary basins, when operational information on the inflow of inflows and the status of hydraulic facilities located on the territory of other countries is not available. Information about the current water reserves in the reservoir and the water content of the season is necessary for predictive assessments of the regime and volume of Ili River flow in Kazakhstan.

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Soil testing system in the Czech Republic – upgrade for agricultural practice

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Abstract

The extraction procedure Mehlich 3 is the official analytical method presently used in this soil testing system for the determination of available macronutrients (P, K, Mg, Ca) in the Czech Republic. The advantage of the simple and easy Mehlich 3 analytical procedures is their uniformity and suitability for determination of several other elements. Under financial support of Czech National Agency for Agricultural Research (project No QJ1530171) extension applicability of the method Mehlich 3 for micronutrients (Cu, Zn, Mn, Fe, B) determination was tested. Simultaneously, more accurate corrections for phosphorus determination in carbonate soils by method Mehlich 3 were made. Phosphorus content determined by Mehlich 3 method in different soils (cambisol, luvisol, chernozem - WRB, 2014) was valuated based on results from field and pot experiments with graded application rates of phosphorus. Simultaneously availability of micronutrients (Cu, Zn, Mn, Fe, B) was determined in these soils. Limits of valuation of micronutrient content in the soil are results of these experiments.
All results from this testing system, including content of macro and micro nutrients in the soil, are stored in the Land Parcel Information System (LPIS) and can be used for determining the most suitable application rates of nutrients for best nutrient management – i.e. rates for high yields and production quality while at the same time being friendly to the environment.
Key words: plant nutrition, macronutrients, micronutrients, Mehlich 3, LPIS.

Introduction

The systematic soil testing system in the Czech Republic has long-term duration - was established 1961. Presently more than 500 thousand hectares agricultural soils are tested every year for determination wide scale soil properties, including content of available nutrients. Since 1999 extraction method Mehlich 3 is used for determination basic macronutrients (content of available phosphorus, potassium, calcium, magnesium). Uniformity, suitability and relatively cheap process of this analytical procedure are crucial point for wide expansion in practice.
The Mehlich 3 extractant can be used for a multiple-element extraction from soils with a relatively wide pH range (with some limitations for carbonate soils) and it has a potential for a simultaneous determination of plant avail-able nutrients, micronutrients (e.g. Mehlich, 1984) as well as available fractions of some risk elements (e.g. Čižmárová et al, 2016; Zbíral, 2016). Suitable and reliable criteria for fertilizer recommendation for Mehlich 3 extractant in the Czech soil testing scheme were established only for K, Mg, Ca and P. Based on comparison different analytical method (i.e. Mehlich 3 versus DTPA and hot water) and through simple calculation of relationship between these extractants, new criteria for available copper, zinc, iron, manganese and boron were suggested (Zbíral, 2016).
The goal of next works was to verify this first proposal of criteria for micronutrients valuation in the soil to improve for individual soils according to results from pot and field experiments.

Materials and Methods

There were valuated 252 results of analyses of different soils (cambisol, luvisol, chernozem) from pot experiments and 84 results of soil analyses from field experiments (cambisol only). Content of micronutrients in soil was detected by Mehlich 3 method (by ICP-OES using

Thermo Jarrel Ash, USA) and simultaneously available fraction of the same elements in the soil by NH_4 acetate extraction was provided.
Next, content of micronutrients in plant material was detected – all results were in accordance with literary sources. Subsequently relationship between available fraction of micronutrients in the soil and content in plants was valuated.

Results and Discussion

Table 1 shows correlative relations between Mehlich 3 and NH_4 acetate methods for microelements determination in the soil. All results have high correlation relationships, except determination of Fe in in field experiment - there was tested only one kind of soil – cambisol.

Table 1. Correlation coefficients (r) between Mehlich 3 and NH_4 acetate methods for microelements determination in the soil

Microelement	pot experiment (cambisol, luvisol, chernozem)	field experiment (cambisol only)
	r	r
B	0.620***	0.374***
Cu	0.600***	0.399***
Fe	0.313***	ns
Mn	0.554***	0.483***
Zn	0.314***	0.361***

(ns – non significant, $p < 0.05$*, $p < 0.01$**, $p < 0.001$***)

Results of analyses show average proportion of available part of copper in the soil 5.2%, next ca 0.6% of iron, 9.9% of manganese, 4.2% of zinc and 28.5% of boron. These parts present a soil reserve of available fractions of micronutrients in amount ca 3.8 kg of Cu.ha^{-1}, 6 kg of Fe.ha^{-1}, 49 kg of Mn.ha^{-1}, 0.7 kg of Zn.ha^{-1} and 1.6 kg of B.ha^{-1}.
It is possible to state that content of copper in the soil detected by Mehlich 3 method was sufficient, detected content 300 mg of iron represents good reserve – but for growing of plants demanding micronutrients it is necessary to improve value on the limit 420 mg of Fe/kg of soil. Concerning manganese content – its reserve was very good and middle value is by 140 – 150 mg/kg of soil. Soil reserve of zinc in category "good content" was ca 5 mg of Zn/kg of soil. Content of boron detected by Mehlich 3 method was ca 1.1 – 1.5 mg/kg of soil. According to amount of boron removed from the soil by plants it is valuate this reserve as high content.
Based on these data and information corrections of suggested criteria of micronutrients valuation (detected by Mehlich 3 method) in the soil were made (Table 2).

Table 2. Verified criteria for B, Cu, Zn, Mn and Fe extracted by Mehlich 3 and determined ICP-OES

Micronutrient	Soil kind	Content in soil (mg/kg)		
		low	medium (good)	high
	light soil	< 0,55	0,56 – 0,75	> 0,75
B	medium soil	< 0,70	0,71 – 1,00	> 1,00
	heavy soil	< 0,85	0,86 – 1,40	> 1,40
Cu		< 1,6		
		(< 2,0)[1)]	1,61 – 4,5	> 4,5
Zn		< 2,2	2,21 –5,0	> 5,0
Mn		<30 (< 45,0)[2)]	30,1 - 200	> 200
Fe		< 60,0	60,0 - 420	> 420

[1]Recomended for cereal crops; [2]It is recommended to use fertilizers for soils with less than 45 mg/kg

Conclusion

Available data and results used to verification of suggested criteria by Zbíral (2016) showed possibility and suitability of Mehlich 3 method (together wit ICP-OES) for boron, copper, zinc, manganese and iron determination in the soil.

Acknowledgements

The research was supported by National Agency for Agricultural Research of the Czech Republic NAZV No. QJ 1530171.

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Water regime modeling of soil constructions with different structure

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Abstract

The main physical, chemical and hydrological properties of the soil constructions with different structure have been researched in the territory of Lomonosov Moscow State University. Sampling has been carried out at the time of making of soil constructions in 2012 and after four years of their functioning in 2016. On the basis of experimental data the prediction of the water regime of soils has been carried out by the method of mathematical modeling in the Hydrus-1D program. Distinct influence of profile textural differentiation on dynamics of profile distribution of moisture has been revealed. And in the process of functioning of soil constructions with the pronounced textural lamination an increase in degree of a differentiation of a profile on moisture was observed.

Key words: soil constructions, mathematical modeling, water regime of soils.

Introduction

The problem of formation of lawn coverings for improvement of environmental conditions in cities is particularly acute. The important characteristic of megalopolises is using of a large number of the soil constructions which are formed by various soil layers. Since any adding of soil on the soil surface forms pronounced differentiation of the top part of soil profile, practically in all cases layered soil constructions are formed. Successful growth and development of plants requires providing of optimum conditions including the propitious water regime of soils. The success of soil constructions' activity is defined by duration of its steady functioning. Now in soil hydrophysics mathematical modeling of processes of incoming and redistribution of water in the soil is used more often, that allows to carry out the prediction of the water regime of soils. The aim of our research is prediction of the water regime of soils with different structure of the top part of soil profile by mathematical modeling.

Materials and Methods

The object of our research is soil constructions, 50x50 cm in size, created in the conditions of Moscow in 2012. Three variants of constructions have been made: variant 1 - control – homogenized on structure and density horizon A arable (0-30 cm); variant 2 – a layered soil construction with the following sequence of layers: A arable (0-6 cm), lowland peat (6-12 cm), sand (12-18 cm), A arable (18-30 cm); variant 3 – mixture of A arable, peat and sand (0-18 cm), A arable (18-30 cm). Thus, constructions differ in structure of the top 18-cm layer, conditions on upper and lower boundaries are completely identical.

The bulk density, particle density, particle size distribution, filtration coefficient, soil structure, pH, the content of carbon, water retention curve have been determined in samples of 2012 and 2016 years. The obtained data have formed the basis of predicting of the water regime of these soil constructions in the Hydrus-1D program. The upper boundary conditions were the precipitation and watering of soils in summer periods. As input parameters approximated data of water retention curves and experimentally obtained values of filtration coefficient for each layer were used. On the lower boundary the condition of a free drainage has been set. The moisture content of soil layers, defined at the moment of making of constructions, was used as initial condition.

Results and Discussion

Summer of 2012 was very droughty, the total amount of precipitation was 240.8 mm. Therefore during the vegetative period regular watering was carried out. The water regime of soil constructions in the first year of their functioning differed greatly for three variants (Fig. 1). The most uniform distribution of moisture content was observed in variant 1 (control). There was a consecutive moistening and wetting through soil stratum according to weather conditions and watering. In variant 2 there is the distinct differentiation of the profile on moisture content throughout all exploration period. The peat layer is characterized by the largest values of moisture, and the subjacent sandy layer has the smallest values. In variant 3 the top mixed layer was characterized by bigger moisture content, than the arable horizon which is settling down under it.

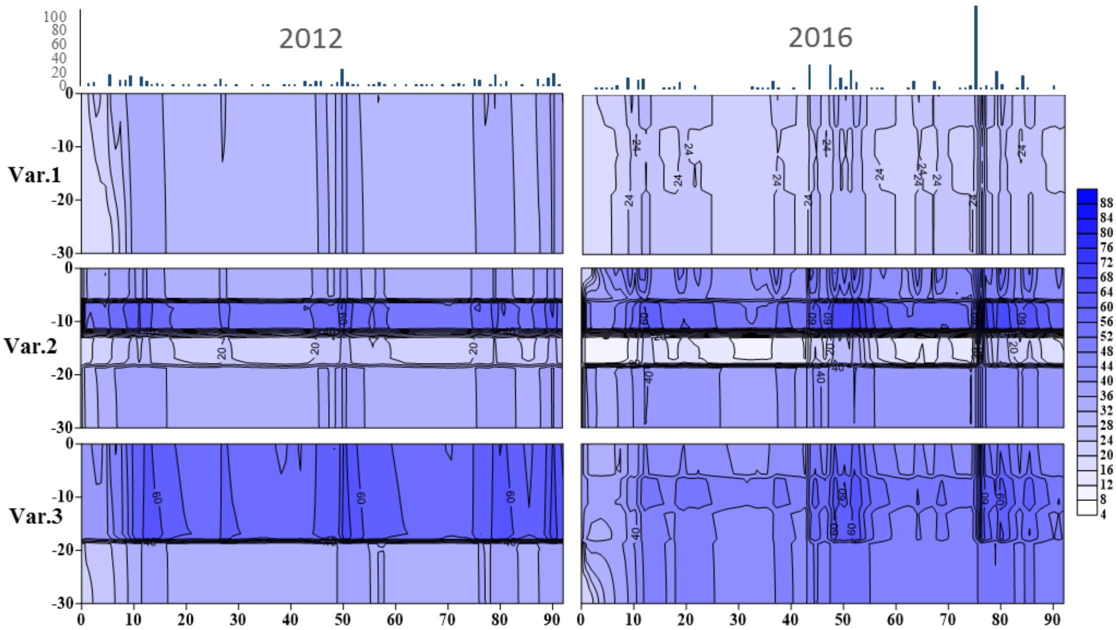

Figure 1. Precipitation dynamics (mm) and volume moisture content distribution (%) in soil constructions

2016 year was more humid, the total amount of precipitation for the exploration period was 403.9 mm, distribution of precipitation is very irregular, there was no watering in this year. In variant 1, despite increase in the amount of precipitation, moisture content of the profile is lower, than in 2012 because of lack of regular watering. At the moment of heavy rainfalls there is a fast moistening of the studied layer. In variant 2 the differentiation of the profile on moisture content has remained, moreover, it became even more contrast: the top part of the studied construction is more humid, and the sand, underlaying a peat layer, on the contrary, became drier. In this variant due to high lamination the probability of formation of air traffic jams is high. In variant 3 there was a relative levelling of an initial differentiation of the profile on moisture content distribution. Only after plentiful precipitation a retention of moisture in the top mixed layer is observed. But there is no such strong differentiation of a profile as in 2012. There is long moisture preservation on border of soil layers after considerable precipitation in variants 2 and 3, contrary to the control, in which excess gravitational moisture quickly was removed out of limits of the studied layer.

Water regime modeling has shown that the layered construction (variant 2) is distinguished from the other types of constructions by the steady differentiation of the profile on moisture content.

Thus, the carried-out water regime modeling of soil constructions with different structure has revealed the following:
1) The great influence on the soil water regime is exerted by the spatial organization of solid-phase components. Soil constructions, quantitatively consisting of the same horizons, but at their placement in a soil profile in the form of separate layers, form the steady differentiated hydrological profile, in contrary to the mixture of these horizons.
2) In the process of functioning layered soil constructions increase the contrast of profile moisture distribution, in contrary to mixture construction in which there was a washout of borders, and more uniform profile moisture distribution was observed.

Acknowledgement

This research was financially supported by Russian Foundation for Basic Research (Project № 16-04-01851).

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Vertical and spatial distribution of major and trace elements in the catena with Retisols in the Central Forest Nature Reserve

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Abstract

In 2017 and 2018, we investigated the vertical and spatial distribution of major and trace elements in four soil profiles of Retisols within a typical catena in the Central Forest Nature Reserve. In 90 soil samples we measured total organic carbon, pH, grain size distributions, total concentrations of Co, Cr, Cu, Fe, Mn, Ni, Pb, Sr, Ti, Zn, Zr and levels of their mobile fractions: exchangeable, bound to organic and other complexes ("organic” fraction) and those phases that are associated with Fe and Mn hydroxides (“hydroxidous” fraction). In the umbric horizon the average total concentration of Fe is 1,2%, Ti – 0,33%, Mn – 482 mg□kg^{-1}, Zr – 292 mg□kg^{-1}, Sr – 90 mg□kg^{-1}, Zn – 39 mg□kg^{-1}, Cr – 21 mg□kg^{-1}, Pb – 21 mg□kg^{-1}, Ni – 9 mg□kg^{-1}, Cu 8 – mg□kg^{-1}. The concentrations of the exchangeable fraction of the metals diminish in order: Fe> Mn> Sr> Zn, Pb> Ti, Cr, Ni, Cu, Co, Zr; the concentrations of the “organic” fraction and the “hydroxidous” fractions show the following order: Fe> Mn>> Ti, Zr, Pb> Co> Ni, Cu, Zn> Cr, Sr and Fe> Mn> Ti> Zn, Sr, Pb> Cr> Cu, Ni, Co> Zr, respectively. In all studied Retisols the total Pb and Zr, the exchangeable fraction of Co, Fe, Mn, Pb and Zn, the “organic” fraction of Cu, Fe, Pb and Zn, the “hydroxidous” fraction of Pb accumulate in topsoil horizons. For the total Co, Fe, Ni, Sr and Zn, the exchangeable Co, Cr, Cu, Mn, Pb, Zn and Zr, the “organic” Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn and Zr and the “hydroxidous” Co, Cr, Cu, Ti, Zn, Zr the loss from the albic horizons and/or the accumulation in the argic horizons were registered. The total concentrations of all studied elements increase in the umbric horizon in the upper part of the catena, at its slope position. In the umbric horizons in its lower part (footslope and toeslope) positions, the concentrations of exchangeable Ni, Cu, Sr and Zr, “organic” Ni, Cu and Zn increases, and the concentration of exchangeable Co, Cr, Pb, Ti and Zn, “organic” Cr, Ti and Co, “hydroxidous” Mn, Ni, Zn, Pb, Zr decreases.
Key words: Albeluvisols, soil, trace elements, iron, manganese, landscape geochemistry.

Introduction

The assessment of background landscapes, which is carried out mainly in biosphere reserves, is given a special attention in the UNESCO and UNEP international programs on the environment. Different-scale geochemical analysis of landscapes is an integral part of background monitoring which currently uses a catenary approach as a main method of the study. This approach is based on identification of the most typical systems and geochemical analysis of their components. With the example of typical catenas that include the most common elementary landscapes and their spatial sequences, the parameters of the radial and the lateral distributions of elements in different blocks of landscapes are estimated (Kasimov, Gennadiev, 2005).

The distribution of the total concentrations of elements in soils of the background landscapes is widely described in literature. The fractionation of metals from the soil media intend to increase our knowledge about the complex nature of metals' occurrence and their pathways in the environment. The results of common chemical extractions of metals from soils are interpreted in terms of site-specific physicochemical conditions and metals’ behavior. The levels of mobile B, Co, Cu, I, Mn and Mo fractions in various soil systems were identified during the studies conducted in the former USSR (e.g. Microelements.., 1973). In Europe a lot of attention was paid to arable soils: the contents of specifically adsorbed compounds of 53 elements was determined in the upper horizons of arable lands in European countries (e.g.

Reimann et al., 2018). The exchangeable and the adsorbed fractions of Cu, Ni, Pb, Zn, the exchangeable Co and the adsorbed Mn were examined in details in Retisols, Phaeozems and Chernozems since the numerated elements can be essential for plant growth and hazardous in polluted environment. The organic fraction of metals have been still poorly studied.

The lateral patterns in metals' distributions have been studied mainly in subtaiga, forest-steppe and steppe catenas (e.g. Semenkov et al., 2016; Samonova et al., 2017). Radial and lateral distributions of metals were analyzed on three key sites in the taiga catenas of the East European and West Siberian Plains (Semenkov, 2016). A better understanding of specific features in the migration and accumulation of Co, Cr, Cu, Fe, Mn, Ni, Pb, Sr, Ti, Zn and Zr is necessary for assessing their occurrence and pathways both in natural and technogenic landscapes. The results of such catenary studies in taiga zone are especially important in the context of environmental monitoring conducted in large cities of European Russia, notably in Moscow.

Materials & Methods

Within the Central Forest Nature Reserve (Tver region, Russia), a model catena that represents a sequence of southern taiga landscapes was selected. The catena included Retisols developing under mixed coniferous (spruce) - broadleaf forests on mantle loam underlain by glacial till with calcareous rock fragments. In total 31 soil samples were collected from 4 soil profiles at summit, slope, footslope and toeslope positions of the catena.

The bulk samples were analyzed for the content of the organic matter using $K_2Cr_2O_7$ wet-combustion method and soil acidity in soil-water suspension using pH-meter "Expert-pH". A parallel extraction of Co, Cr, Cu, Fe, Mn, Ni, Pb, Sr, Ti, Zn and Zr from bulk samples was used to separate the metals' mobile fractions. The following reagents were applied for the extraction: (1) acetate-ammonium buffer (AAB) with pH 4.8 with soil:solution ratio 1:5, (2) acetate-ammonium buffer with 1% EDTA (AABEDTA) with soil:solution ratio1: 5 and (3) 1N HNO_3 with soil: solution ratio 1:10. The concentrations of the elements were determined in a certified laboratory with ICP-MS method using "Elan-6100" equipment ("Perkin-Elmer" company, USA). The fraction bound to the organic and other complexes was estimated as the difference in the metals' concentrations in the AAEDTA and AAB extracts. The fraction of the metals bound to hydroxides of Fe and Mn was calculated as the difference in their contents in nitric acid and AAB extracts.The specific regional features in the studied soils' geochemistry were revealed by comparing total metals' contents with their clarkes estimated for the upper continental crust. The clarkes according to the recommendations given in (Kasimov, Vlasov, 2015) are represented by the following values (the subscripts, mg□kg^{-1}): Fe_{41000} Mn_{770} Sr_{270} Zr_{240} Cr_{92} Zn_{75} Ni_{50} Pb_{17} (Grigoriev, 2009), Cu_{27} Co_{15} (Hu, Gao, 2008).

Results & Discussion

The studied soils in the catenary sequence have all the characteristics typical of Retisols (WRB, 2014) that develop in the taiga landscapes of the East European Plain. They have loamy composition, acidic pH in upper horizons; clear albic and argic horizons.

In all soils, the vertical textural differentiation is clearly pronounced. According to the granulometric composition, the soils have loamy texture and contain more than 10% of particles smaller than 10 μm. The albic horizons are enriched with silty fractions. The soils are very differentiated according to the changes in the proportions of the clay fraction, which is partly due to composite two-stage parent material. The pH varies from acidic (4.4) to neutral and slightly alkaline (8,2) reaction, which is a result of the presence of calcareous rock fragments in the lower part of the parent material (glacial till). The soil organic matter content drops sharply with depth, which is typical for soils in the taiga zone (Glazovskaya, 2009).

Table 1.The average total contents and the variation coefficients* of the metals in the soil catena

Hori-zons	Fe* (%)	Mn (mg kg^{-1})	Ti (mg kg^{-1})	Co (mg kg^{-1})	Cr (mg kg^{-1})	Cu (mg kg^{-1})	Ni (mg kg^{-1})	Pb (mg kg^{-1})	Sr (mg kg^{-1})	Zn (mg kg^{-1})	Zr (mg kg^{-1})
hortic	0,3	1756	773	3,4	13	10	7	22	49	81	72
n=12	82	66	112	103	74	26	51	77	35	49	130
umbric	1,2	482	3345	4,5	21	8	9	21	90	39	292
n=6	60	72	15	50	40	22	32	37	12	39	39
albic	1,5	576	3488	6,9	27	13	13	15	101	37	347
n=8	43	53	7	47	36	49	36	11	6	23	37
argic	1,5	685	3064	8,4	38	19	20	15	99	52	287
n=8	23	30	9	20	27	18	26	8	12	28	31
proto-calcic	1,6	650	2733	9,0	40	18	22	15	111	60	211
n=3	26	19	6	13	19	6	8	15	12	13	25
Litera-ture sources **, min–max	0,8–4,6	100–2300	–	3–23	5–140	5–60	7–90	5–33	50–400	30–100	–

* the variation coefficients are given below the horizontal line, **(Semenkov, 2016)

The contents of the exchangeable fraction of Co, Cr, Cu, Ni Sr, Zn corresponds to the range of their mean levels registered in unpolluted Retisols (Semenkov, 2016). Higher concentrations were found for Fe, Mn, Pb, which is probably due to the development of gleyic processes causing increase in mobility of the elements with variable valence. The variation coefficients estimated for the exchangeable fraction contents in the total population of the soil samples diminish in order: Mn (253%)> Ti, Zn (177-176)> Co, Sr, Pb, Zr, Fe (153-105)> Cu, Ni, Cr (74-64).

The average contents of some metals (Co, Cr, Cu, Ni, Pb, Zn) associated with organic and other complexes correspond to the literature data (Semenkov, 2016), for Fe its content is higher, and that of Mn is lower than the typical levels published in the literature sources. The variation coefficients estimated for this fraction in the total population of the soil samples diminish in order: Cr (296%), Sr (289), Zn (266)> Fe (158)> Ni (124), Pb (123), Cu (112), Mn 103)> Co (85), Zr (80), Ti (72).

The concentrations of Cu, Mn, Ni, Pb, Sr adsorbed by Fe and Mn hydroxides agree well with the background levels of this fraction given in the literature (Semenkov, 2016). Lower concentrations are found for Co, Cr, Fe и Zn, which is probably related to the fact that the parent loamy material is relatively poor in the total concentrations of the elements. The variation coefficients estimated for this fraction in the total population of the soil samples diminish in order: Mn(138%), Sr(116) > Pb(93), Zn(87) > Co(74), Zr(69), Ni(63), Ti(60) > Fe, Cu(50) > Cr(39).

In the upper (hortic and albic) horizons of the studied Retisols the total contents of Pb and Zr as well as the concentrations of some metals in "exchangeable" (Co, Fe, Mn, Pb, Zn), "organic" (Cu, Fe, Pb, Zn) and "hydroxidous" fractions (Pb) increase relative to the parent material. The relative loss from the albic horizon and/or relative accumulation in the argic horizon are found for total Co, Fe, Ni, Sr and Zn, "exchangeable" Co, Cr, Cu, Mn, Pb, Zn and Zr, "organic or complex" Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn and Zr, as well as for the Co, Cr, Cu, Ti, Zn and Zr in "hydroxidous" fraction.

Laterally, the total contents of Co, Cr, Cu, Fe, Mn, Ni, Pb, Sr, Ti, Zn and Zr are higher in the humus horizons in the soils of the upper part of the catena. The concentrations of exchangeable Ni, Cu, Sr, Zr and “organic” Ni, Cu, Zn are higher in the humus horizons of its lower part (footslope and toeslope), while the concentrations of the exchangeable Co, Cr, Pb, Ti and Zn, “organic” Cr, Ti and Co, as well as “hydroxidous” Mn, Ni, Zn, Pb and Zr show lower values.

Acknowledgement

This study was conducted with financial support from RGS-RSCF № 17-05-41036 (contract 04/2017/RGO-RFFI).

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Soil salt neoformations (Central Mongolia)

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Abstract

Saline neoformations is an important characteristic of the solid phase of arid soils, since the formation of salt accumulations is closely related to the problem of the genesis of soil profiles, and to the possibility of their agricultural use. We considered the composition and forms of salt neoformations in the soils of Central Mongolia, in which unique conditions for their manifestation are realized. The most important of them are sandy coarse-grained granulometric composition with a high content of coarse sandy particles and clastic material, extremely low water flows, relatively small temporal variability in soil moisture and extreme daily and annual temperature differences. In the studied soils slow crystallization and the small number of nucleation centers lead to the formation of predominantly needly-like crystals and "brushes" of salts – calcite, barite, astrachanite and halite. Specific thermo-hydrological phenomena and the forces arising under these conditions explained the formation of acicular salt crystals in the investigated soils.
Keywords: saline soils, salt neoformations, Mongolia.

Introduction

Diagnosis of saline neoformations is an important characteristic of the solid phase of arid soils, is under the influence of soil solution equilibrium, since the formation of salt accumulations is closely related to the problem of the genesis of soil profiles, and their presence in soils influences the possibility and methods of their agricultural use (Kovda, 1946). The composition of salt accumulations depends on the composition of soil-forming rocks and soil solutions and the depth of groundwater. In their turn, with a close mineralogical composition, their (morphological) shape and dimensions can be completely different: impregnation, powdering, concretion forms, cutans, individual crystals, their aggregates, etc. The formation of certain morphological forms depends on many factors – the granulometric composition of the soils, the type and characteristics of the water regime, the nature of the evaporation of solutions and the temperature differences, the mode of soil processing and moistening.

The purpose of this work is to consider the composition and forms of salt neoformations in the soils of Central Mongolia, in which unique conditions for their manifestation are realized – a sandy coarse-grained (granular) granulometric composition and low variations in soil moisture under extreme daily and annual temperature differences.

Materials and Methods

The study was focused on the soils of Central Mongolia: Gobi desert and Steppe Region. The warm period (April – October) is the main time of the soil evolution processes, the Gobi Desert and Steppe regions under study are characterized by the following temperature regime, the amount of precipitation and soil moisture (0–50 cm layer). According to the Institute of Meteorology and Hydrology of Mongolia for the period 1986–2005, the mean values of temperature, precipitation, and soil moisture for these zones are 14.2±6.7 °C, 118±4 mm, 16.1±2.9 mm and 12.0±6.7 °C, 199±8 mm, 25.7±3.5 mm, respectively (Nandintsetseg, Shinoda, 2011). Soil samples (Gobi Desert and Steppe Zone) were taken to the depth of the soil moistening (0–20 cm) in September 2016.

Gobi Desert Zone
Site 1 – the northern alluvial fan descending from Züün Saihan ridge, at 2 km down from its foot, the bank of erosional gully about 1 m deep (Endosalic Calcisols Yermic, loam, WRB 2006). Site 2 – the base of alluvial fan from Züün Saihan ridge, where the topography is getting nearly flat, at about 17 km north of the foot of the ridge (Endosalic Calcisols Sodic, sandy). Site 3 – the Bayan Zag saxaul forest, the edge of the eolian sand dunes, at 3 km northwest from the famous Flaming Cliff dinosaur site of Berkey and Andrews (Sand grandular). Iron in the form of films on the grain surface and there is soda, which gives a high pH and electrical conductivity. Site 4 – the northern piedmont plain of the Gurvan, where the locals plant vegetables, such as carrots, potato, melon onion (Endosalic Calcisols Sodic, sandy). Site 5 – the active eolian sand dune within the piedmont hills of Gobi Altay range, top (Sand).
Steppe Zone
Site 6 – the narrow zone with solonchak soil along the NE trending fault (Haplic Solonchaks Aridic, sandy loam). Site 8 – the ancient active sand dunes of Elsen Tasarhai.
The study was based on granulometric and gross analyzes, which were supplemented by electron microscopic studies (SEM and EDS analysis). The SEM analysis was carried out on a scanning electron microscope VEGA 3 LMH (TESCAN, Czech Republic). The X-max 80 energy dispersive spectrometer (Oxford Instruments, Great Britain) was used to analyze the elemental composition of the most representative regions. The granulometric composition of the samples as a whole was determined by the sieve method, fraction <2 mm by laser diffraction on a size analyzer Particles SALD-2300 (SHIMADZU, Japan). The total composition was determined by the X-ray fluorescence method (Pioneer S4, Bruker AXS, Germany) using the silicate analysis technique.

Results and Discussion

The gross composition of fine earth clearly corresponds to the granulometric analysis: sands (sites 3, 5 and 8) contain significantly more SiO_2 (72–85 %) than foothills and plains (57–73 %). The content of Na_2O and K_2O indicates a high content of Na- and K-feldspars, the content of which is maximal in young sands (site 5) – 4.6 and 3.6 %, respectively. The solonchak (site 6) is characterized by an increased content of Na and S, chlorine is also present (according to the EDS analysis), but its content is significantly lower than the accuracy of its determination by the silicate method, by which the samples are analyzed.
Consider the manifestations of salt growths in the studied soils. Carbonates in the Gobi Desert soils form clayey-sandy in composition, rounded and rather loose microaggregates up to 300 µm in size (sites 1 and 2). Microaggregates formed in irrigated lands (Bulgan Garden, site 4), denser, larger size 100–700 µm. However, their number is much smaller: the grains of primary minerals predominate in the soil. Microaggregates are characterized by the presence of round pores with a diameter of 10–20 µm. The vesicular voids are originated as a result of the changes in the moisture and temperature conditions (McFadden et al., 1998; Lebedeva et al., 2016) for watering and drying.
On the surface of grains of primary minerals larger than 2 mm and predominantly more than 10 mm, calcite forms large enough cutans (fur coats) from intergrown needles that grow perpendicular to the surface of the grain. The thickness of the cutans reaches 300 µm. Similar formations, consisting of acicular crystals, are more rounded due to weathering, occur in the reddish sands of site 3. In addition to cutan from needle crystals, "calcite brushes" are formed. Their thickness is substantially less than 100 µm, and they consist of separate thin (up to 2–3 µm) acicular calcite crystals.
Needle calcite crystals are found in soils quite often, but needle-like crystals of NaCl were first discovered in soils (solonchak, site 6). It could be assumed that they can be formed by the roots of plants, but the formation of "brushes" with a high degree of probability makes it

possible to assert that in these conditions it is precisely needle-like crystals that can grow. Most likely, they are formed on the surface of large enough primary particles. On the surface of clay microaggregates, only NaCl crystals of cubic form are encountered, which is most typical for crystals of this salt. Needle crystals of radial-ray packing on the surface microaggregates and grains of primary minerals also form astrachanite (sodium and magnesium double sulfate). Sodium sulfate thenardite on the soil surface forms only microcrystalline accumulations of anhydrous salt, it is possible that in these conditions due to desiccation, needle crystals, characteristic of mirabilite (crystal hydrate), are simply not stable. In addition, soda was diagnosed in the composition of clay-salt microaggregates (minerals 2: 1 of illite-smectite group).

Soda was also found in sample 3 (red sands, eolian sand dune) in the calcite-clay (minerals 2: 1 of illite-smectite group) pseudomycelium. The latter holds together and retains the grains of the primary minerals. The presence of soda explains the extremely high pH values of ~10 of the aqueous extract of this sample, close to the pH values of the solonchak. The alkaline reaction of the medium involves the formation of Fe- and Mn-Fe-oxide "coats" (films) on the surface of microaggregates and primary particles. The high content of soda (and, correspondingly, the pH of the water extract) is due to the high content of Na-feldspars, the weathering of which leads to the formation of soda (Polynov, 1952). So, mosaic films were found on the surface of weathered (with the formation of parallel needles) grains of Na-feldspar, whose composition is close to the composition of pseudomycelium according to the EDS analysis.

According to the results of a natural experiment – the formation of sandy barite concretions in Site 5 (Kharitonova et al., 2017), with rapid crystallization (the strong supersaturation of the solution with a change in its temperature and, accordingly, a change in the salt solubility) a large number of crystallization centers (in our case fine particles of clay minerals) lead to the formation of small xenomorphic (irregular shape) of the crystals. Conversely, with a slow crystallization and a small number of crystallization centers (in our case this is the surface of clastogenic grains), relatively large idiomorphic crystals are formed.

In soils, not only their crystalline features, determine the shape of crystals of different salts but also by external factors – supersaturation, composition and temperature of the solution, its motion. In real soil conditions, many factors continuously change, which leads to a large number of morphological forms of crystals. However, with relatively constant environmental conditions, the Curie principle apparently works primarily: the shape of the crystals retains symmetry elements that, due to geometric selection, are common with the host matrix. Because of geometric competition, crystals, whose direction of maximum growth rate is normally located to the substrate, displace less well-oriented. It should be noted that the formation of parallel needle structures during slow weathering of Na-feldspar does not contradict the hypothesis (conclusions) of needle-shaped salt neoformations in low-moistured soils.

Conclusion

We considered the composition and forms of salt neoformations in the soils of Central Mongolia (Endosalic Calcisols Yermic, loam; Endosalic Calcisols Sodic, sandy; Haplic Solonchaks Aridic, sandy loam; Sands), in which unique conditions for their manifestation are realized. The most important of them are sandy coarse-grained granulometric composition with a high content of coarse sandy particles and clastic material, extremely low water flows, relatively small temporal variability in soil moisture and extreme daily and annual temperature differences. In the studied soils slow crystallization and the small number of nucleation centers lead to the formation of predominantly needly-like crystals and "brushes" of salts – calcite, barite, astrachanite and halite. Specific thermo-hydrological phenomena and the forces arising under these conditions explained the formation of acicular salt crystals in the investigated soils.

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Aromatic lignin compounds as a precursors of humus in soils (according to ^{13}C NMR spectroscopy)

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Abstract

A characteristic feature of lignin structures are their tendency to condensation reactions, which can lead to the formation of new stable C-C bonds. This lignin property with its high resistance to degradation divide it from other natural polymers and largely determines its action in biochemical processes, including the formation of humic acids. The determination of lignin in plants, soils and humus acids involved the alkaline oxidation with copper oxide at 170^0 C under pressure in nitrogen environment. Comparison of ^{13}C-NMR spectra of native lignin preparations, isolated from different species of tree and herbaceous plants, with a spectrum of humic acid diagnosed that, the number of peaks at 102, 115, 119, 131, 152, 166 ppm also have a lignin genesis. Secondly, heterogeneous set of peaks in the spectra of different plants and, consequently, in the molecules of humic acids of different soils, must also be different. Thirdly, lignin of southern taiga trees is the source of more advanced in space molecules of humic acid with developed aliphatic part. Cinnamilic phenols from steppe plants form a spatially compact structure of Chernozem humic acids.
Financial Support: RSF №17-14-01120.
Key words: humus, lignin phenols, ^{13}C-NMR spectra, soils.

Introduction

Lignin is the most common natural phenolic compound of plant origin, and the lignification of cell walls (lignin fills the space between the cellulose fibers) is an essential evolution stage of the vegetable world, which ensures the functioning of the excretory and transport systems in vascular plants and their support in the soil. In terms of humification, lignin is interesting not only as a structural component of plant falloff relatively resistant to decomposition but also as an irregular trisubstituted biopolymer of large molecular weight composed of phenylpropane units and possessing colloidal properties. This is a compact microgel of a netlike structure whose particles are strongly branched and extremely polydispersed [1]. The relative proportions of lignin components and phenols are determined by the phylogenetic origin of plants and allow the formation of various low- and high-molecular-weight products of lignin decomposition in the soil, which are involved in humus formation and can act as agents of allelopathic interactions, inhibit soil enzymes, precipitate proteins, inhibit or catalyze biochemical reactions in soils, inactivate nitrification, and form coal and kerogen deposits.

We previously showed [2, 3, 4] that the complex aromatic structure, the colloid and hydrophobic properties, and the high biochemical stability of lignin suggest three most probable ways of lignin transformation in soils depending on the thermodynamic environmental conditions: (1) the stabilization and conservation of lignin polymers as highly condensed polynuclear aromatic structures under reductive conditions; (2) the insignificant transformation of biopolymers because of an increase in its solubility under contrasting redox conditions at the preservation of the main lignin structures (precursors of humic acids); and (3) the degradation of lignins under oxidative conditions to simpler phenolic acids (agents of pedogenetic processes and biochemical transformations). However, it is still not clear how the properties of soil humus depend on the biochemical composition of the different falloff types, what are the specific forms and transformation mechanisms of aromatic phenols of plant origin into humic acids, and what is the role of separate phenolic compounds in the regulation of soil processes. Therefore, the immediate aim of this work was to study the transformation of aromatic lignin structures in the following series: plants–falloff–soils–humic acids–buried organic matter of different ecosystems.

Materials and Methods

Amount and composition of lignin phenols are investigated in Chernozems Haplic (Stavropol region of Russia) and Greyzems Haplic (Brjansk district, Russia) of arable land, Gleysols Mollic (Moscow district, Russia), Cambisols Humic of juniper's forest and pine's forest of Tien-Shan (Kyrgyzstan), Leptosols Umbric of alpine meadow (Northern Caucasus, 2200 m, Russia), Leptosols Mollic of subalpine meadow-steppe (Northern Caucasus, 1200-1300 m, Russia). Ecosystems with different types of vegetation were studied: arable land, steppe, pine, spruce, birch, aspen, larch, cedar, junipers forests, alpine and subalpine meadows. Lignin phenols were determinate in wood and plant tissues, root and plant falloff, litters, soils and humic acids.

The determination of the lignin in the plants, soils, and humic acids involved the alkaline oxidation with copper oxide at 170°C under pressure in a nitrogen environment; the precipitation of humic acids; and the concentration of the phenolic products under pressure on compact disposable C18 columns. After the samples were passed through the columns, the columns were dried and the lignin was dissolved in ethyl acetate. The lignin preparations were isolated by the evaporation of ethyl acetate using a rotor evaporator [1]. The phenolic components of the lignin were separated using a gas-liquid chromatograph after preliminary derivatization and conversion into trimethylsilyl esters. A gas chromatograph with a mass spectrometer (Hewlett-Packard, Palo Alto, CA, United States) equipped with a flame-ionization detector and a capillary column was used. Nitrogen was the main and marking gas. The injector temperature was 250□C; the detector temperature was 300°C. The individual reaction products (vanillin; syringic aldehyde; and vanillic, syringic, *p*-coumaric, and ferulic acids) were identified by comparing the retention times (in minutes) and peaks with those of known components in known concentrations used as external standards. The following standards were used: phenylacetic acid, 6.040 min; vanillin (4-hydroxy-3-methoxybenzaldehyde), 8.069 min; ethylvanillin, 8.518 min; syringic aldehyde (3,5-dimethoxy-4-benzaldehyde), 9.321 min; vanillic acid (4-hydroxy-3-methoxybenzoic acid), 9.626 min; syringic acid (3,5-dimethoxy-4-hydroxybenzoic acid), 10.538 min; *p*-coumaric acid (4-hydroxycinnamic acid), 10.840 min; and ferulic acid (4-hydroxy-3-methoxycinnamic acid), 11.981 min. Although the method is highly sensitive and can determine trace amounts of phenols, the analysis was accompanied by significant losses of lignin decomposition products (up to 50%). To improve the reproducibility of the analytical results, glucose was added to the soil samples as an oxidation catalyst and ethylvanillin was added as an internal standard before the alkaline oxidation. Phenylacetic acid was added to the samples as the second internal standard before the derivatization. The reproducibility was thus increased to 95%. The alkaline oxidation of vascular plant materials and residues with copper oxide in the soil yields 11 phenols [1], which can be grouped in accordance with their chemical nature into three structural families: vanillic (V), syringic (S), and cinnamilic (C) ones. The first two phenol types are found in mixed oxidation products of plant tissues as aldehydes (al), ketones, and acids (ac); the latter include only acid forms: ferulic (F) and *p*-coumaric (K) acids. The phenol mixture obtained after the oxidation of lignin is best described by the parameters characterizing the weight combinations of its components. The sum of the oxidation products is thus indicative of the total lignin content in the sample. In the plant tissue and soil samples from the above objects of study, the carbon and nitrogen were determined using a Vario El CNS analyzer (Elementar GmbH, Hanau); the humic acid preparations were isolated, and their ^{13}C NMR spectra were recorded.

^{13}C NMR spectra were recorded for 25 humic acids (HA) preparations. The preparations were isolated from the studied soils, including iron–manganese nodules, by triple extraction with a

0.1 M NaOH + 0.4 M NaF mixture from the samples decalcified with 0.05 N H2SO4. After the separation from colloids by centrifugation (Beckman Model J-6 centrifuge, 2500 g, 15 min), the HA preparations were purified from mineral salts by electrodialysis (MWCO 12000–14 000) [3]. The dialyzed and frozen_out HA preparations (50 mg) were dissolved in 0.6 mL of 0.3 M NaOD/D2O. Spectra were recorded on a Bruker Avance DRX 500 NMR spectrometer at 25.18 MHz and 290 K. The content of lignin phenols was determined in 25 HA preparations.

Results and Discussion

The rate of lignin decomposition in soils is largely determined by the source of this biopolymer: the type of plant tissues and their anatomic structure. Although insufficient data are available on the biochemical composition of the different organisms involved in humification, it is considered established [1] that different types of plant tissues (gymnosperms and angiosperms, woody and nonwoody, and aboveground and underground) have contrasting lignin parameters. First, the lignin of coniferous plants (soft wood lignin) contains vanillin phenols as major structural units: up to 60 mg/g Corg in juniper roots and up to 80 mg/g Corg in the fir falloff. The content of cinnamic alcohols in the needles, wood, and especially roots of pine and juniper is low; syringic acids and aldehydes are almost absent in the needles, and S/V = 0. Second, the lignin of deciduous trees (hardwood lignin) predominantly consists of similar amounts of vanillic and syringic structures. The lignin in deciduous species of Caucasian mountain forests (birch, beech, and chestnut) hardly differs from that in the tree leaves of the temperate zone and the walnut mountain forest of the Tien-Shan and contains similar amounts of vanillic and syringic phenols. The S/V and C/V ratios are higher than 0 but lower than 1. The content of cinnamic phenols is close to 0. The third lignin type is the lignin of herbaceous plants, which contain the largest amounts of cinnamic structural units: their content in steppe and meadow grasses and herbs increases to 20–30 mg/g C, which is higher than in woody plants by 4–6 times. The content of syringic phenols in herbs is similar to that in angiosperm wood but exceeds that in leaves by 5–6 times. Ferulic acids are mainly associated with hemicelluloses in the cell walls of grass fibers. Their content reaches 15–20 mg/g Corg in the aboveground phytomass and roots of grasses.

The isolation of lignin oxidation products from the litters of different plant associations showed that their lignin parameters were less contrasting than those in plant tissues, and the content of lignin was significantly lower than in living plant tissues. The lowest content of lignin was typical for the F and H horizons of the forest litter in the spruce (3.06 mg/g Corg), cedar (3.08 mg/g Corg), aspen (1.58 mg/g Corg), and beech (2.16 mg/g Corg) forests. The highest contents of lignin were found in the high-mountain ecosystems of thin juniper forests (62.56 mg/g Corg). The elfin birch forests (10.87 mg/g Corg), walnut forests (9.10mg/g Corg), and pine forests (13.70 mg/g Corg) were characterized by a medium content of lignin in their litters. The composition of the coniferous litter was characterized by the accumulation of vanillic phenols (up to 33 mg/g Corg under the juniper canopy) and retained the tendency toward a decrease in the content of syringic and coumaric structures. The deciduous forest litter contained similar proportions of vanillic and syringic phenols and a lower content of ferulic acids (V : S : C =4 : 4 : 1; 2 : 1 : 1). At the same time, the steppe detritus layers showed a clear accumulation of cinnamic phenols and especially ferulic acids (K/F < 1).

The results suggest different characters of the organic matter transformation in the soils of different ecosystems. The steppe biotransformation of lignin is characterized by the highest degrees of biopolymer modification in the considered vertical soil series (from 5% in the Caucasus region to 20% in the Tien-Shan) and the highest values of the oxidation parameter ((Ac/Al)v= 0.10–0.60) in the chernozems, chernozemlike soils, and cinnamonic soils. In the forest decomposition of lignin, is about 1.5% for brown Caucasian soils and 15% for those of the Tien Shan; the (Ac/Al)v ratio has medium values. The meadow transformation type of lignin structures is characterized by near-zero *T* values and minimum acid/aldehyde ratios.

The 13C NMR spectroscopic study of 25 HA preparations showed that the lignin of higher plants is involved in the formation of specific humus compounds. In general, HAs are similar to soil samples in the content of lignin oxidation products and lignin parameters; they inherit characteristic properties of plant tissues but show a better ordering of structural lignin fragments. Their proportions of vanillyl, syringyl, and cinnamyl phenols strongly vary among the tissue types but are similar within the homotypic ecosystems (1 : 1 : 1 for herbaceous communities of steppes and subalpine meadows and 3 : 4 : 1 for woody cenoses). These facts are embodied in the NMR spectra. It is known that the peaks at 147 ppm (region of aromatic bonds) and 56 ppm (region of aliphatic bonds) in the 13C NMR spectra of HAs are due to compounds of lignin origin. The coefficient of correlation between the content of lignin (VSC) in the humus soil horizons of humid landscapes and the 13C NMR peak area of the chemical bonds of lignin origin is 0.94 for the aliphatic region of the HA spectrum (56 ppm) and 0.93 for the aromatic region of the HA spectrum (147 ppm). In the chernozem HAs, the contribution of the chemical bonds of lignin fragments in the nuclear region of the spectrum is double that in the aliphatic region; in the HAs from meadow soils, the peak areas of lignin nature in the aromatic and aliphatic spectral regions are almost similar.

The comparison of the 13C NMR spectra of native lignin preparations from different woody and herbaceous plant species obtained by Karmanov and Kocheva [5], with the spectra of our 25 HA preparations, revealed that the signals inherited by Has from plant tissues are also clearly identified at 102, 115,119, 131, 152, and 160 ppm . The sets of peaks vary among the plant species; hence, they should also vary among the HAs from different soils; i.e., the chemical structures of lignin from coniferous and deciduous or cereal and herbaceous species differ not only in the content of the main types of intermonomer bonds β–O–4, β–5, β–β, and Carom–C, but also in the composition of macromolecules, i.e., the proportions of the three types of monomeric units: vanillyl (guaiacyl), syringyl, and *p*_coumaryl ones (V : S : C). For example, the characteristic signals of the *p*_coumaryl units from herbs include characteristic peaks at 131.4–131.5 ppm (C-2 and C-6 in *p*_hydroxyphenylpropane units) and signals at 160.1 and 166.7 ppm related to the C-4 and C-β atoms in esters of *p*_coumaric structures. The signals at 53.5 and 53.8 ppm indicate the presence of coumaran and pinoresinol structures (in the macromolecules, monomeric units are linked by the β–5 (phenylcoumaran) and β–β (pinoresinol) bonds).

The signals in the region of 100–160 ppm are due to the presence of aromatic structural units in Has from soils under forest. This region can be subdivided into four intervals: 100–117 ppm, signals of tertiary aromatic carbon atoms located in the ortho position to the C atoms with an oxygen function (C-2 and C-5 in the noncondenced vanillyl (guaiacyl) units or C-2 and C-6 in the syringyl units); 117–125 ppm, signals of tertiary aromatic carbon atoms without C atoms with an oxygen function in the ortho position (C-2 and C-6 in the *p*-hydroxyphenylpropane units and C-6 in the vanillyl (guaiacyl) units); 125–142 ppm, signals of quaternary aromatic carbon atoms, mainly C-1 and C-5; and 142–160 ppm, signals due to etherified aromatic carbon atoms. In the 13C NMR spectra of Has from soils of coniferous forest, characteristic signals are observed at 152.1–152.4 ppm, which are due to the C-3 and C-5 atoms bound to the –OCH3 groups. The unsubstituted C-2 and C-6 atoms in the syringyl units also give signals at 102–104 ppm, and the signals at 119 ppm indicate the presence of the vanillyl (guaiacyl) units (C-6). In the spectrum of coniferous lignin, there are no peaks at 152.2 and 152.5 ppm, which are due to the C-3 and C-5 atoms bound to the –OCH3 groups. However, the uncondensed units of coniferous lignin contain a significant number of the C-5 atoms, which give a characteristic shift at 115.6 ppm. The general view of HA spectra shows that lignin from coniferous plants of the southern taiga zone becomes a source of more developed, elongated HA molecules with a well-developed aliphatic moiety (high peaks in the aliphatic region of the spectrum); feruryl and coumaryl phenols from steppe plants form compact structures of chernozem HAs with a well-defined aromatic moiety. Thus, the results of fine biochemical methods contradict the established concept of lignin as a group of natural polymers with closely related structures and general structural type. Meanwhile, different types of plants and plant communities produce phylogenetically specific and strictly individual set of phenolic acids and aldehydes, which determine the structural features of HAs and may be used as biomarkers in the study of buried soils and the paleoecological reconstructions of past regional environments.

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Soil structural quality, compaction and land management in the Republic of Moldova

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Abstract

Soil degradation as a result of the compaction process and structural deterioration comprised the entire surface of agricultural soils, becoming an acute problem in Moldova. Soil compaction is one of the most aggressive factors of anthropogenic influence on the soil physical properties with immediate effects on the agricultural management. The physical quality assessment was carried out for zonal soils included in the Moldova's Soil Quality Monitoring. The results showed that chernozems virgin are characterized by an excellent hydrostatic structure (aggregates of 1-5 mm - 80-85%); aggregates >10 mm (agronomical unfavorable) make up 1-2%. In the 0-25 cm layer of arable chernozems dominate the fraction >10 mm (40-70%); the 25-35 cm layer is characterized by a massive structure, this layer has not been tilling in the last period, its destructurized, lost compaction resistance and is very compacted and impermeable to water and plant roots. Compaction of chernozems is also enhanced by the low flow of organic matter in the arable layer (dehumification), the frequent passage of heavy machinery, the abandonment of soil. This has led to the ecological degradation of compacted soils, loss of fertility and their economic value. Compaction can be reduced, and soil restored by special tillage measures, where scarification at a depth of 10-20 cm is of the greatest importance. The tillage can be supplemented with organic fertilizers (manure) and green fertilizers (vetch) or mulch. Soil compaction monitoring should become a component part of farmland management.
Key words: chernozems, degradation, monitoring, physical properties.

Introduction

Soil is a natural body made up of relatively loose material resulting from pedogenetic processes. Soil fertility can be characterized by a series of indicators, which can be included in the following groups: agrophysical, hydrophysical, agrochemical, agrobiological. Agrophysical indicators include: texture, structure, porosity, compaction (apparent density, penetration resistance, compaction rate, specific resistance to plowing), useful edafic volume, agrophysical index of soil fertility [2]. The fertility of a soil is closely related to its structural state. Soil structure is important because it ensures the coexistence of two important soil physical properties, permeability and water retention capacity, while improving the nutrient status of soil and decreasing the intensity of erosion. Texture is one of the most important and stable features of the soil. It influences the thermic, hydric, air and nutrient regime, adsorption capacity, humus accumulation, soil performance conditions, fertilizer application rates and times, crop placement.

Compaction of the soil is one of the most aggressive factors of anthropogenic influence on the physical properties of the soil with immediate effects on the agricultural management and the environment. Soil compaction affects water dynamics in the soil, intensifies erosion, disrupts the nitrogen and carbon cycle in the soil, energy needs and agricultural efficiency, soil biology, and crop production. Soil-induced soil compaction can lead to soil degradation, surface water pollution, increased consumption of natural resources and mineral fertilizers [1, 5]. The research purpose - to highlight changes in some agrophysical characteristics of arable soils in the center zone of Moldova.

Materials and Methods

The average statistical parameters of the physical properties determined for zonal (arable and natural) soils, selected for the network of key polygons included in the Soil Quality Monitoring of the Republic of Moldova [5], were used as material and methods [5].

Results and Discussion

The Plateau of Central Moldova in the altitude range of 180-210 m, as a result of pedogenesis in forest and steppe conditions is characterized by a complex soil cover. Generally, in this part of Moldova the hydrothermic regime corresponds more to the formation of chernozems than forest soils. The average annual temperature is 9.0 - 9.5°, the sum of active temperatures higher than 10° varies between 3000 and 3100°, the annual precipitation amount - 550-600 mm. Evaporability - 800-850 mm, the moisture coefficient (Ivanov-Vâsoţkii) - 0.7-0.8. The dominant forest vegetation led to the formation of gray soils, the steppe vegetation - to chernozems [6].

Structural composition of gray soils. The virgin gray soils are characterized by a high crumb-granular and hydrostabile structure in the 0-30 cm layer. According to data, the most valuable fractions of 1-5 mm predominate in the structural composition of virgin gray soils, 65-70% of these aggregates are water-stabile. The cloggy structural elements with a diameter greater than 10 mm constitute 20-25% of the total amount. Fraction content less than 0.25 mm is equal to 22% in the Aht horizon and 7% in the AEh horizon.

In the structural composition of the 10-30 cm arable layer dominates the cloggy fraction more than 10 mm (60-70%). In the summer period these soils are characterized by a virtually monolithic structure of the middle and lower part of the arable layer, which in no way differs from the monolithic natural structure of the underlying Btw horizon. The arable layer, as a result of dehumification and destruction, lost resistance to compaction [5].

Structure composition of chernozems. Chernozems typical fallow are characterized by an excellent granular water-stable structure. According data, the most valuable fractions of 1-5 mm are dominant, and 80-85% of these aggregates are hydrostable. Aggregate agronomic invaluable with a diameter of more than 10 mm (cloggy structural elements) are practically missing (1-2% of the total quantity). The same applies to the dust content fraction less than 0.25 mm.

In the structural composition of typical arable chernozems dominates the cloggy fraction with a diameter greater than 10 mm (40-70%). These soils are characterized by virtually monolithic structure in the 25-35 cm postarable layer. For the last 25 years, this layer is not working, being destroyed as a result of the intensive work until 1990, lost its compaction resistance, becoming very compacted.

Typical loamy-clayey chernozems can be considered as high productivity soils only if they are characterized by a granular or crumb hydropstable valuable agronomic structure (consisting from aggregates of 0.25-10 mm in size). The restoration of the glomerular structure is the main problem in ensuring the high agricultural productivity of these soils and combating their degradation.

Soil compaction is a rather acute problem of Moldovan agriculture, which occurs either naturally, in the case of clayey and alluvial soils, either due to anthropogenic causes, through agricultural works on the wet soil. This process has intensified over the last decades by the fact that the conventional agricultural management system has not taken into account an adaptation of the local climate and soil conditions [6].

The secondary compaction and deterioration of soil structure in Moldova extends over the whole area of land, with intensive agro-technical works (arable, vineyards, orchards). Deterioration of the structure is also conditioned by the intensive process of dehumification (loss of organic matter) of arable soils. Compaction and mechanical degradation of soil structure occurs due to the use of agricultural technology; compaction and physic-chemical degradation occurs due to precipitation water, which leads to the replacement of calcium cations in the soil adsorption complex with hydrogen. Fertility of arable soils as a result of secondary compaction was reduced on average by 10% for the entire area of agricultural land [3].

The primary compaction of the soils of Moldova refers more to the vertic soils and the wet soil of the meadows. These soils (17.8 th. ha) are characterized by unfavorable physical properties: fine texture with increased content of fine clay (>35%); high compaction, high apparent density, low structural hydrostability, extremely low permeability, high volume variation (swelling and contraction) by water soaking and drying. In terms of resistance to plowing are soils very heavy. Due to their unfavorable physical properties, they have a 20-40% have a low productivity, compared to uncompacted soils. Approximately one-half of these soils is arable land, and another half is used as pasture land [3].

Degree of compression. The soil compaction state, as well as the loose requirement, can be determined on the knowledge basis of soil compaction degree. In addition to its use as a general indicator of the settlement status, it is used in practice to determine the need for the work of loosening of overloaded soils. Negative values of the degree of compaction, and in particular less than "-17", show a too loose soil, the value "0" separates the soils loosened from the settled ones, and the positive values, and in particular over "+18", show a highly compacted soil.

The virgin soils are considered unsuitable, the soils appear to be weak and moderately compacted. The criteria to be considered when determining the need for soil permeability in order to adjust the hydrophysical regime are: clay in the humiferous horizon over 40%, apparent density above 1.4 g/cm^3, the degree of soil compaction higher than "0" [1].

Compact soils, irrespective of the origin of this process, raise the issue of compression combating. This can be done mechanically by works performed at the depth of the compacted layer: subsoiling works at 35-40 cm deep on shallow compaction soils and scarification works (deep deflection) at a depth of 60-70 cm on soils with deep compaction. Research has shown that this work should be repeated at intervals of 5-6 years [4].

Currently it is widely accepted as one of the most negative consequences of conventional agriculture, surface compacting (secondary) and stratification of the soil profile. The causes of soil compaction are multiple, and the methods for its correction are deduced in the synthesis as follows: soil processing at the appropriate humidity, reduction of the number of passes on the soil surface, decrease of agricultural equipment pressure per unit area, dense crops, soil depth variation, soil drainage improvement, soil organic matter growth.

Land management. In relation to the state of soil compaction, there are two main problems. Thus, on uncompacted soils measures are required to prevent secondary compaction, while on already compacted soils, irrespective of causes, it is necessary to reduce excessive compaction. This can be accomplished mechanically by works at the depth of the compacted layer: 30-40 cm deep subsoil, and deep scarification at deep depths, which can reach 60-70 cm on deep of compacting soil.

Conclusions

The phenomenon of soil compaction is present in the Republic of Moldova on the entire surface of the agricultural land. Over the last 20-30 years there have been no subsoiling works, which led to the settling of 30-50 cm deep agricultural land, impermeable for water and roots. Compaction of the soil has been intensified by water stagnation, frequent crossings with heavy machinery on the ground, abandoning in the form of a heavily overburdened ground of some soil surfaces. This has led to the ecological degradation of compacted soils, loss of fertility and their economic value.

The causes of degradation of the arable soil structure are the dehumification of the plowing layer and the intensive working of the soil with heavy machinery. The deterioration of the structure poses a great danger to the state of physical quality of the soil and confirms that the existing agricultural system does not ensure the long-term preservation of the production capacity of typical arable chernozems.

Compaction can be reduced, and soil restored by special work measures, where scarification at a depth of 10-20 cm is of the greatest importance. The work can be supplemented with organic fertilizers, green fertilizers or mulch. Soil compaction monitoring can be done with penetrometers, simple and efficient tools.

Practically, in all of the investigated soil profiles under the recent arable layer, a compact postarable layer with extremely compact prismatic structural elements was found. The liquidation of this layer, in conditions of total economic crisis, becomes problematic. It is necessary to periodically return to the autumn plowing at a depth of 35 cm every 3-4 years to bring this layer to the ground surface where it will disintegrate under the influence of frost and thaw. The partial destruction of this layer can also be done by working the soil with the chisel at a depth of 35-40 cm.

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Changes in the soil phosphorus content after triple superphosphate application into alkaline chernozem and the effect on yields of barley biomass

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Abstract

In 2017 a pot experiment with 4 treatments (incl. unfertilized control treatment) was established with spring barley, variety KWS Irina, in the outdoor vegetation hall of Mendel university in Brno, Czech Republic. Chernozem (with a low supply of phosphorus and alkaline pH – 7.37) was used for this trial. The rates of phosphorus (0.3 – 0.6 – 1.2 g P per pot = 5 kg of soil) were increased by using the triple superphosphate fertiliser (45% P_2O_5), treatments 2 – 4. Nitrogen was applied in the form of CAN (27% N) at a rate of 1 g N per pot in all the treatments incl. the control. The content of post-harvest soil phosphorus increased significantly with the applied rate (41 – 73 – 117 – 166 mg P/kg). Dry matter yields of the aboveground biomass increased significantly in all fertilised treatments as against the control (31.75 – 39.25 – 45.66 – 48.50 g DM per pot), without significant differences between the two highest rates of P-fertiliser. Triple superphosphate is a suitable P-fertilizer for increasing of soil P-content on alkaline soils with a joint effect on yield.
Keywords: fertilisation, pot, soil, supply.

Introduction

Phosphorus is an essential nutrient for the provision of sufficient crop production, sufficient foods, for the increasing human population on the Earth (Reid & Scholas, 2005). Phosphorus deficiency is a main limiting factor for cereal production in many regions of the world (Holford, 1997). P deficiencies also diminished yield of barley (Rowe & Johnson, 1995). Overwhelming evidence indicates that for annual crops, phosphorus fertilizers should largery be applied preplant. Phosphorus moves to plant roots primarily by diffusion, and young seedlings of most annual crops are very sensitive to phosphorus deficits (Burns, 1987). The significant decrease in use of mineral phosphate fertilizers began in the Czech Republic after political-social changes in the year 1989 (Čermák et al., 2014). More than 75% of arable land in the Czech Republic (low category - satisfactory - good) therefore requires nowadays fertilization with phosphorus. A similar situation is also in orchards, vineyards and hop fields (Smatanová & Sušil, 2015). Soil testing as a remarkable and unique activity that synthesises a large amount of research information and scientific knowledge for practical needs of the identification and prevention of the majority of disproportions in plant nutrition in a given fields. Soil testing provides farmers with the highest quantity of practically applicable information (Raij, 1998).
The aim of present study was to examine spring barley biomass accumulation and mineral nutrition under different P fertilization treatments.

Materials and Methods

The pot experiment was established (including sowing) on 31st March 2017 in the outdoor vegetation hall of the Botanical Garden and Arboretum of Mendel University in Brno. Mitscherlich vegetation pots were filled with 5 kg of medium heavy soil with alkaline soil reaction ($pH/CaCl_2$ – 7.37) characterised as chernozem with these agrochemical parameters

(Mehlich 3, mg/kg): P – 47 (low); K – 226 (good); Ca – 6,081 (very high); Mg – 322 (high). The experiment was set up as complete randomized block design with 4 P fertilization treatments (Tab. 1).

Table 1. Treatments of the experiment

Treatment No.	Description	Rate of P (g/pot)	Rate of N (g/pot)
1	P0	0	1
2	P1	0.3	1
3	P2	0.6	1
4	P3	1.2	1

Phosphorus was applied in the form of triple superphosphate (45% P_2O_5) and nitrogen in the form of CAN – calcium ammonium nitrate (27% N) at a rate of 1 g N per pot in all the treatments including the control. The pots were watered with demineralized water to a level of 60% of the maximal capillary capacity and were kept free of weeds. The aboveground biomass of spring barley (variety KWS Irina) was harvested at the stage of milk-wax maturity (10 plants/pot) on 23 June 2017. Soil analysis prior to the experiment and after the harvest were carried out using Mehlich 3 method (0.015 M NH_4F + 0.2 M CH_3COOH + 0.25 M NH_4NO_3 + 0.013 M HNO_3) (Mehlich, 1984). Plant samples were ground and digested in the microwave Milestone 1200 MLS system in concentrated HNO_3 and H_2O_2. Concentrations of P, K, Ca and Mg in soil extracts were determined using ICP-OES iCAP 7400 Duo, Thermo Fisher Scientific (Newington, USA).
The results were processed statistically using one-way ANOVA and means were compared according to Scheffe (P = 95%).

Results and Discussion

The content of post-harvest soil phosphorus
Inorganic phosphorus enters in the soil solution by mineralization or fertilizer additions. It was reported several times that the systematic phosphorus fertilization increases the plant extractable soil phosphorus content (Lásztity & Csathó, 1995; Izsáki, 2009). The accumulation rate was found to be dependent on the soil type, cropping system, climatic conditions, as well as on the phosphorus dose. Phosphorus content in soil after harvest of our experiment is shown in Table 2. Phosphorus content in a soil significantly increased with icreasing dose of P-fertilizer up 73 (P1) – 117 (P2) – 166 (P3) mg/kg in comparison with 41 mg/kg in non-fertilized control (P0) and the supply categories changed too, from low to satisfactory and high. Phosphorus fertilizer is essential for optimum production, especially when soil test levels are low (McKenzie et al., 1998) as in our experiment.

Table 2. The content of post-harvest soil phosphorus

Treatment No.	Description	Dose of P (g/pot)	Soil P content (mg/kg)	Supply category
1	P0	0	41 a	low
2	P1	0.3	73 b	satisfactory
3	P2	0.6	117 c	high
4	P3	1.2	166 d	high

Different letters (a, b, c, d) indicate significant differences between treatments

Dry matter yields of the aboveground biomass
The yields of aboveground biomass (g DM/pot) is shown in Table 3. The lowest yield was found in P-non fertilized treatment (31.75 g DM/pot), then the significant increase of yield was obtained with the increase of applied phosphorus (39.25-45.66-48.50 g DM/pot) without significant differences between the two highest rates of P-fertiliser.

Table 3. Dry matter yields of the aboveground biomass (g DM/pot)

Treatment No.	Description	Dose of P (g/pot)	Yields (g DM/pot)
1	P0	0	31.75 a
2	P1	0.3	39.25 b
3	P2	0.6	45.66 c
4	P3	1.2	48.50 c

Different letters (a, b, c, d) indicate significant differences between treatments

McKenzie et al. (1998) described that phosphate fertilizer significantly increased barley silage yield at 25 of 32 site-year locations. Varieties responded differently to applied P. Some varieties responded to P fertilization regardless of soil test level. Applied P commonly increased yield by about 25%, but occasionally response was much higher. Nyborg et al. (1999) conducted field experiments at 60 sites to determine the yield response of barley to phosphorus fertilizer. On the unfertilized plots, barley yield increased with increasing concentration of extractable P in the soil. Prystupa et al. (2004) describe in container experiments with phosphorus (dose corresponding to 19 kg P/ha – P1 and 57 kg P/ha – P2) increase of aboveground dry matter content of barley at heading: 602 (N0P0) - 878 (N0P1) - 978 (N0P2) g DM/m^2. If the nitrogen was apply additionally, yield of barley aboveground biomass was increased only in connection with a lower P-dose: 896 (N0P0) - 1622 (N0P1) - 1390 (N0P2) g DM/m^2.
Triple superphosphate is a suitable P-fertilizer for increasing of soil P-content on alkaline soils with a joint effect on yield.

Acknowledgement

This study is a part of the project of NAZV No. QJ 1530171 called “Extension of applicability and actualization of categories for determination of the content of available macroelements and microelements in a soil for ensuring of the sustainability of fertility and productive capability of agricultural soils” which is financed by the Ministry of Agriculture of the Czech Republic.
We express our thanks to the staff of the Botanical Garden and Arboretum of Mendel University in Brno for their helpfulness and assistance with the experiment.

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Assessment of the basic kinetic of catalase in the soil (Province of Konya, Turkey)

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Abstract

On the kinetics of enzymatic processes of soils, numerous studies have been carried out in which the kinetic parameters Vmax and KM are determined using the Michaelis-Menten equation. As the value of the reaction rate, the reaction enzyme activity values are usually used for a short period of time from the start of the reaction. In contrast to these studies, we used analytical methods to determine the initial rate of the enzymatic reaction. Calculations are made for determining the values of the initial velocity and kinetic parameters of the enzyme catalase in the soil.

Key words: initial velocity, kinetic parameters, catalase activity, soil.

Introduction

In studying the mechanism of enzymatic catalysis in enzymology, kinetic methods are widely used: determination of the rate of the enzymatic reaction as a function of various factors - temperature, pH, enzyme and substrate concentration, the presence of cofactors of inhibitors, adsorption of enzymes, etc.(Aliev et al., 1984; Aseeva et al., 1979).

Numerous studies have been carried out on the kinetics of enzymatic processes in soils (Aliev et al., 1981; Aliev et al., 1984; Aseeva et al., 1979; Khaziev, 1983; Vodopyanov et al., 2010; Mikayilov et al., 2011; Kızılkaya et al., 2015), that allow one to assert that the methods of classical stationary kinetics are used to describe enzymatic processes in the soil and to understand the mechanism of action of soil enzymes.

The simplest scheme of enzymatic catalysis involves the reversible formation of an intermediate complex of the enzyme (**E**) with the reacting substance (substrate, **S**) and the destruction of this complex with the formation of reaction products (**P**). In the simplest case, the reaction equation with the enzyme has the form: (Vodopyanov et al., 2010; Cornish-Bowden, 1979; Kurskiy et al., 1977):

$$\mathbf{E}+\mathbf{S} \underset{k_{-1}}{\overset{k_{+1}}{\rightleftarrows}} \mathbf{ES} \xrightarrow{k_2} \mathbf{E}+\mathbf{P} \qquad (1)$$

where **E** – enzyme; **S** – substrate; [**ES**] – enzyme-substrate complex (so called Michaelis complex); **P** – product; k_{+1} – rate constant for the formation of an enzyme-substrate complex from the enzyme and substrate.; k_{-1} – rate constant of dissociation reaction of enzyme-substrate complex on enzyme and substrate; k_2 – the rate constant of the reaction of conversion of the enzyme-substrate complex to the enzyme and product.

Expression for initial speed (n_0) reactions look like this (Cornish-Bowden, 1979; Kurskiy et al., 1977; Mikayilov et al., 2011; Kızılkaya et al., 2015):

$$v_0 = \frac{\mathbf{V}_{\mathbf{max}}[\mathbf{S}]_0}{\mathbf{K}_{\mathbf{M}}+[\mathbf{S}]_0} \qquad (2)$$

where $[\mathbf{S}]_0$ – initial concentration of substrate, $\mathbf{V}_{\mathbf{max}}$ - maximum reaction rate with complete saturation of the enzyme with substrate and $\mathbf{K}_{\mathbf{M}}=(k_{-1}+k_2)/k_{+1}$ – is called the *Michaelis constant of the Briggs-Haldane theory*.

Equation (2) is the fundamental equation of enzymatic kinetics and is usually called the *Michaelis-Menten* or *Briggs-Haldane equation*. It serves as a useful starting point for analyzing the kinetics of enzymatic processes.

It is known that with time the reaction rate ***v=d[P]/dt*** decreases, since the accumulation of the product decreases. Decrease in speed can be explained by the following reasons:
- since in the course of the reaction the substrate concentration decreases, the degree of saturation of the enzyme by the substrate also decreases;
- reaction products can inhibit enzyme activity;
- with an increase in the concentration of products, the equilibrium reaction can shift to the left;
- it is possible to inactivate the enzyme or coenzyme due to the instability of the conditions under which the experiment is carried out;
- all of these factors can act simultaneously.

In order to avoid the influence of these factors on the kinetics of enzymatic reactions, they try to operate not by the speed of the reaction in general, but by the reaction rate at the initial time (t=0, i. e. initial speed υ_0. In this initial period of time, all sorts of undesirable factors do not have time to show their action. One of the main tasks of enzymatic kinetics is to find the value of the initial velocity versus υ_0 time.

The analytical method for determining the initial rate of enzymatic reactions is based on establishing the most accurate (adequately describing) analytical expression of the kinetic curve υ=P(t). To do this, we can use a polynomial of degree n in t:

$$\left[\mathbf{P}(t)\right] = a_0 + a_1 t + a_2 t^2 + \ldots + a_n t^n = \sum_{k=0}^{n} a_k t^k, \ \left(n = 3,4,5,6,7\right) \tag{3}$$

Coefficients a_i are found using mathematical packages. The value [P(t)] is measured at regular intervals of time t.

Therefore, if there is an analytical equation for the kinetic curve υ=P(t), then using the formula $v_0 = d\left[\mathbf{P}\right]/dt\Big|_{t=0}$, we can determine the initial velocity υ_0. For the expression (3), it has the form:

$$v_0 = d\left[\mathbf{P}\right]/dt\Big|_{t=0} = \left(a_1 + 2a_2 t + \ldots\right)_{t=0} = a_1 \tag{4}$$

In principle, the more terms the model (3) contains, the better it is possible to describe the kinetic curve.

The method of determination ν_0 using (4) has its advantages and disadvantages.

On the one hand, this method can be used regardless of whether the true equation of reaction speed is known; the method is also suitable in cases where the process is complicated in time by the denaturation of the enzyme. On the other hand, the use of (4) gives much less information about the kinetic curve. Coefficients a_0, a_1, a_2, …. - have no physical meaning, and they can not be transformed into parameters related to the mechanism of the enzymatic process this (Cornish-Bowden, 1979).

After determining the value of the initial speed υ_0, further on the basis of the formula (2), it is easy to find the kinetic parameters $\mathbf{V_{max}}$, $\mathbf{K_M}$ и $\mathbf{V_{max}}/\mathbf{K_M}$.

The indicator of the ecological state of soils, biological activity is show up presence and activity of catalase (H_2O_2:H_2O_2), which characterizes the potential capacity of the ecosystem to maintain homeostasis.

The role of catalase in the soil is that it destroys the peroxide poisonous to organisms (Galstyan, 1978; Kuprevich et al., 1977; Khaziev, 1983, 2005).

$$\left[Katatlaz\right] + 2\left[\mathrm{H_2O_2}\right] \underset{k_{-1}}{\overset{k_{+1}}{\rightleftarrows}} \left[Katalaz\mathrm{H_2O_2}\right] \xrightarrow{k_{+2}} \left[Katatlaz\right] + 2\left[\mathrm{H_2O}\right] + \left[\mathrm{O_2}\right]\uparrow$$

The catalase activity in the soil depends more on the air regime, soil texture, oxidation-reduction potential, and other conditions [10]. The change in the properties of soils on the

background of development has an effect on the activity of catalase. With agricultural development, it is possible to disrupt the operation of enzyme complexes, so the study of the catalase activity in soils is actual.
The problems of changing the kinetic characteristics of catalase in the soils of Turkey, based on the use of the initial velocity, have so far remained unexplored. The purpose of our studies was to increase the accuracy of determining the initial velocity and kinetic parameters of studying the kinetic characteristics of catalase (v_0 , K_M , V_{MAX} , V_{MAX} / K_M) in the soils of the Chumra region (Konya Province, Turkey). These parameters are an important characteristic of soil biological activity and soil fertility.

Materials and Methods

The study area is located in Çumra, Central Anatolia, Konya province, central Turkey between 37-380 east longitude and 33-340 north latitude at 1013 m of altitude. The climatic conditions of the Chumra area and its surroundings are formed under the influence of various geographic factors, of which the most important is continentality: summers are hot and dry, and winters are cold and snowless. The average annual temperature is about 11^{0}C, and the average annual precipitation is 324mm. The amount of precipitation decreased noticeably in recent years as compared to previous years of research.
On the experimental plot of the agricultural faculty of the University of Selcuk (Konya) was laid a soil cut. The experimental plot (with the sugar beet grown traditional for the region) was irrigated with a drop irrigation method.

Figure 1. Location of the pilot site (Konya)

Soil samples were selected in the 0-30 cm layer. The physicochemical characteristics of the samples studied are presented in Table 1. The soil of the experimental site has a heavy soil texture composition throughout the profile. According to the international classification, the soil is alluvial carbonate heavy loam.

Table. 1. Physico-chemical characteristics of the soil (0-30 cm)

pH	Corg	N	CaCO3	EC	Clay	Dust	Sand	Texture
1:1	%	%	%	dS/m	%	%	%	
7.63	0.86	0.13	2.37	0.832	40.80	53.52	5.68	SC*

*SC – Silty Clay

To determine the catalase activity, the gas metric method was used in the Galstyan modification (Galstyan, 1978; Khaziev, 2005).

Results and Discussion

The catalase activity was determined with constant stirring in air-dry soil samples using freshly prepared substrates of different concentrations (3, 6, 9, 18 и 24 %). The amount of released oxygen was fixed for 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 and 5 min. (Table 2 and Figure 2).
The rate of decomposition of hydrogen peroxide with catalase in soils was expressed in terms of the volume of oxygen released in ml ([P] = O_2) per 0.5, 1.0,…, 4.5 and 5 minute per 1 g of dry soil. The experiment was carried out at a temperature of 18-20° C.

Table 2. The amount of oxygen released [P], in ml O_2 per 1 g of soil

i	Time, t	Substrate concentrations, H_2O_2, %					
	min	3	6	9	12	18	24
1	0,5	2,37	5,57	9,07	10,93	13,97	12,40
2	1,0	6,93	11,37	13,13	16,77	19,37	16,80
3	1,5	7,93	13,07	15,30	21,90	25,37	19,05
4	2,0	8,40	15,83	17,17	25,63	26,93	20,65
5	2,5	8,20	18,20	19,73	28,63	29,23	21,52
6	3,0	8,47	20,20	21,97	30,37	31,60	22,11
7	3,5	8,80	20,80	22,03	30,93	31,63	22,96
8	4,0	9,00	20,43	23,20	32,03	32,20	23,76
9	4,5	9,33	21,00	24,40	32,80	33,83	24,66
10	5,0	9,53	20,70	24,47	34,17	34,93	25,57

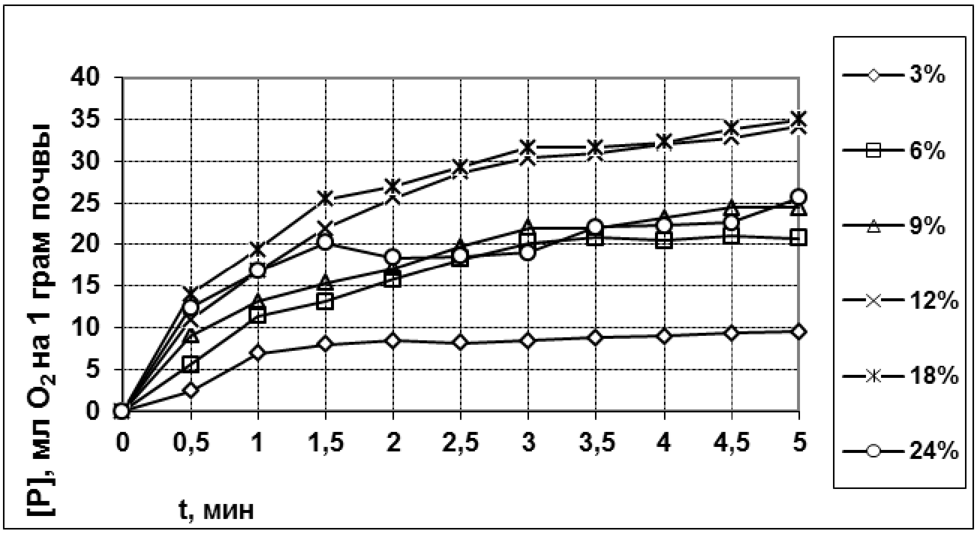

Figure 2. Change in volume of released oxygen in ml ([P] = O_2) per 1 g of soil

Using experimental data using the mathematical package Statistica 12 for polynomials of 4, 5, 6, and 7 degrees and each substrate concentration (3, 6, 9, 12, 18 and 24 %), the coefficients and basic statistical parameters of mode (3) l adequacy were calculated. Then, using the values of these coefficients, the values of the initial catalase enzyme speed (Table 3) and the basic statistical parameters showing the adequacy of the models (3) were calculated using formula (4) (Table 4).

Table 3. The value of the initial velocity v_0 (ml O_2 / minute per 1 g soil)

№	Concentration of Substrate	The initial speed V_0 (ml O_2 / minute per 1 g soil)			
	$[S]_0$	Degrees of a polynomial (3)			
	%	4	5	6	7
1	0	0	0	0	0
2	3	9,9187	6,45751	0,2326	-6,2821
3	6	13,1444	15,81568	14,93456	2,6424
4	9	19,2821	24,5523	30,0087	23,76976
5	12	22,1924	25,5420	30,2236	33,0360
6	18	29,6878	34,6685	39,7757	39,5005
7	24	27,8943	33,2218	37,5814	41,2383

Statistical analysis or models selection criteria

When we are dealing with multiple models, the question is how to find the best model among competing models. Depending on the structure of the models, different statistical criteria can be used to find the best model. For comparison of model fitting, we used the eleven comparison criteria (Burnham and Anderson, 2002; Hoffmann, 2010, et al). These criteria are given below.

ESS- Estimate sum of squares (Hoffmann, 2010); R^2_{adj} - Adjusted coefficient of determination Theil H (1971); σ- Standard error of the estimate is a measure of the accuracy of predictions (Chapra and Canale 2010); MAPE- Mean absolute percentage error (Chapra and Canale 2010).; D- Willmott's index of agreement (Willmott, 1981); UI- Theil's Forecast Accuracy Coefficient (Theils, 1958); AICc- Akaike information criterion (Akaike, 1973); F- Fisher Criteria, the factual value of F-test is compared with the tabulated point $\mathbf{F}_{tabl}(\alpha, k_1, k_2)$ whose value should be determined by a special table based on the significance level α and the degrees of freedom $k_1 = p-1$ and $k_2 = n-p$. Here (Montgomery et al, 2012):

if $\mathbf{F} > \mathbf{F}_{tabl}(\alpha, k_1, k_2)$, then the model is adequate. At this point the regression analysis ends;

if $\mathbf{F} < \mathbf{F}_{tabl}(\alpha, k_1, k_2)$, then the model is inadequate. Then the starting model should be changed and all the calculations be repeated.

When models are *nested*, any of these criteria are applicable (Archontoulis and Miguez, 2015). In this paper, the models we have considered are nested.

In our study, computation of model parameters was done with STATISTICA-12 program using the Levenberg-Marquradt method.

Analyzing the statistical indicators of all the models considered, given in Table 4, it was established that the relationship between [P] and t is best described by a polynomial of the 4^{th} degree.

Table 4. The basic statistical parameters of models (3) for 4, 5, 6 and 7

№	Statistical parameters	Degrees of a polynomial (3)			
		4	**5**	**6**	**7**
1	ESS	15,93	33,98	173,51	397,81
2	R^2_{adj}	0,97	0,96	0,88	0,80
3	σ	1,79	2,61	5,89	8,92
4	MAPE, %	5,85	12,07	598,26	95,14
5	D	0,993	0,991	0,970	0,947
6	UI	0,038	0,047	0,094	0,145
7	AICc	1,82	2,58	4,21	5,04
8	F	204,07	139,19	37,60	19,72
9	F(α= 0,05)	6,61	6,61	6,61	6,61
10	F(α= 0,01)	16,26	16,26	16,26	16,26

Further, to determine the parameters V_{Max} and K_M of the model (2), the found initial velocity values were used (Table 3). For all the considered degree of the polynomial (3), using the Statistica 12 program, the values of these kinetic parameters and their statistical parameters were calculated (Table 5).

Table 5. Basic statistical parameters of models (2)

	Estimate	**Standard error**	**t-value df = 5**	**p-level**	**Lo. Conf Limit**	**Up. Conf Limit**
$[\mathbf{P}(t)] = a_0 + a_1 t + a_2 t^2 + a_3 t^3 + a_4 t^4$						
$\mathbf{V_{max}}$	44,5896	5,8128	7,6709	0,0006	29,6472	59,5320
$\mathbf{K_m}$	11,9193	3,3285	3,5810	0,0159	3,3631	20,4755
$[\mathbf{P}(t)] = a_0 + a_1 t + a_2 t^2 + a_3 t^3 + a_4 t^4 + a_5 t^5$						
$\mathbf{V_{max}}$	58,2428	10,7673	5,4092	0,0029	30,5645	85,9211
$\mathbf{K_m}$	14,9743	5,4128	2,7664	0,0395	1,0601	28,8884
$[\mathbf{P}(t)] = a_0 + a_1 t + a_2 t^2 + a_3 t^3 + a_4 t^4 + a_5 t^5 + a_6 t^6$						
$\mathbf{V_{max}}$	78,8743	36,2784	2,1741	0,0817	-14,3824	172,1309
$\mathbf{K_m}$	21,0899	16,7247	1,2610	0,2629	-21,9024	64,0821
$[\mathbf{P}(t)] = a_0 + a_1 t + a_2 t^2 + a_3 t^3 + a_4 t^4 + a_5 t^5 + a_6 t^6 + a_7 t^7$						
$\mathbf{V_{max}}$	267,0588	777,0818	0,3437	0,7451	-1730,4936	2264,6112
$\mathbf{K_m}$	116,4604	391,8019	0,2972	0,7782	-890,6985	1123,6193

Analyzing the statistical indicators (**Standard Error, t-value for df = 5, p-level, Lo. Conf and Up. Conf Limit**) parameters V_{Max} and K_M model (2), once again shows that the results of our analyzes are better described by a 4th degree polynomial. The final value of the kinetic parameters V_{Max}, K_M and V_{Max} / K_M, calculation using the initial velocity values determined from the 4th degree polynomial is given below (Table 6).

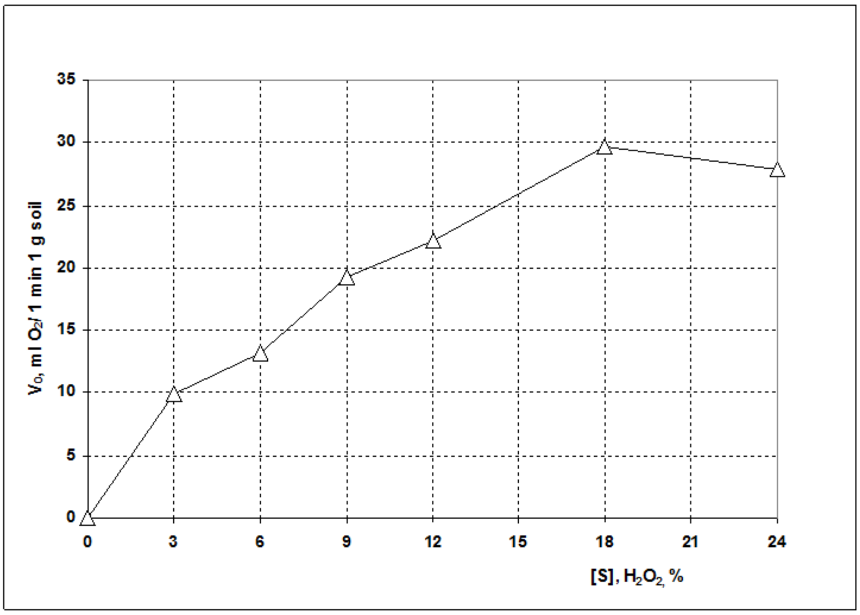

Figure 3 Change in initial velocity values from substrate concentration

Table 6. Kinetic parameters (V_{Max} and K_M) of the investigated soil

Model, degree=4	V_{max}	K_M	V_{max} / K_M
	$\frac{ml\ O_2}{min\ 1\ g\ soil}$	%	
(5)	44,5896	11,9193	3,7409

Conclusion

The conducted studies show that the dependence of the accumulation of products of the enzymatic reaction for catalase on the duration of incubation at different substrate concentrations in the Konya province soils, the number of reaction products increases nonlinearly, moreover, is described by the most accurate and adequate model-polynomial of the 4th degree. Using this model, the initial velocity values for each substrate concentration were calculated. The curves of the dependence of the initial rate of the catalase reaction in the soil on the substrate concentration for the soils of the Chumra region have a monotonous form. Thus, we were able to improve the accuracy of determining the initial reaction rate and the kinetic parameters V_{max} and K_M of the enzymatic reaction of decomposition of hydrogen peroxide with catalase in real soil conditions.

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Interconnection between activity of soil microbiota and content of organic matter, temperature and moisture in arable soil level

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Abstract

Changes in structure and physiological statute of soil microbial community that are caused by natural and anthropogenic exposures to the different ecosystems (agroecosystems and bioecosystems) are presented. The above changes are registered with the parameter of microbial metabolic coefficient which could characterize the soil resistance while competitive assessment of different agrotechnical operations (soil treatment, placement of herbicides and fertilizers).
It was defined that the stability of the microbial community changed both during the years of the crop rotations and the vegetation season in the different phases of crops growth and development and depended on the intensity of the mechanical treatment of the arable soil level while soil processing. In the conditions of sufficient and high level of agroecological system energy supplies the intensity of the microbial community, and hence the carbon content accumulated by microbial biomass, was determined by soil temperature and moisture.
Based on the values of the coefficient of stability in the seasonal period it was defined that the natural cenoses are less environmentally sustainable in comparison with anthropogenic agrocenoses. It is explained by the different rates of mineralization process of organic residues and release of carbon and nitrogen as the main nutrition resources of nutrition for various forms of microorganisms.
Key words: organic matter, soil microbiota, resistance coefficient.

Introduction

Annually while implementing the soil management operations the main part of the soil elements is withdrawn along with the yield, especially with the yield of annual crops. In this regard, there is the risk that in a few decades the content of the main soil elements will be exhausted. Moreover, as the result not appropriate soil management caused decreasing the soil fertility and deteriorating the phytosanitary parameters of the fields [2, 4].
One of the ways for increasing the soil fertility and sustainability of agroecosystems is using of non-traditional form of fertilizers, first straw of cereal crops and crops grown on green manure. Straw and green mass of different crops are effective and not expensive organic fertilizers that allow improving soil fertility and crop productivity [1, 3].
An important role in maintaining the stability of agrobiocenoses is given to soil treatment operations that provide dissemination of incoming organic matter on the different depth of soil level and create different water and temperature conditions in the root layer of the soil [5]. The activity of the microbial community plays an important role for stabilization of biological indicators of soil fertility and productivity of different agrobiocenoses.

Materials and Methods

Microbial metabolic coefficient (QR) was calculated as: QR=Basal respiration/Substrate of induce respiration
Carbon content (CCmb) accumulated by microbial biomass was calculated as: CCmb= Substrate of induce respiration*40.04+0.37.

Results and Discussion

The soil treatment operations that differ on depth, method and intensity of working tools coercion on the soil, along with improving water, temperature and aeration conditions, increase the availability of nutrients from mineral fertilizers, crop residues, and straw of cereal crops, grain and green manure. As the result, it causes the optimization of the conditions for functioning the microorganisms and the changes in the direction of soil biochemical processes to humus accumulating.

In the agrobiocenoses of cereal and tilling crops rotation, the level of basal respiration was determined by the content of organic matter in the arable soil level. The minimum value of the above parameter was resulted while cultivation of vetch and oat mixture (0,19 µg C - $CO2^{-g}$ $soil^{-hour}$), the maximum – while winter wheat cultivation (1,52 µg C - $CO2^{-g}$ $soil^{-hour}$). The above values correlated with changes in organic matter contents in the arable soil level and was confirmed by our calculations (Fig.1).

The correlation between the basal respiration and organic matter content in the arable soil level is defined and described by a linear function. The value of coefficient of determination while ploughing treatment is 0,48; while minimum treatment – 0,87 that indicates average relationship between the parameters while ploughing treatment and strong relationship – while minimum treatment (Fig.2).

One of the main indicator of the microbial community activity is the mass of carbon accumulated by soil biota and its share in the total carbon of organic soil matter.

It was defined that during the period of intensive biomass accumulation of barley the content of organic carbon in the arable soil level was 41,8 - 43,0 t^{-ha} and carbon of microbial biomass – 803 - 950 $kg\text{-}^{ha}$. While the cultivation of annual grasses the above parameters decreased to 34,2 - 36,5 t^{-ha} and 543 - 686 kg^{-ha} accordingly (Fig.3).

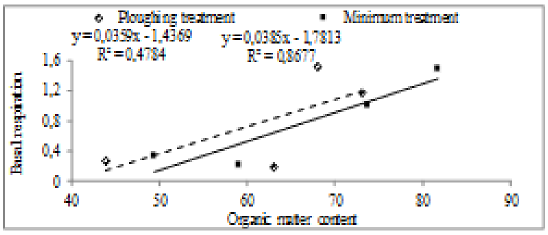

Figure 1. The relationship between basal respiration (µg C - $CO2^{-g}$ $soil^{-hour}$) with organic matter content (t^{-ha}) in the arable soil level during the period of maximum crop biomass accumulation

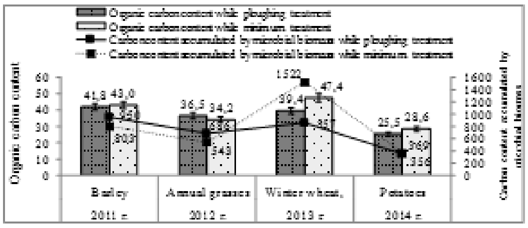

Figure 2. The relationship between basal respiration (µg C - $CO2^{-g}$ $soil^{-hour}$) with organic matter content (t^{-ha}) in the arable soil level during the period of active crops growth and development

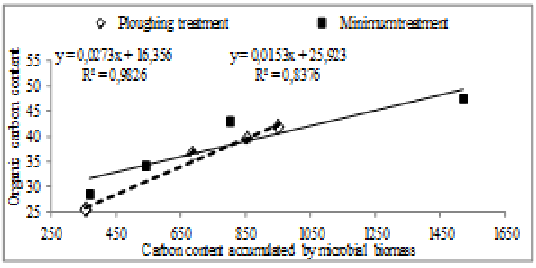

Figure 3. Influence of organic carbon content in the arable soil level (t^{-ha}) on carbon accumulation by microbial biomass (kg^{-ha}) during active crops growth and development

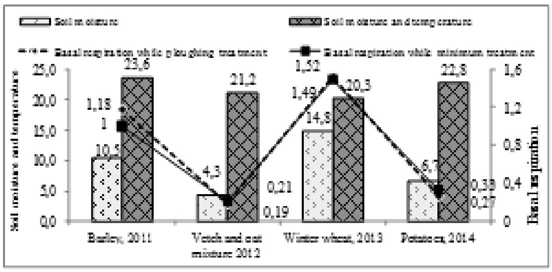

Figure 4. The relationship between basal respiration (µg C - $CO2^{-g}$ $soil^{-hour}$) with organic matter content (t^{-ha}) in the arable soil level during the period of active crops growth and development

The high content of organic carbon content of 39,4 - 47,4 t^{-ha} while the cultivation of winter wheat caused the increase of carbon content accumulated by microbial biomass to 857 - 1522 kg^{-ha}. The low content of organic carbon content while the cultivation of potatoes caused the decrease of carbon content accumulated by microbial biomass to 356 - 369 kg^{-ha}.
The above relationship is described by a linear function with coefficient of determination while ploughing treatment is 0,98; while minimum treatment – 0,84 that indicates strong relationship between the parameters (Fig.4).
An important role in the processes of microbiological transformation of straw, green manure and crop residues belongs to the meteorological conditions of the vegetation season. The previous researches defined that a more intense decomposition of organic residues was observed at soil temperature of more than 20^0C and soil humidity of 60-70% of minimum water content. When deviating from the optimal values of one of these parameters, the intensity of organic matter decomposition was determined by the parameter with the minimum value – soil humidity (Fig.5).
The value of soil humidity for light loamy soil was optimal while cultivation of winter wheat – 14,8%, favorable – 10,5% while cultivation of barley and not sufficient – 4,3% while cultivation of vetch and oat mixture and potatoes – 6,7%. The above parameters caused the definite level of basal respiration: 1,49 - 1,52 μg C - $CO2^{-g}$ $soil^{-hour}$ in the phase of milky and wax ripeness of winter wheat; 1,00 - 1,18 μg C - $CO2^{-g}$ $soil^{-hour}$ in the earing phase of barley; 0,19 - 0,21 μg C - $CO2^{-g}$ $soil^{-hour}$ before harvesting vetch and oat mixture; 0,27 - 0,33 μg C - $CO2^{-g}$ $soil^{-hour}$ in the flowering phase of potatoes.
The relationship between soil moisture and basal respiration is described by exponential function with coefficient of determination while ploughing treatment is 0,91; while minimum treatment – 0,96 that indicates strong relationship between the parameters (Fig.6).
In the conditions of sufficient and high level of agroecological system energy supplies the intensity of the microbial community, and hence the carbon content accumulated by microbial biomass, was also determined by soil temperature and moisture. While the researches the soil temperature (20,3 - 23,6 ^{0}C) in the period of active crop growth and development was favorable for intense activity of soil biota. The parameters of soil moisture, on the contrary, varied from 4,3% in vetch and oat mixture field (acute moisture deficit) to 14,8% in winter wheat field (optimal moisture) that caused different influence on values of the carbon content accumulated by microbial biomass – from 615 kg^{-ha} in 2012 to 1190 kg^{-ha} in 2013 (Fig.7).
Statistical data processing determined weak relationship between the carbon content accumulated by microbial biomass and soil moisture while ploughing and strong relationship while minimum treatment with the coefficients of determination of 0,39 and 0,74 accordingly.
The main indicator of stability of different agrobiocenoses functioning is the microbial metabolic coefficient (QR) or the metabolic coefficient (q_{CO2}) that defines the ratio of processes of organic substances synthesis and disintegration, and consequently, and nutrition resources for microorganisms and varies from zero (superstability agrobiocenoses) to one (unbalanced agrobiocenoses).

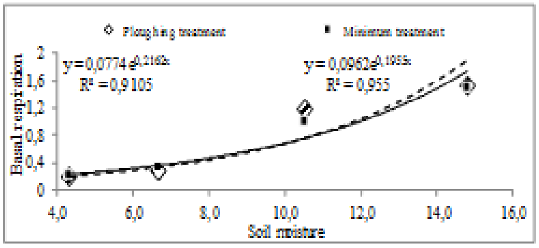

Figure 5. Influence of soil temperature (^{0}C) and soil moisture (%) on the basal respiration of soil microbiota (μg C - $CO2^{-g}$ $soil^{-hour}$)

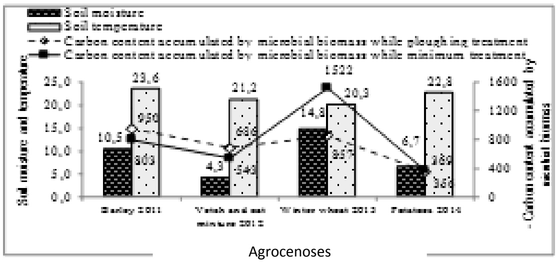

Figure 6. Influence of soil moisture (%) on the basal respiration of soil microbiota (μg C - $CO2^{-g}$ $soil^{-hour}$)

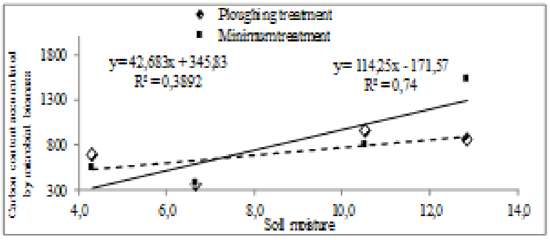

Figure 7. Influence of soil temperature (^{0}C) and soil moisture (%) on the carbon content accumulated by microbial biomass (kg^{-ha})

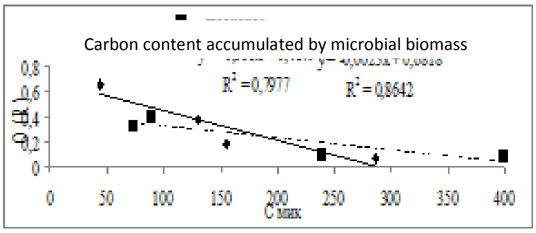

Figure 8. Correlation between the carbon content accumulated by microbial biomass (μg C-g soil) and microbial metabolic coefficient (QR) at different stages of ecosystem functioning

While the seasonal period the highest stability of microbial cenoses was achieved at the stage of ecosystem stabilization – 0,07 in agrocenoses and 0,08 in natural cenoses.

At different stages of agrobiogeocenoses functioning with sufficient (more than 10 t^{-ha}) income of organic matter from straw of winter wheat and green manure crops into the soil the agroecological systems on the intensity of microbial community activity (carbon content accumulated by microbial biomass) and value of the coefficient of stability (microbial metabolic coefficient) was practically equal to natural ecosystems such as long-term fallow land.

On the basis of the values of the coefficient of stability in the seasonal period it is defined that the natural cenoses (QR = 0,32) are less environmentally sustainable in comparison with anthropogenic agrocenoses (QR = 0,23). It is explained by the different rates of mineralization process of organic residues and release of carbon and nitrogen as the main nutrition resources of nutrition for various forms of microorganisms.

It is defined the strong correlation between the carbon content accumulated by microbial biomass and the stability of microbial community (QR) at different stages of ecosystem functioning that was confirmed with the values of the coefficients of determination – 0,80 in agrocenoses and 0,86 – in natural cenoses (Fig. 8).

Conclusion

Thus, natural and anthropogenic impact on different ecosystems (agroecological systems and biogeosystems) cause the changes in the structure and physiological status of soil microbial communities that reflected with the value of the microbial metabolic coefficient. The above coefficient can be used for characterization of the soil stability while comparative assessment of impacts from implementing the agrotechnical operations (soil treatment, placement of herbicides and fertilizers).

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Modeling of phosphate removal by Mg/Al-LDH functionalized biochar and hydrochar from aqueous solutions

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Abstract

High porosity and specific surface area as well as excellent stability confirm that biochar and hydrochar can be used as matrices for stabilizing LDH flakes and creating LDH-biochar and LDH-hydrochar composites. Mg/Al-LDH functionalized biochar and hydrochar composites are environmentally friendly adsorbents for removal of phosphorus (P) from aqueous solutions which can subsequently be used as P-fertilizer. In the present study, Mg/Al-LDH functionalized apple wood biochar and hydrochar were prepared using co-precipitation method and their adsorption characteristics for P were examined through batch experiments. Moreover, important factors affecting adsorption including contact time (5-120 min), initial P concentration (25-200 mg/L), pH (3-10), ionic strength (deionized water and 0.001, 0.01, and 0.1 mol/L KCl) and adsorbent dosage (1, 2, 3, and 4 g/L) were investigated. Based on results, the P adsorption by Mg/Al-LDH modified biochar and hydrochar were comparable with Mg/Al-LDH and were greater than biochar and hydrochar. The pseudo-second-order model best described the adsorption kinetics of P for Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar with equilibration times of 30, 60 and 30 min, respectively. As expected, P adsorption decreased with increasing pH and ionic strength. The highest P removal was attained at pH 4, adsorbent dosage of 4 g/L and in the presence of deionized water as a background solution. There were no significant differences between phosphate removal efficiency of Mg/Al-LDH, Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar in studied conditions. Adsorption characteristics of the adsorbents revealed that phosphate adsorption mechanism involved a combination of interlayer anion exchange, electrostatic attraction and formation of surface inner-sphere complexes. The Mg/Al-LDH modified biochar and hydrochar composites as cost-effective and efficient adsorbents suggest alternative biochar- and hydrochar-based composites for removal of P from water that could be used as P-fertilizers.

Key words: Adsorption, Biochar, Composite, Hydrochar, Layered double hydroxide.

Introduction

A destructive consequence of P delivery into surface waters can be eutrophication. Eutrophication interferes with the natural functions and the structure of aquatic ecosystems, raises water treatment costs, and may help formation of harmful algal blooms (Lalley et al. 2016). On the other hand, since non-renewable rock phosphate resources are limited, which will make its value go up when not enough P fertilizers are available to ensure future food security (Najafi, 2017). Therefore, recovery and reuse of lost P provide a double benefit of protecting environmental water quality and improving food security by minimizing supply risks. Adsorption is regarded as a high-performance method for this purpose because of its convenience, high selectivity and no secondary contamination (He et al. 2010). Layered double hydroxides (LDHs), are brucite-like compounds that have been used as an effective adsorbents for phosphate removal from aqueous medium because of their high positive charge, easily exchangeable interlayer anions, and large specific surface area (Hosni and Srasra, 2010). However, the wide application of LDHs is inhibited because of problems including low renewability, high cost, difficult disposal after use (Li et al. 2016), and difficult particle separation (Goh et al. 2010). However, when the nano-sized LDH particles are attached to larger particles such as biochar or hydrochar, their environmental applications would be highly beneficial. This type of composites has additional environmental benefits such as carbon sequestration and soil fertility improvement (Wang et al. 2016).

Biochar is a pyrogenic recalcitrant porous material produced from biomass heating in an oxygen-limited medium. Hydrochar is an energy-dense solid produced through hydrothermal carbonization (HTC). Advantageous properties and features such as stable carbon matrix, environmentally friendly, low cost, high porosity, high specific surface area, and easy preparation and operation qualify biochar and hydrochar as matrix for stabilizing LDH flakes and creating LDH-biochar and LDH-hydrochar composites. Xiao et al. (2018) interpreted the biochars applications such as carbon fixators, fertilizers, sorbents and carbon-based materials based on the biochar multi-level structures. Hence, some novel composites from biochar, hydrochar and LDHs nanoparticles have lately been prepared for adsorption of phosphate from water (Zhang et al. 2013 and 2014; Li et al. 2016; Wan et al. 2017). These engineered biochars and hydrochars proved to offer a high removal potential for anions from aqueous solutions.

Many researchers have investigated the effects of ionic strength, pH, and adsorbent dosage on phosphate adsorption with different adsorbents (Zhao et al. 2008; Li et al. 2009); nevertheless, there is notably not a wealth of literature on adsorption characteristics of LDH-biochar and specially LDH-hydrochar composites for the phosphate. Such an investigation can offer insights and provide information on how to produce high-efficiency Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar composites involved in development of biochar and hydrochar technologies. The present study in addressing such a gap employs self-assembly co-precipitation method in order to prepare Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar composites for phosphate removal from aqueous mediums.

Material and methods

Apple wood biomass was obtained locally for producing biochar and hydrochar. Biochar was produced from the apple wood feedstock through slow pyrolysis at 600 °C for 1 h under Ar flow conditions (Wang et al. 2016). Hydrochar was produced through hydrothermal carbonization of the feedstock at 180 °C and 11 bars pressure for 12 h (Zhang et al. 2014). The resulting biochar and hydrochar were gently crushed, sieved into 0.5–1.0 mm, washed with deionized water and oven-dried at 105 °C for 24 h before using (Li et al. 2016). Analytical grade $AlCl_3.6H_2O$, $MgCl_2.6H_2O$, $KH_2PO_4.H_2O$, and NaOH, were purchased from Merck Company. LDH-Biochar and LDH-Hydrochar composites were synthesized by a spontaneous self-assembly method through co-precipitating mixed metal solutions of Mg and Al chlorides and continuing with aging at 80 °C for 3 d according to the literature (Wan et al. 2017). The Mg/Al-LDH particles were synthesized via a combined fast co-precipitation and hydrothermal treatment route following the literature (Mohammadi et al. 2016). Obtained samples were dried at 80 °C in an oven overnight, crushed and sieved into 0.5–1.0 mm.

For the kinetic experiments, 0.1 g of adsorbent was added into a set of 100 mL Erlenmeyer flask containing 50 mL of 0.03 mol/L KCl solution with P concentration of 50 mg/L. The flasks were shaken on a rotary shaker (at 170 rpm) for different times (5-120 min). Then, the flasks were picked up and the dispersions were filtered by a microsyringe (0.22 µm). To determine the phosphate concentration of the filtrate at a wavelength of 880 nm, a Philler Scientific SU6100 spectrophotometer (USA) was employed. The kinetics data of P adsorbed on Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar were fitted with Pseudo-first- (Equation (1)), pseudo-second-order (Equation (2)), Elovich (Equation (3)), and intra-particle diffusion (Equation (4)) models (Tran et al. 2017):

$$q_t = q_e(1 - e^{-k_1 t}) \quad \text{First-order model} \quad (1)$$

$$q_t = \frac{k_2 q_e^2 t}{1 + k_2 q_e t} \quad \text{Second-order model} \quad (2)$$

$$q_t = \left(\frac{1}{\beta}\right) ln(\alpha\beta) + \left(\frac{1}{\beta}\right) lnt \quad \text{Elovich model} \quad (3)$$

$$q_t = K_{dif} t^{0.5} + C \quad \text{Intra-particle diffusion model} \quad (4)$$

in which, q_e and q_t represent the amount of adsorbed P (mg/g) at equilibrium time and time t, respectively; k_1 (1/min) and k_2 (g/mg min) are the adsorption rate constants, α (mg/mL min) is the initial adsorption rate constant, β (mL/mg) is related to the extent of surface coverage and activation energy for chemisorption, K_{dif} (mg/mL min$^{0.5}$) is the intra-particle diffusion rate constant, and C (intercept) represents the boundary layer effect (Ding et al. 2012).
Isotherm experiments were performed through adding 0.1 g of adsorbents to a set of 100 mL Erlenmeyer flask containing 50 mL of 0.03 mol/L KCl solution with a P concentration range of 25-200 mg/L. The flasks were shaked on a rotary shaker (at 170 rpm). After 2 h, dispersions were filtered by a microsyringe (0.22 µm) and phosphate concentration was determined as described above. Freundlich and Langmuir isotherm models were used to describe the P adsorption process on LDH, LDH-biochar, and LDH-hydrochar (Zhang et al. 2014; Li et al. 2016):

$$q_e = K_F C_e^{\frac{1}{n}} \quad \text{Freundlich} \quad (5)$$

$$q_e = \frac{b K_L C_e}{1 + K_L C_e} \quad \text{Langmuir} \quad (6)$$

where, K_F (mg$^{(1-n)}$ L^n/g) represents the Freundlich a□nity constant; n is the Freundlich linearity constant, K_L (L/mg) is the Langmuir bonding coefficient; b (mg/g) represents Langmuir maximum capacity or monolayer adsorption capacity, and C_e (mg/L) denotes the equilibrium concentration of the adsorbate (Li et al. 2016).
To test the pH influence on the adsorption process, 0.1 g of adsorbent was added to a 100 mL Erlenmeyer flask containing 50 mL of 0.03 mol/L KCl solution with P concentration of 50 mg/L and was thoroughly mixed. Following that adjusting the pH of dispersions at 3, 4, 5, 6, 7, 8, 9 and 10 by 0.1 mol/L KOH and HCl solutions was done. After being shaken for 2 h, the solution's pH of dispersions was determined using a pH meter (HANNA, pH 209) and the P concentration of the filtrates was measured. To test the ionic strength influence, 0.1 g of adsorbent was added to a 100 mL Erlenmeyer flask containing 50 mL of deionized water, 0.001, 0.01 and 0.1 mol/L KCl solution with P concentration of 50 mg/L at pH 4. After shaking for 2 h, the concentration of phosphate in the filtrate was measured. To test the adsorbent dosage influence, 0.05, 0.1, 0.15 and 0.2 g of adsorbent were added to a 100 mL Erlenmeyer flask containing 50 mL of 0.03 mol/L KCl solution with P concentration of 50 mg/L at pH 4. Phosphate concentration in the filtrate was determined after shaking for 2 h.
All adsorption experiments were conducted at three replicates. Data analysis (the two-sample t-test) was performed by SPSS, Version 21 software package (SPSS Inc., Chicago, IL, USA). Comparison between adsorbents and other parameters was performed by single and two-factor ANOVA and standard deviations were computed for all replicate samples. All kinetics and isothermal data were fitted using GraphPad Prizm (Version 6.07) software (GraphPad Software, Inc., La Jolla, CA, USA), and the determination coefficient (r^2) and standard error of estimate (SEE) values of the fitted equations were determined. The SEE for determination of the goodness of data fit to the models was calculated as follows (Hoseini et al. 2015):

$$SEE = [\frac{\sum(q_e - q_e^*)^2}{(n-2)}]^{0.5} \quad (7)$$

where n value is the number of measurements and q_e and q_e^* are the amount of P adsorption (mg/g) measured by experiment and predicted by models, respectively.

Results and discussion

Adsorption kinetics

The P adsorption kinetics on the Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar showed an initial fast adsorption, followed by a slow adsorption that reached equilibrium at 30, 60 and 30 min, respectively (Fig. 1). Similar results for P adsorption onto Mg/Al-LDH-biochar composite (Wan et al. 2017) and Mg/Al-LDH (Khitous et al. 2016) have already been reported. The adsorption rate of phosphate by Mg/Al-LDH-biochar was lower than Mg/Al-LDH and Mg/Al-LDH-hydrochar that may be related to heterogeneity of Mg/Al-LDH-biochar surface (Goh et al. 2010; He et al. 2010).

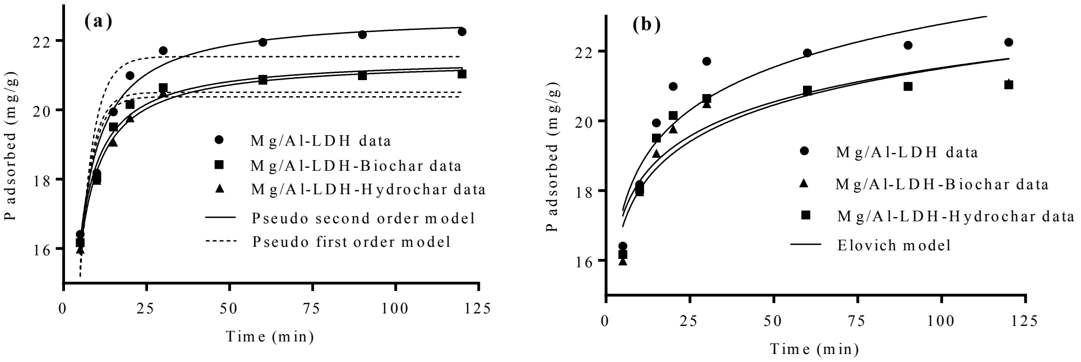

Fig. 1. Kinetics of phosphate adsorption on the Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar (P concentration=50 mg/L, pH=4, adsorbent dosage=2 g/L, I=0.03 mol/L KCl at 22 °C).

Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar removed more than 89%, 83%, and 84% of solution phosphate at the equilibrium time, respectively. However, the two sample t-test showed that there were no significant differences between P adsorption on the Mg/Al-LDH, Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar despite contact time. The adsorption rate of Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar composites was much higher than previously reported LDHs and engineered biochars and hydrochars (Yao et al. 2011; Zhang et al. 2014).

The kinetic parameters of P adsorption on the Mg/Al-LDH, Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar were shown in Table 1. The Elovich, pseudo-first- and pseudo-second-order kinetics models could duly account for the adsorption data, indicating the coexistence of multiple mechanisms in adsorption of P on Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar. However, higher r^2 and lower SEE of pseudo-second-order model in comparison with pseudo-first-order model indicated that phosphate adsorption process was predominantly controlled by chemical interactions (Zhang et al. 2013). In addition, the maximum adsorption capacities obtained from pseudo-second-order model are close to the experimental results (Table 1).

Table 1. The kinetic model parameters for phosphate adsorption simulation

Adsorbent	q_{max*} (mg/g)	Pseudo-first-order				Pseudo-second-order				Elovich			
		q_e (mg/g)	k_1 (1/min)	r^2	SEE	q_e (mg/g)	k_2 (g/mg min)	r^2	SEE	α (mg/mL min)	β (mL/mg)	r^2	SEE
Mg/Al-LDH	22.26	21.54	0.245	0.811	1.006	22.76	0.021	0.972	0.387	6337	0.561	0.849	0.899
Mg/Al-LDH-biochar	21.09	20.38	0.274	0.815	0.836	21.45	0.026	0.993	0.166	22452	0.661	0.871	0.698
Mg/Al-LDH-	21.04	20.51	0.279	0.847	0.737	21.51	0.028	0.981	0.259	55310	0.705	0.813	0.814

* The maximum P adsorption in 50 mg P/L solution

The k_1 and k_2 represent the P adsorption power of adsorbents. The k_2 values of Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar were 0.021, 0.026, and 0.028 g/mg min, respectively, which were found to be much higher than that of biochar (0.0005 g/mg min) (Yao et al. 2013). The k_1 values of Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar were 0.245, 0.274, and 0.279 1/min, respectively which were about hundred times greater than that of biochar (0.0026 1/min) (Yao et al. 2011). The α values of Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar were 6337, 22452, and 55310 mg/mL min, respectively, and the β values of the adsorbents were 0.561, 0.871, and 0.705 mL/mg, respectively (Table 1).
The relationship between $t^{1/2}$ and q_t was not linear within the whole adsorption time for all adsorbents (Fig. 2) suggesting that the intra-particle diffusion model was not capable of expressing the P adsorption kinetics within the whole adsorption time.

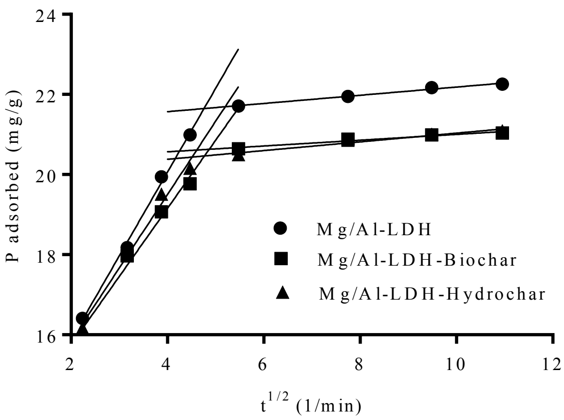

Figure 2. The plots of intra-particle diffusion model for the adsorption of P onto the Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar (P concentration = 50 mg/L, pH = 4, adsorbent dosage = 2 g/L, I = 0.03 mol/L KCl at 22 °C).

However, each data set could be divided into two phases with r^2 more than 0.94 (Table 2), indicating that the intra-particle diffusion occurs within the related adsorption period. Also, the intra-particle diffusion was not the only rate-limiting step because of every line not passing through the origin (Fig. 2).

Table 2. Constants and correlation coefficients of intra-particle diffusion model for phosphate adsorption on the Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar

Adsorbent	Phase 1				Phase 2			
	K_{dif} (mg/mL min$^{0.5}$)	C	r^2	SEE	K_{dif} (mg/mL min$^{0.5}$)	C	r^2	SEE
Mg/Al-LDH	2.091	11.7	0.996	0.148	0.102	21.2	0.987	0.034
Mg/Al-LDH-biochar	1.700	12.4	0.983	0.263	0.109	20.0	0.954	0.069
Mg/Al-LDH-hydrochar	1.831	12.2	0.988	0.240	0.072	20.28	0.945	0.051

Adsorption isotherms
The Langmuir and Freundlich isotherm models were used to fit the batch data of P adsorption on Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar and the results were summarized in Fig. 3. Also, the parameters of the fitted models were shown in Table 3. The phos-

phate adsorption by the adsorbents was described by the Langmuir model better than the Freundlich model. The maximum P adsorption capacities of the Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar calculated by the Langmuir model (*b*) were 61.3, 55.6, and 51.7 mg/g, respectively. However, the two sample t-test showed that there were no significant differences between P adsorption on the Mg/Al-LDH, Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar.

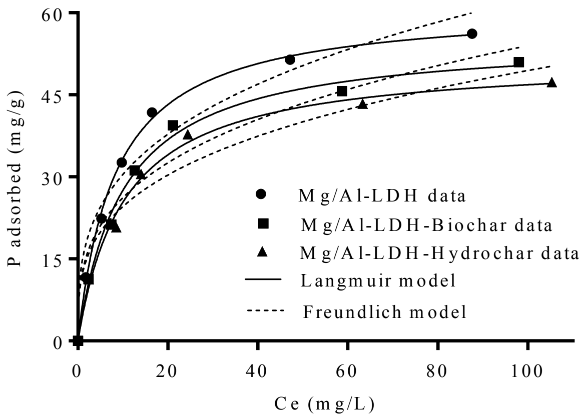

Fig. 3. Fitting Freundlich and Langmuir isotherm models to data of phosphate adsorption by Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar (pH = 4, adsorbent dosage = 2 g/L, I = 0.03 mol/L KCl at 22 ^{o}C).

The present study showed that the phosphate adsorption capacities of biochar and hydrochar were 0.45 and 0.16 mg/g in initial P concentration of 50 mg/L while those of Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar were 22.38, 21.30, and 20.75 mg/g, respectively. So, the phosphate adsorption capacities of biochar and hydrochar were negligible as compared with Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar composites. In addition, compared with the previous reports for different adsorbents (Das et al. 2006; Yan et al. 2015; Li et al. 2016), Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar showed greater phosphate adsorption capacity. Therefore, functionalizing of biochar and hydrochar surfaces with Mg/Al-LDH particles dramatically enhanced the P adsorption capacities of biochar and hydrochar. In addition, means comparison by t-test showed that the P removal efficiency of Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar were similar to that of Mg/Al-LDH. The high adsorption capacity of Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar suggests the spent composites have potential application as P-fertilizers.

Table 3. Freundlich and Langmuir model parameters calculated for phosphate adsorption

Adsorbent	Freundlich				Langmuir			
	K_f (mg$^{(1-n)}$ L^n/g)	1/n	r^2	SEE	b (mg/g)	K_L (L/mg)	r^2	SEE
Mg/Al-LDH	14.82	0.313	0.959	4.582	61.3	0.119	0.998	0.982
Mg/Al-LDH-biochar	12.71	0.314	0.957	4.253	55.6	0.098	0.994	1.578
Mg/Al-LDH-hydrochar	12.22	0.304	0.956	4.0	51.71	0.096	0.993	1.581

The K_L values of Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar were 0.119, 0.098, 0.096 L/mg, respectively (Table 3). This parameter pertains to the adsorption strength and the higher K_L value shows the higher adsorption ability of adsorbent in low P concentrations (Tran et al. 2017). The *n* value in the Freundlich isothermal model denotes the heterogeneity of the site energies and according to the Freundlich theory, the adsorption isotherm becomes linear when n = 1, favorable when n < 1, and unfavorable when n > 1 (Tran et al. 2017). The *n* values of the Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar were obtained as 3.19, 3.18 and 3.29, respectively. The K_F values of Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar were 14.82, 12.71, and 12.22 $mg^{(1-n)}$ L^n/g, respectively. The high values of K_F indicate high adsorption capacity (Hosni and Srasra, 2010). Approximately the same values of r^2 for two models confirmed that the adsorption of phosphate on the Mg/Al-LDH, Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar was controlled by multiple processes (Table 3). The similar results were also reported by the previous researchers (Li et al. 2016; Khitous et al. 2016).

Effect of pH

The adsorption of phosphate on the Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar was significantly affected by pH and the adsorbed phosphate decreased with increasing pH from 3 to 10 (Fig. 4). The ideal pH for Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar was 4.0. Krishnan and Haridas (2008) reported that the optimum pH to reach the maximum adsorption of phosphate by coir pith was 3.0. They explained that different pH values may change relatively dominant phosphate species in solution and anions tendency onto the adsorbent sites.

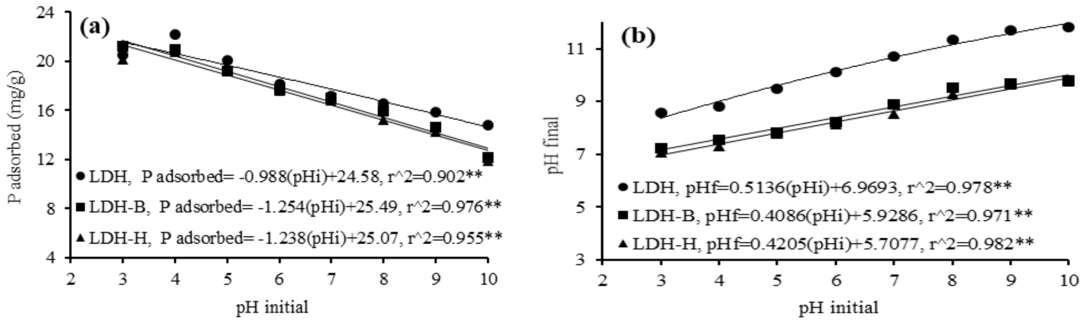

Fig. 4. Negative correlation of phosphate adsorption with solution pH (a) and the effect of initial solution pH on the equilibrium (final) solution pH (b) (P concentration = 50 mg/L, adsorbent dosage = 2 g/L, I = 0.03 mol/L KCl at 22 °C).

In general, the HPO_4^{2-} and $H_2PO_4^-$ are the dominant P species in the pH range of 3–10, but the concentration of $H_2PO_4^-$ decreases with increasing solution pH. The $H_2PO_4^-$ is more easily adsorbed on the adsorbent surface because of a lower adsorption free energy than HPO_4^{2-} (Krishnan and Haridas, 2008). In addition, the competitions between phosphate species and OH^- ions at higher pH values would also reduce the adsorption of phosphate by the adsorbent (Li et al. 2016). The initial solution pH had slightly more effect on the Mg/Al-LDH-biochar and hydrochar than Mg/Al-LDH because of slightly more slope of their regression lines (Fig. 4a). This may be due to the slightly more pH buffering capacity of Mg/Al-LDH-biochar and hydrochar (Fig. 4b). However, means comparison by t-test for paired samples revealed that no significant differences were observed between P adsorption on the Mg/Al-LDH, Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar regardless pH levels.

Linear regression models were significantly fitted (r>0.90**) to P adsorption (mg/g) and final solution pH (pH_f) in different initial solution pH levels (Fig. 4a and b). These relationships can be used to forecast the P loading on the adsorbents and final solution pH in different pH values. It was found that for Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar the equilibrium pH (final pH) was generally higher than the initial pH (Fig. 4b). Higher equilibrium pH than initial pH concerns the release of the adsorbent hydroxyl groups into the solution (Khitous et al. 2016). Thus, the increase in pH after adsorption of phosphate may indicate that the adsorption of phosphate on the Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar may be mainly controlled by chemical interactions.

Effect of ionic strength

The adsorption of phosphate on Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar depended on ionic strength (Fig. 5). This may explain the reason why electrostatic mechanisms such as ion exchange play a significant role in the phosphate adsorption on Mg/Al-LDH, Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar (Goh et al. 2010).

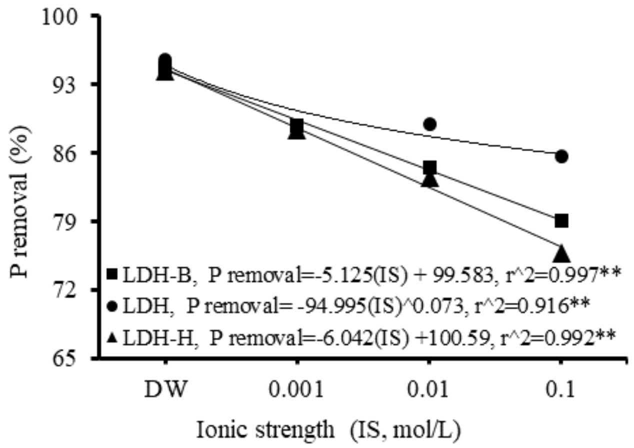

Fig. 5. Phosphate removal by Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar under different concentrations of potassium chloride (P concentration = 50 mg/L, pH = 4, adsorbent dosage = 2 g/L at 22 °C).

Increasing ionic strength leads to a decrease in activity coefficient of phosphate ions, and eventually P adsorption (Zhao et al. 2008). However, the phosphate removal percentage with Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar at 0.1 M KCl was considerable (86%, 79%, and 76%, respectively). This confirms the higher binding affinity of phosphate ions over chloride ions for active sites. Similar results have been reported by previous studies (Goh et al. 2010; Hosni and Srasra, 2010). Also, the less important effect of ionic strength on P adsorption by Mg/Al-LDH compared to that by Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar could explain that the role of electrostatic mechanisms on P adsorption by Mg/Al-LDH was less important than by Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar. Means comparison by t-test revealed that there were no significant differences between P removal efficiency of the Mg/Al-LDH, Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar despite ionic strength. Phosphate removal efficiency by Mg/Al-LDH, Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar at different levels of ionic strength could be predicted by regression equations presented in Fig. 5.

Effect of adsorbent dosage

Phosphate removal rate (%) increased but the phosphate removal amount (mg/g) decreased with increasing adsorbent dosage (Fig. 6). All adsorbents that were examined removed more than about 97% of solution phosphate at an adsorbent dosage of 4 g/L (Fig. 6a), which was the optimum solid-to-solution ratio for adsorption of phosphate. Similar results have been reported by previous researchers (Xue et al. 2016; Yan et al. 2015). Increasing phosphate removal with increasing solid-to-solution ratio is related to increasing active adsorption sites. Also, decreasing P removal with increasing solid-to-solution ratio is because of the fact that some adsorption sites remained unsaturated in high adsorbent levels (Xue et al. 2016).

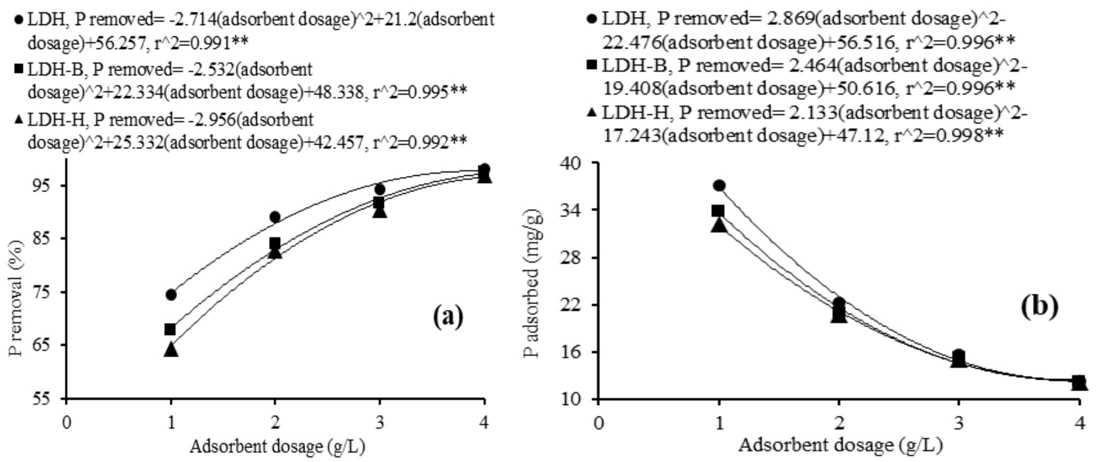

Figure 6. Effect of Mg/Al-LDH, Mg/Al-LDH-biochar, and Mg/Al-LDH-hydrochar dosage on removal (a), and P adsorption (b) (P concentration = 50 mg/L, pH = 4, I = 0.03 mol/L KCl at 22 °C).

The means comparison by t-test showed that there were no significant differences between P removal efficiency of the Mg/Al-LDH, Mg/Al-LDH-biochar and Mg/Al-LDH-hydrochar despite adsorbent dosage. In addition, the exponential and polynomial equations were well fitted (r^2>0.99**) to the data (Fig. 6a and b). So, these models can be used to predict the P removal efficiency and P adsorption at different adsorbent dosages and to achieve a given loading of phosphate by adsorbent in purification of wastewaters (Wan et al. 2017).

Acknowledgments

This paper is published as a part of a Ph.D. dissertation supported by the Vice Chancellor for Research and Technology of University of Tabriz, Iran. Authors are thankful to the University of Tabriz for their supports.

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Soil penetration resistance in cultivated different type soils

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Abstract

Penetration resistance (PR) indicates soil compaction and it is essential for soil workability in sustainable agricultural management. The objective of this study was to determine the soil compaction and its spatial variability on different soil orders under dry farming cultivation conditions located in 396.4 ha area of Kavak- Samsun, Turkey. A total number of 120 soil samples and PR readings were taken by grid system from the study area. Penetration resistance was measured at 5 cm depth intervals between 0 and 40 cm soil depth, and gravimetric water content, field capacity and soil texture were also determined for 0–20 cm and 20–40 cm soil depths. Some interpolation models and GIS techniques were used in order to generate spatial distribution maps for PR. Penetration resistance values in some parts of the area were higher than the critical value of 2 MPa for root growth limitation, the mean PR values at all depths were considerably lower than the critical value despite a relative increase in PR with soil depth. The areas with values greater than 3.0 MPa, except for 0–5 cm, were generally located in the fields with high sand content, and compacted or formed hard pan especially in Entisol and Vertisol orders. In contrast, for 0–5 cm, the areas with PR greater than 3.0 MPa, were usually located in the northeast of the study area and had high clay content.

Key words: Penetration, interpolation models, soil orders, cultivation.

Introduction

Intensive agricultural practices have significant effects on soil degradation through loss of soil organic matter, decline of soil structure, resulting soil compaction and root growth (Usowics and Lipiec, 2009; Busscher and Bauer, 2003). One of the main goals of soil tillage is to prepare suitable medium for seed germination or root growth. On the other hand, from soil preparation to harvest, intensive field traffic can harm soil structure by compaction which is a major problem for agricultural lands (Selvi et al., 2017). Dexter (2004) reported that a measure of soil microstructure can be an index of soil physical quality that is consistent with observation on soil compaction, on effects of soil organic matter content and on root growth. Soil compaction, occurs usually loss or reduced in size of the largest pores, increases soil bulk density and soil strength, and decreases macro porosity, soil water infiltration and water holding capacity (Dexter, 2004). Soil compaction also affects root penetration and consequently crop production (Hakansson et al. 1988). Particularly, Ungureanu (et al., 2015) indicated that artificial compaction of agricultural soil includes in the rising of soil bulk density, respectively in the decrease of soil porosity, especially due to the contact with the tires or tracks of tractors and agricultural machinery.

Penetration resistance is an empirical, easy and cheap measurement technique of soil strength, and widely used to assess soil compaction and the effects of soil management (O'Sullivan et al., 1987; Castrignanö et al., 2002). Numerous studies indicated that soil compaction depends on several factors such as; compressing loads of heavy machinery, type of parent materials, soil texture, moisture content, organic matter content, structural stability, sodicity and salinity (Soane, 1990; Baumgart and Horn, 1991; Barzegar et al., 1996; Hamza and Anderson, 2005). Critical penetration resistance for successful root development in soil is about 1.7 MPa or 2.0 MPa (Canarache, 1990; Arshad et al., 1996). Gülser et al., (2016) reported that PNT values had the significant positive correlations with clay content (0.367**) and BD (0.366**), and significant negative correlations with AWC (-0.351*) and gravimetric water content (-0.408**). In addition, Veronese-Junior et al. (2006) similarly reported that PNT values increased with decreasing soil moisture content. Utset and Cid (2001) also determined that the PNT on a Rhodic Ferralsol over a 30 m x 30 m area after irrigation practices was considerably affected by the soil moisture condition, bulk density and micro topography. Gülser and Candemir (2012) reported that the results indicated that total porosity (F) was one of the most important soil properties that affected penetration resistance (PR) directly in the clay textured soil. Indirect effects of the other soil properties on PR were also mediated by F. The different organic wastes had different effects on PR of clay soil due to changing soil structure with increasing MWD and F. It can be concluded that all organic waste application had positive effects on improving soil properties; the same application rates of different organic wastes had different effects on the PR values with changing the structure of clay soil. The objective of this research was to determine the spatial variability of soil compaction and provide suggestions for improved management on different soil orders which have been used for a long period for agricultural activities under conventional soil tillage methods.

Materials and Methods

This study was carried out on the fields of four villages (İdrisli, Muhsinli, Çayırlı and Beyköy) of Kavak district in Samsun province located in the central Black Sea Region of Turkey. The study area is about 50 km far from Samsun. The elevation of the study area is between 600 m and 825 m from sea level and it covers approximately 397 ha (Figure 1).

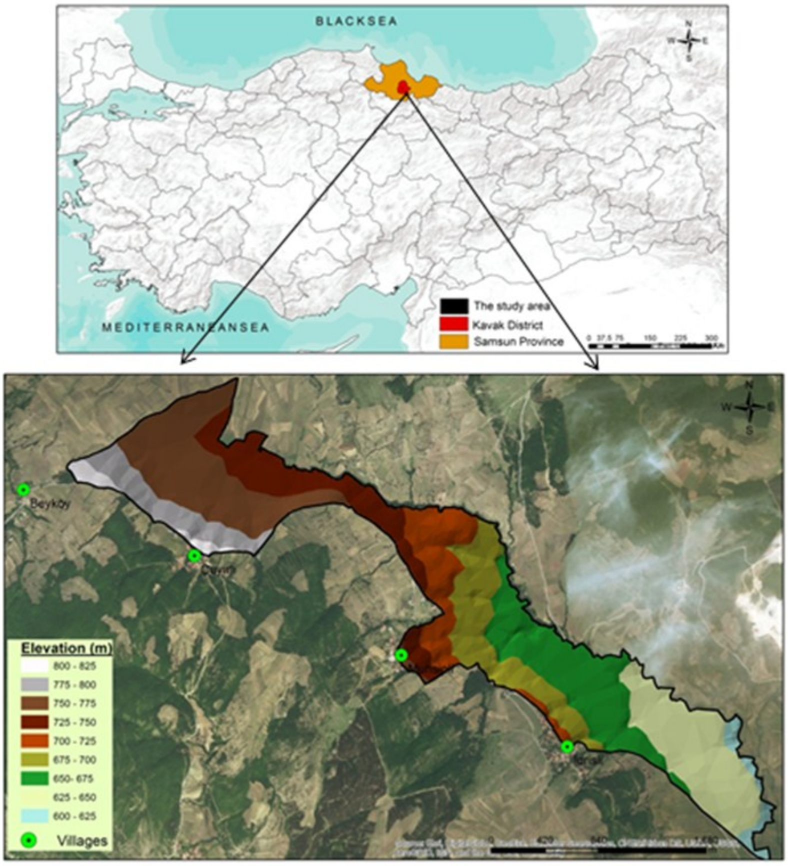

Figure 1. Location of the study area

According to Thornthwaite (1948), the climate in the region is semi-arid. The average temperatures in August and January are 19.4°C and 0.9°C, respectively. The mean annual temperature, rainfall and evaporation values are 10.2°C, 512.53 mm and 641.5 mm, respectively. In addition, according to Soil Survey Staff (1999), the study site has a mesic soil temperature regime and xeric moisture regime. The research areas have been cultivated for rainfed agriculture particularly cereals such as wheat and barley for more than 50 years.
The majority of soils were classified as Vertisol, Inceptisol and Entisol (Soil Survey Staff, 1999). There were seven different soil series on digital soil map performed in detail and scaled 1:25.000. Three of them were classified as Entisol due to their young age, other two were classified as Inceptisol and the last one was classified as Vertisol. According to soil map, Yenikışla soil series covers the largest area (25.47%) whereas Aşağıyazı soil series covers the smallest area in the study area (8.30%) (Figure 2).

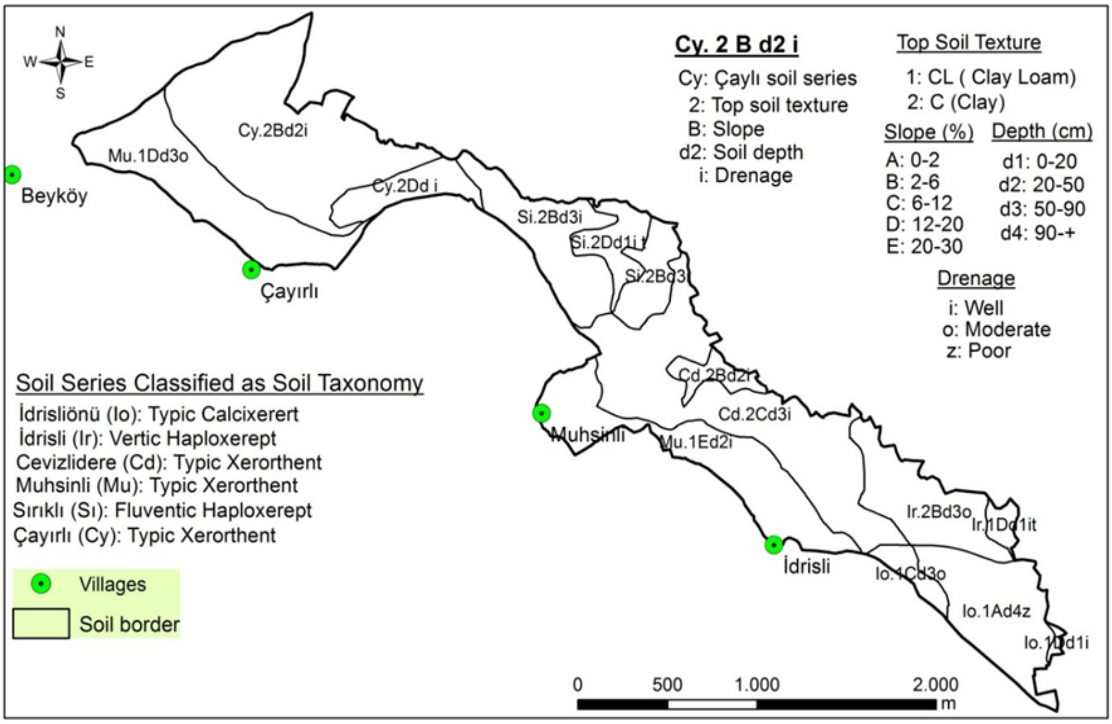

Figure 2. Soil map of the study area

The study area was divided into 250 m × 250 m grid squares. In total, 119 grid points were established. Soil samples were taken from these points in July, 2017. The disturbed soil samples of roughly 2 kg were taken from both the surface (0–20 cm) and subsurface (20–40 cm) soil depth at the center of each grid (Figure 3). The soil texture and gravimetric water content of soil samples were determined using methods described by Gee and Bauder (1986), and Blake and Hartge (1986) respectively.
Penetration resistance (PR) in 0-5 cm, 5-10 cm, 10-15 cm, 10-20 cm and 20-25 cm depths were measured in field with three replications by using a standard cone penetrometer which had a cone with a semi-angle of 30º, a base area of 2 cm2 (Bradford, 1986). The measurements were made by pushing the penetrometer vertically into the soil at an approximate speed of 2 cm s–1 (Eijkelkamp 1990).

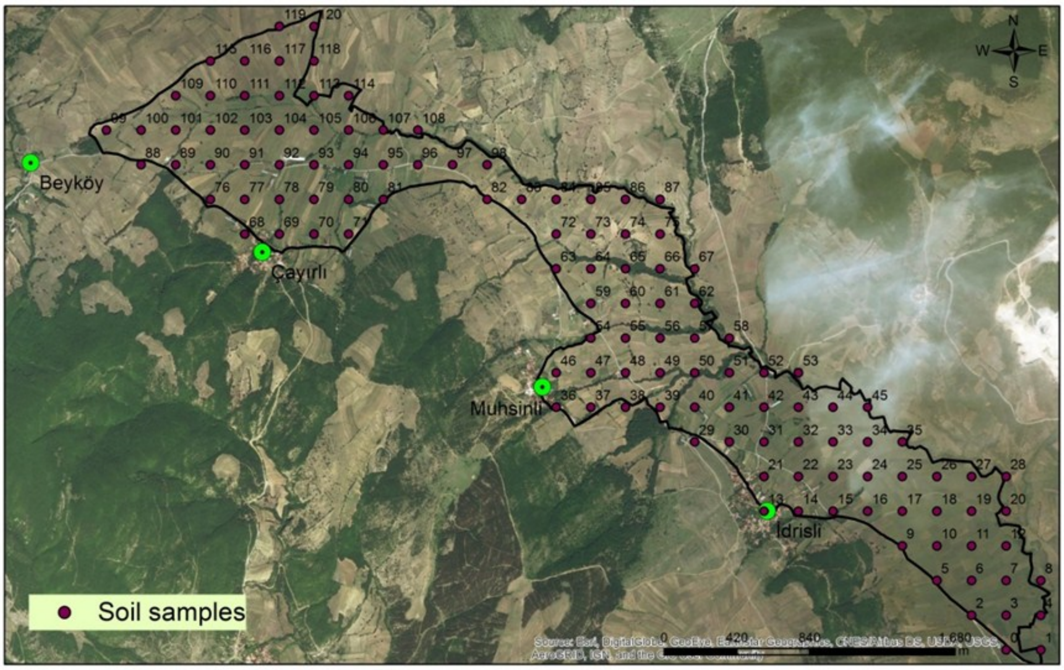

Figure 3. Soil sampling design in the study area

The data obtained for each depth increment was recorded for calculations of PR (PR5, PR10, PR15, PR20, PR25, for each depth between 0 and 25 cm). The equation used for calculation of PR was given as below;

$$PR = F/A*0.0981$$

Where; PR is the penetration resistance (MPa), F is the force (kgF), A is the base area of cone (cm2) (Korucu 2002).
In this study, different interpolation models (Inverse Distance Weighing-IDW, Radial Basis Function-RBF and Kriging) were applied for creating the spatial distribution of each depth of soil depth. Kriging is a geostatistical technique similar to IDW in that it uses a linear combination of weights at known points to estimate the value at an unknown point.
Kriging uses a semivariogram, measure of spatial correlation between two points so that weights change according to the spatial arrangement of the samples. In contrast to other estimation procedures, Kriging provides a measure of the error or uncertainty of the estimated surface. Several types of Kriging interpolation exist such as Ordinary Kriging, Simple Kriging (SK), and Universal Kriging.
In the current study, root mean square error (RMSE) was used to assess the interpolation techniques. The lowest RMSE refers the highest accurate prediction. Estimates were determined using the following formula:

$$RMSE = \sqrt{\frac{\sum (z_{i^*} - z_i)^2}{n}}$$

Where; Zi is the predicted value, Zi* is the observed value, and n is the number of observations.

Results and Discussion

Slope is an important factor influencing soil tillage, overland flow generation causing soil erosion which only occurs when slope exceeds a critical angle and it increases with the absence of vegetation cover. In this study, the slope map was formed by digitization of 1/25.000 scale topographic map within GIS software and categorized into six sub-slope groups. These slope groups are presented in Figure 4. It can be seen that 41% of the study area has less than 15 % slope (very gentle and gentle) and 21.6% has more than 15% slope, varying from steep to very steep, from which runoff can easily occur. In addition to that, most of the study area has east and north east aspect.

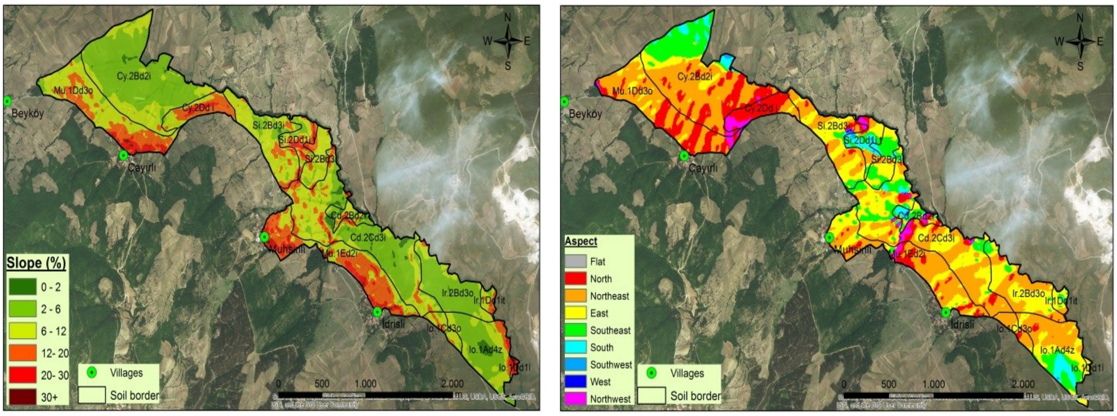

Figure 4. Slope and aspect maps of the study area

Interpolation analysis of PR values for each soil depth was performed to identify the best suitable predictive model from nine different semivariogram models (IDW with the weights of 1, 2, and 3, RBF with thin plate spline (TPS), and Krigings with Spherical, Exponential and Gaussian variograms). All the interpolation techniques were tested and the variogram or function of each model was compared to identify the one yielding the best suitable result in terms of penetration soil depths (Table 1). Finally, semivariograms of spherical model in the Simple Kriging was used to estimate or predict for PR_5, PR_{10}, PR_{15} and PR_{20}, except PR_{25}. The spherical model of Ordinary Kriging was used for PR_{25}.

Table 1. Cross validation according to interpolation methods

Depth (cm)	Enterpolation Models														
	IDW			RBF			Kriging								
							Ordinary			Simple			Universal		
	1	2	3	TPS	CRS	SWT	Gau.	Exp.	Sph.	Gau.	Exp.	Sph.	Gau.	Exp.	Sph.
0-5	0,771	0,765	0,766	0,945	0,777	0,768	0,774	0,774	0,773	0,757	0,757	**0,755**	0,774	0,774	0,773
5-10	0,954	0,944	0,949	1,217	0,965	0,948	0,934	0,942	0,937	0,933	0,946	**0,928**	0,934	0,942	0,937
10-15	0,922	0,904	0,901	1,086	0,909	0,901	0,896	0,901	0,897	0,892	0,889	**0,885**	0,896	0,901	0,897
15-20	0,924	0,904	0,898	1,013	0,892	0,890	0,887	0,889	0,889	0,884	0,891	**0,881**	0,887	0,889	0,889
20-25	0,674	0,661	0,659	0,777	0,658	0,657	0,653	0,658	**0,650**	0,669	0,670	0,660	0,653	0,658	0,651

Grossman et al. (2001) indicated that penetration resistance had a limited effect on plant growth, and Carter (2006) reported that root development was limited when penetration resistance was over 2 MPa. In the study area, the spatial distribution maps for PR values prepared using the semivariograms parameters combined with digital soil map are presented in Figures 5. These maps of PR values for each soil depth showed significant differences and their distribution ratio and area were given in Table 2.

Table 2. Spatial distribution ratio and covered area of penetration resistance (PR) values

PR (MPa)	Area (da)	Ratio (%)	PR (MPa)	Area (da)	Ratio (%)
PR_5			PR_{20}		
0.0-1.5	1030,9	25,9	0-2.0	0,2	0,0
1.5-2.0	2444,5	61,5	2.0-3.0	438,0	11,0
2.0-3.0	497,5	12,5	3.0-4.0	2444,4	61,5
PR_{10}			4.0-5.0	1090,3	27,4
0.0-1.5	111,7	2,8	PR_{25}		
1.5-2.0	1581,4	39,8	0-2.0	0,2	0,0
2.0-3.0	2061,1	51,9	2.0-3.0	9,2	0,2
3.0-5.0	218,8	5,5	3.0-4.0	94,8	2,4
PR_{15}			4.0-5.0	3868,8	97,4
0-2.0	186,9	4,7	Total	3972,9	100,0
2.0-3.0	2804,6	70,6			
3.0-4.0	912,7	23,0			
4.0-5.0	68,6	1,7			

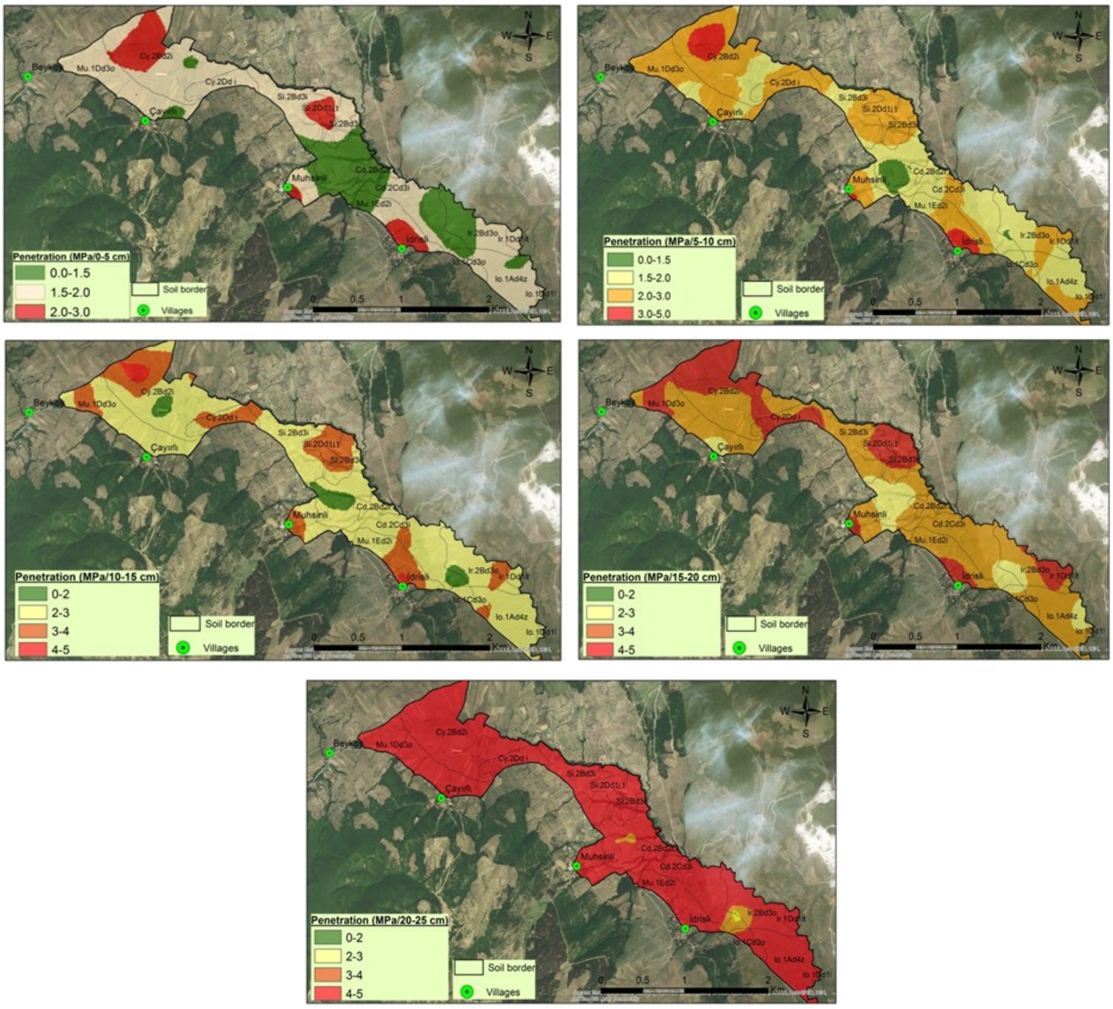

Figure 5. Spatial distribution of soil penetration resistance for each depth

According to the results of this study, only 12.5% of the total study area's soils was under potential risk in 5 cm depth due to more than 2 MPa PR located on some part of Çayrılı and Sırıklı soil series classified as Typic Xeroorthent and Fluventic Haploxerept and coded as Cy.2Bd2i and Si.2Dd1it. In fact, the PR_5 value of the most of the study area was considerably lower than the critical value for limiting root growth, despite the fact that they increased relatively with soil depth and exceeded the limiting value for compaction in the subsurface soil.
PR values greater than 3 MPa are generally considered to limit soil aeration and root growth, depending upon soil matric water tension (Hakansson and Lipiec, 2000), whereas the soils with PR values higher than 1.5 MPa are generally accepted by taking into consideration a compaction problem (Özgöz 2009). In 10 cm depth PR values of the study area' soils, almost half of the study area has lower critical PR value and 2061.1 ha was found between 2.0-3.0 MPa whereas, land mapping units called as Cy.2Bd2i and small part of Mu.1Ed2i were determined the highest PR values. As for PR_{15} distribution in the study area, it was determined almost at the same pattern with PR_{10}. As the reason of this case particularly for Cy.2Bd2i and Si.2Dd1it, it can be said the soils of those land mapping units with PR values higher than 3.0 MPa were located in the areas with high sand and gravel content and shallow soil thickness. In addition, some parts of Idrisli and İdrisliönü soil series classified as vertisol have also over critical value of PR due to high clay content. Therefore, because the soils with high clay content have high potential for compaction, farmers need to be very careful about the timing and soil tillage method. Finally, after 20 cm soil depth, PR_{20} and PR_{25} values exceeded the limiting value for compaction in the subsurface soil (in plow layer) in the almost all study area (more than 95%). For that reason, after 20 cm soil depth in where formed on hard pan should be broken with mechanical application and other field management practices that could prevent compaction in these locations.

Conclusion

In this study, the spatial variability of soil compaction were investigated in the rainfed agricultural fields cultivated with the conventional soil tillage methods for several years. Penetration resistance values for 5, 10, 15and 20 cm soil depths were predicted using the Spherical model of Simple Kriging, while PR values for 25 cm depth were predicted using the Spherical model of Ordinary Kriging.
The PR results showed that all PR values through 10 to 25 cm soil depth, except 0-5 cm depth, were generally higher than the critical value of 2 MPa which limits optimum plant root growth in plant production at agricultural fields. The PR values in 5 cm soil depth was lower than critical value of 2 MPa in 87.5% of the study area. It indicates that conventional tillage used in the study area more than several years caused soil compaction. Agricultural areas with PR values greater than 3.0 MPa were generally located in the fields with high clay content, and compacted or formed hard pan especially in Entisol and Vertisol orders. As a suggestion, the hard pan formed after 20 cm soil depth in the study area should be broken with using deep soil tillage methods and other mechanical field management practices to prevent soil compaction and to improve plant production and quality in sustainable agricultural management. The farmers living in this locations need to be very careful about the timing and method of soil tillage since the soils with high clay content have high potential for compaction.

Acknowledgement

The authors gratefully acknowledge the scientific research of grant Ondokuz Mayis University (BAP: PYO.ZRT.1901.18.001).

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Regulation of agrophysical condition of irrigated soils of Uzbekistan

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Abstract

On irrigating takir, meadow and grey earth-meadow soil, by application of new technology of preparation of grounds to crop cotton on ridges and crests between rows 90 cm. were created and the optimum density of addition were supported. And also favorable water, air, thermal, nutritious modes and biological activity soil, promoting to increase of productivity cotton on 3-6 s/ga.
Is established, that mulching new irrigated of grey earth-meadow ground at come way of showing by a transparent polyethylene film, with dung, with lignin optimum density of addition (l,25-1,40 g/sm). General on regularity (47-50%), waterproof of units, improving structural - modular structure, inserting on 2-9%, waterproofing in l,5-2 times, increasing the sum of active temperatures from 133 up to 316 C. Liquidates deficiency of heat ground and soil scab, reduces physical evaporation, stimulates intensive growth and development and, thus, provides maximal use of a soil moisture and nutritious elements. Creation of optimum water-physical, temperature and nutritious modes soil of crests at mulching improve ecological conditions at the expense of reduction negative influence organic and industrial wastes on an environment. Roved intensive growth, development, maturing and increase of productivity with high technological qualities of a fiber cotton at use a film - on 8,2 s/ga, dung - 5,1 s/ga, lignin - on 5,2 s/ga.
Key words: soil, agro physical, mulching, irrigated, growth, structural, cotton, agricultural, technology, water-physical, biological, air properties, temperature, ecological, cultivation, melioration.

Introduction

Favorable agro physical properties of soils were one of major conditions of display of soil fertility, reception high and stable of crops of agricultural cultures. These properties appreciably define (determine) a choice of technology of processing's, receptions melioration and chemicalition. In this connection use soils in modern agriculture is necessary to carry out in view of regional features them of agro physical properties. Intensification of agriculture owes accompanied by measures warning agro physical degradation at processing's, melioration influences, etc.
Value of agro physical's properties of soils, problem of their regulation and optimization now get the special urgency. The modern technologies of cultivation of agricultural cultures are accompanied by many negative consequences, one of which degradation of agro physical's properties is especial on irrigated soils. Influence operational of systems of agricultural engineering and irrigation without scientifically proven agro technician conduct to significant decrease (reduction) of their fertility and productivity agricultural of cultures.
Besides agro physical the status soils Enders essential influence on an orientation both speed of processes of transformation and carry of substances, availability of elements of a feed (meal), i.e. actively form agro ecological a situation.
Now, it was known, that one of perspective receptions of increase of fertility and regulation of density, water-physical, biological, air properties, nutritious and temperature mode irrigated soils both increase of a crop cotton and other agricultural cultures is the creation powerful plough-land of a layer by deep pouching up to 40 sm and more and also sowing cotton-crops on ridges and crests and mulching of ground (Keshkarov, 1969; Kondratyuk, 1972; Muhamedjanov, 1978; Umarov etc. 1974, 1979, 1987; Rijov etc. 1980; Turapov, 1994; Suleymanov, 1993; Sapojnikov, 1994; Halikulov, 1996 and etc.

Materials and Methods

In condition intensification of anthropogenous influence on ground we studied of water-physical properties, their changes at various densities and have developed receptions of optimization with the purposes of increase of fertility irrigated of grounds.

For a bookmark field and know-how the key sites on new irrigated tardier soils of territory of and Mirishkar of areas of the Kashkadariy area, namely, in facilities (economy) Kasbiy and Mirishkor were chosen.

On old irrigated meadow alluvial soils of a facilities (economy) by him (it). And I. Naimov Babkent of area of Bukhara area was incorporated field and know-how. The field experiences on mulching and sowing cottons on crests were carried out (spent) on new irrigated sierozem-meadow soils a facilities (economy) by him and Navai Bayaut area of Syr-Darya area. Repeated four-multiple, cotton plant of grades: 108-F, Tashkent- 1 and AN-Bayaut-2. In field conditions crop carried out (spent) rows by a way: accommodation of plant 90:20xl,2. As nitric fertilizers brought in ammoniac saltpeter, urine, nitrophoska; potassium-potassium chloride and also applied manure of large horned cattle, artificial structural forvftion (K-9), industrial wastes (ammonium lignin) and transparent polietilen film. Experiences accompanied phonological by supervision for shoots, growth, development, dynamics (changes) budding, flowering and maturing cotton-plants. Tacked into consideration dry weight of stalks and roots, crop of a cotton-plants, and also contamination of ground. Phonological of supervision was carried out (spent) of the technique UzSSIC (1973). The field experiences pawned in the autumn and spring on a technique UzSSIC and GavSSISA, according to which the preparation of ground for crop is carried out since autumn under autumn polishing, the fields are leveled, then cutting of a ridge and crests. As the instrument for cutting of ridges and crests we used the heap of cultivator CCP-3,6 (with between rows 90sm), modified by us (With № 31535561). The field experiences on mulching various mulch material at combing a way of sowing, where beet win rows of cotton plants in 90sm, used a film of width 45sm and thickness 100 microns. At mulching of crests manure, lignin and K-9 covered each number (line) of crops. The ground under mulch during vegetation was not processed. Having watered, top-dressing of crops and beet win rows processing were made on bottom of futons.

Except for the special measures, offered by us, on optimization of properties soils, on skilled sites was applied usual agro technician, accepted in facilities (economy). The field experiences were carried out on variants:

l. Polishing-land + hand-made article of the checks + alignment arable + sow having watered (washing) + sow processing (harrowing + chiseling with malovation + repeated harrowing with malovation) + crop cotton plant with between row 90sm (control).

2. Polishing-land + alignment arable + hand-made article of ridges + sow having watered + crop with between row 90 sm.

3. Polishing-land + alignment arable + hand-made article of crests + sow having watered + crop with between row 90 sm.

For study mulching by various materials on properties of ground, growth, development and productivity of plants tested next variants:

l. Smooth field + background - (control).
2. Crests + background - (control).
3.Crests + background + To - 9- 18 kg/ga (with crop).
4.Crests + the background + HaB03 - 6 t/ga (was brought in the autumn).
5.Crests + background + mulching with manus- 6 t/ga (with crop).
6.Crests + the background + lignin- 6 t/ga (was brought in in the autumn).
7.Crests + background + mulching with lignin 6 t/ga (with crop).
8.Crests + background + mulching (with crop).

Results and Discussion

The various ways of preparation of grounds to crop on any other business rendered influence on density of ground. Most condensation of ground is marked, when cotton plant sowing on a smooth field, after pouring. In this variant hardness remained rather high in a layer 20-50sm up to I,47-1,52g/sm^3 and by the end vegetation there was some reconsolidating up to 1,34-1,52g/sm^3 . On ridges and crests after crop cotton-plant density plaything of horizon in comparison with an initial status has increased a little. However, both after crop, and in the subsequent periods vegetation cotton plant in all soil types did not exceed optimum sizes, making 1,10-1,35g/sm^3 . By the end vegetation density was a little increased, but was in limit optimal of sizes (l,12-1,36g/sm^3).
Quantity (amount) of the most valuable units (10-0,25 mm) after play on a smooth field made 44-46% on ridges and crests – 48%. During vegetation of cotton-plants on all soil differences on ridges and crests more favorable soil conditions for dividing of a layer were created, than on a smooth field. In the end of vegetation when the humidity of ground was reduced till 6-10%, quantity agronomic of valuable units on ridges and crests made 43-50%, and on the control - 39%. On researched soils the size of factor depends on receptions of processing. Before crop on a smooth field the processing was carried out (spent) intensive before-sowing, therefore some destruction of units and increase dispersion of ground was observed. In plough a layer is marked large puréeing of units (29-33%), than at a usual way of processing of ground 27-32%. Because of absence of strong structure on a smooth field has taken place formations (education) powerful soil crusts, which thickness reached (achieved) 1 1,5 mm its (her) least size is marked on crests of -6,4 mm. And that's way; on ridges and crests at the expense of optimization of physical properties of ground the favorable conditions of water modes are created.
In year of realization of field experiences irrigation the norm cotton-plant on all types' soils and variants was various. The account of water has shown, that it's (her) charge for vegetation of cotton-plant on a smooth field was more, than on ridges and crests. In the period vegetation on all soils under ridges and combing more favorable mode of humidity both after irrigation and between them was created. In near rots layer (0-70 and 0-100sm) the humidity did not fall below than 60%. In control variant, in a layer 0-70sm, the humidity has decreased up to 40 %. On ridges and crests, due to preservation of optimum density of ground both more friable arrangement of lumps and units, more economic charge of water and high mode of humidity was observed, than on a smooth field.
The ground under ridges and crests during cotton-plants vegetation had higher waterproof, than on a smooth field. The changes during vegetation on all soils and variants, basically, correlate with density and common poring of plough of a layer. At crop cotton-plant on crests the restoration of salts in a soil structure occurs more slowly, than on a smooth field.
Thus, under ridges and crests, in comparison with a smooth field are created and are kept during the most part vegetation more favorable conditions not only on density, portion and on water properties of ground.
The crop cotton-plants ridges and crests promoted more rational use of nutritious elements in soils to plants that has rendered positive influence on development and harvest of cotton-plants. Due to this earliest and amicable shoots cotton-plants were is marked. On a smooth field the extent of the main root is strongly reduced, of lateral branches is significant smaller.
The data on a crop at a spring bookmark on new irrigated takir soils shown about significant advantage of crop cotton-plants on ridges and crests: it was, accordingly 6,1 and 7,0s/ga and on 6,6 and 8,3s/ga is higher, than in the control. The common crop of row-cotton on old irrigated meadow has made on a smooth field (control) 35,8s/ga. On ridges and crests (spring bookmark) the crop has made 41,6 and 40,0s/ga and 39,7 and 38,8s/ga. At an autumn book-

mark on ridges and crests the crop in 39,5 and 38,6s/ga against 33,5s/ga on the control was assembled. Expertness on new irrigated-meadow to ground has confirmed this law. The crop of a row-cotton on ridges and crests in comparison with the control was on 2,8-3,2s/ga above (table l).

Table l. Growth, development and crop cotton-plants depending on the technologists' of preparation of ground to crop (average)

Variant	Height of the main stalk, sm			Quantity of sim-podiy	Quantity (amount)of boxes, th.		A crop of a row-cotton, s/ga	An in-crease, s/ga
	1,06	1 07	1 08		1,08	having ripened		
Spring bookmark								
New irrigated taker ground								
Control	21,6	44,2	67,2	14,4	11,3		37,4	0
Ridges	22,2	48,2	72,0	14,2	12,8		43,5	6,1
Crests	25,1	47,1	72,8	15.8	13,0		43,9	6,5
t-8,3% - 95 - 4,4s/ga								
Old irrigated meadow ground								
Control	15,3	29,8	60,7	11,3	8,7	2,6	34,7	0
Ridges	15,2	32,3	65,4	12,7	11,3	4,6	40,7	6,0
Crests	15,7	32,7	62,9	12,2	10,8	4,5	39,4	4,8
t- 5.4% -95 - 7.9s/ga								
New irrigated sierozem to meadow ground								
Control		44,5	79,3	8,7	8,6	2,8	31,9	0
Crests		46,8	80,7	9,5	8,9	3,8	34,5	2,7
	t-2,4% - 95 - 3,3 /ga							

The advantage of new technology of preparation of ground to sowing cotton-plants is confirmed by results production of experiences. The increase of a crop of a clap -row cotton on ridges has made 4,4-5,3 on crests 5,4-6,1s/ga. The most part of a crop of a row-cotton on crests was assembled for the first and second taxes. Mulching various mulch materials promoted decrease (reduction) of density new irrigated of sierozem-meadow ground. The greatest condensation of ground, in comparison with other variants, was on a smooth field and preservation before the end of vegetation. On mulching crests during development of cotton-plants density arable of horizon in comparison with control variants, is a little bit less. Both after crop, and in the subsequent periods of development cotton-plant, in a layer 0-30sm density was kept in baud 1,25-1,43g/sm^3.

It is known that the entering of organic fertilizers promotes creation of more favorable conditions, which raise efficiency of plants. Entering of organic fertilizers and mulching of manure, lignin and transparent polyethylene film a little improving of poring of ground. The organic fertilizers, as mulching material, in conditions new irrigated sierozem to meadow ground, promoted increase general porous of ground, in comparison with the controller, in a layer

0-10 sm on 3,4-4,1; 10-20 sm -5,2-3,8; 20-30 sm -2,3-1,2%. In variant with a transparent polyethylene film in layers 0-10, 10-20 and 20-30sm general porous in the period of vegetation was less, than in variant with organic fertilizers, accordingly on 0,8-4,8; 0,4-4,1; 0,4-1,2 %. The influence of organic fertilizers is especial artificial structure forming K-9, on a status pores of units of ground in the period vegetation of cotton-plants was more appreciable, than under a transparent polyethylene film (table 2).

Mulching of ground by a transparent polyethylene film in conditions of new irrigated sierozem to meadow of ground completely protects ground from formation (education) soil crust, and organic mulch, reducing thickness crust creates favorable conditions for reception shoots without crust runoff processing's.

Table 2. Influence mulching on growth development and crop of cotton-plant

Va ria nt	Shoots, % on 9.05	Height of the main stalk, sm			Quan- in simp th on 5.08	In boxes, th		Average weight of I -st box, g	Crop, s/ga	An in- crease on omp. var.2, s/ga
		5.06	5.07	5.08		5.09	Ripe ning			
1	1.0	9.1	44 5	79 3	8 7	8 5	2 8	5 09	31 9	-2.6
2	9.1	9.6	46 9	80 7	8 9	8 9	3 8	5 13	34 5	0
3	10 5	9.2	49 7	83 5	9.3	9.2	3 9	5 17	35 6	I 1
4	16 7	10 4	47 9	79 9	8 7	9.0	3.9	5 16	36 8	2 3
5	76 4	12 1	53 8	82 4	10 3	10 7	4.5	5 31	39 6	5 1
6	21 4	10 3	48 2	80 8	8 5	8 9	4.0	5 13	36 5	2 0
7	66 9	12 1	53 9	81 4	10 1	10 7	4.7	5 27	39 7	5 2
8	84 7	13 5	58 5	88 6	10 6	10 9	5 6	5 30	42 7	8 2

t-2.37% -3.35s/ga

The quantity (amount) of the most valuable units after first watering at processing ground in all control variants of experiences has made 42%, and on mulching variants is much higher than 47-52%. Organic fertilizers, is especial lignin, and K-9, at once after their entering in a layer 0-15sm render influences on water-strength of units, but by the end vegetation some is marked reduction of their number, that connected with development of root weight, activity of micro flora and processing of soils. The essential change on micro united has taken place on the top layer (0-5 and 5-15 sm) ground, where was brought in quality mulch-cover manure and lignin.

Small dusting also has increased coarse-dusting of a fraction in comparison with control's variants were decreased. In the period vegetation on a skilled site of all variants combing of crop cotton-plants developed more intensively, is especial on variants with organic mulch-cover and polyethylene film, than on a smooth field. So, on July 5, of distinction between variants on height plants have made: accordingly 6,9-8,3; 7,0-9,0 and 11,6-14,0sm, the quantity (amount) simpering of branches on registration plants of control variants was 5,7-5,9-th, and in variant with manure mulch -7,1-th, legnin -6,9 and under a polyethylene film - 7,8 pieces. In this period the quantity (amount) buds, flowers in the control has made, accordingly 6,7-7,2 and 1,6-1,9-th, that on 1,2-1,7; 1,5-2,0; 2,8-3,3 and 0,7-1.0; 0.6-0.9; 1,1-l,4-th it is less, than at mulching. By September 5 on each plant of cotton of control variants was formed 8,5-9,0-th of boxes, from which 2,8-4,0-th of 33-45 % were opened. At the same time on mulching lignin and manure variants the quantity (amount) of boxes was 10,7-th, under a film - 10,9-th and K-9 -9,2 th on one of plants, and opened, accordingly - 4,5-4,7; 5,6-3,9; 42-44, 51 and 42 of % from number formed. The crop of row-cotton, in comparison with control, was higher on 5,1-8,2s/ga. The greatest crop has made -42,7s/ga on variant 8 (under a film), whereas on a smooth field (control) -34,5s/ga. The rather high crop has made 40 s/ga on variants covered with organic kind mulch-cover, in comparison with control by variants (32-34s/ga).

Conclusion

Thus, optimization of properties, conditions and modes soils with the help of new technology of the basic processing with mulching of ground provides amicable shoots, development cotton-plant higher and before frosting the tax and general crop of row-cotton at much (significant, considerably) smaller industrial expenses on I is of production with good technological properties of a fibber.

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Assessing the Wind Erosion Risk by the Sand Blasting Technique

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Abstract

Wind erosion is one of the dominant degradation processes in arid, semi-arid and semi-humid regions of the world that are vulnerable to erosion and land degradation. Availability of a simple procedure to measure the strength of dried soil crust provides the benefits of implementing more effective precautions to the risk of wind erosion for these fragile ecosystems. The aim of this study is to test a practical tool and approach designed in the National Soil Erosion Research Laboratory (USA) that directly measures the susceptibility of the soil to wind erosion processes. The technique is basically using a conventional sand blasting tool that blasts a dried soil crust for different times, ranging from 2 to 60 seconds, and the amount of soil detached by the impacting sand is recorded. In the initial tests, we measured soil detachment under a vertical blasting. Nevertheless, the impacting angle can be adjusted to simulating different saltation processes. The response, the amount of soil loss at different blasting time, indicates the structure of soil crust and a measure of the crust strength or erodibility against wind erosion. For crust formation, soil samples are exposed under a simulated rainfall for 30 min at 10 mm h-1. The soil samples are air dried for at least one week before sand blasting. We tested two soils from US Pacific Northwest that are vulnerable to wind erosion. We found the technique very sensitive to cropping and management history despite the bulk soil properties are very similar. The method is considered to be useful both for evaluating soil crust strength against wind erosion processes.
Key words: Rainfall simulation, sand blasting, structural crust, wind erosion.

Introduction

In semi-arid and arid regions of the world, wind erosion is defined as one of the dominant land degradation processes in terms of sustainability of the natural resource (Lal, 1990; Oldeman, 1992). Availability of a simple, accurate and reliable method of measuring the strength of dried soil crust could provide considerable contributions for implementing more effective precautions to the risk of wind erosion and for improving the wind erosion prediction erosion models for these fragile ecosystems (Zobeck et al. 2003; Uzun et al. 2017).
Soil crusts affect the erosive potential of the wind that sorts the sediments, transports, and deposits (Valentin,and Bresson, 1992). Crust formation occurs under the rainfall conditions at the surface of most soils. The textural composition of the soil is extremely important in terms of crust formation and types. For example, the physical crust is more closely related to wind erosion susceptibility in soils with relatively higher clay content. In sand soils, the structural sieving crust formation is visible even in very low precipitation conditions (Rajot et al., 2003). In this study, we aimed to test a practical tool and approach designed in the National Soil Erosion Research Laboratory (USA) that directly measures the strength of dried soil crust in terms of the susceptibility of the soil to wind erosion processes.

Materials and Methods

Study area

The soil samples used in the research in the USDA-ARS National Soil Erosion Research Laboratory were obtained from two different soil series called Palouse (silt loam) and Nansene (silt loam) in the ARS Research Station in Whitman Country, Pullman, USA. Some physical and chemical properties of these soils are given in Table 1 (Deviren Saygin et al. 2018). Leco TruMac CNS Macro Analyzer was used to determine the soil organic carbon contents. And, Malvern Mastersizer 3000 instrument was used to extract particle size distributions. The water -stable aggregate contents of the soils was determined by Yoder's wet sieving set reported by Kemper and Rosenau (1986). Soil pH (1: 1) and cation exchange capacity (by ICP) were done at A & L Great Lakes laboratories. The semi-arid climate conditions are dominant in the area where the soil sampling is made and the annual minimum and maximum temperature values are 2.8 °C and 14.6 °C and the annual average total rainfall is 518 mm.

Table 1. Some chemical and physical properties of the research soils (derived from Deviren Saygin et al., 2018)

Soil Series	VCS[a]	CS[b]	MS[c]	FS[d]	VFS[e]	S[f]	C[g]	TC[h]	pH[i]	SOC[j]	CEC[k]	WSA[l]
Palouse	0	2.3	4.6	6.4	12.3	64.8	9.7	Silt loam	4.7	2.27	16	74.1
Nansene	0	0.5	2.5	4.9	15.6	67.1	9.5	Silt loam	5.0	1.12	16.6	56.9

[a,b,c,d,e,f,g] is the % of very coarse sand, coarse sand, medium sand, fine sand, very fine sand, silt and clay contents of samples, respectively. [h] is the texture classes; [i] is the pH value; [j] is the soil organic carbon content (%); [k] is the cation exchange capacity (meq (100 gr^{-1}); [l] is the water stable aggregates (%)

Sand blasting technique

First of all, for crust formation, soil samples are exposed under a simulated rainfall for 30 min at 10 mm h-1. The soil samples are air dried for at least one week before sand blasting. We tested two soils from US Pacific Northwest that are vulnerable to wind erosion (Figure 1).

Figure 1. Drying soil crust samples after simulated rainfalls

After preparing the soil samples, sand blast tool is prepared for experiments. The technique is basically using a conventional sand blasting tool that blasts a dried soil crust for different times, ranging from 2 to 60 seconds, and the amount of soil detached by the impacting sand is recorded (Figure 1). In the experiment, air pressure is set up 42 psi (pounds per square inç) when blowing sand. Firstly, we conduct a calibration check for blasting product output. White silica sand is used for experiments. Sand output is set as 0.17-0.18 gram/sec in the calibration measurements.

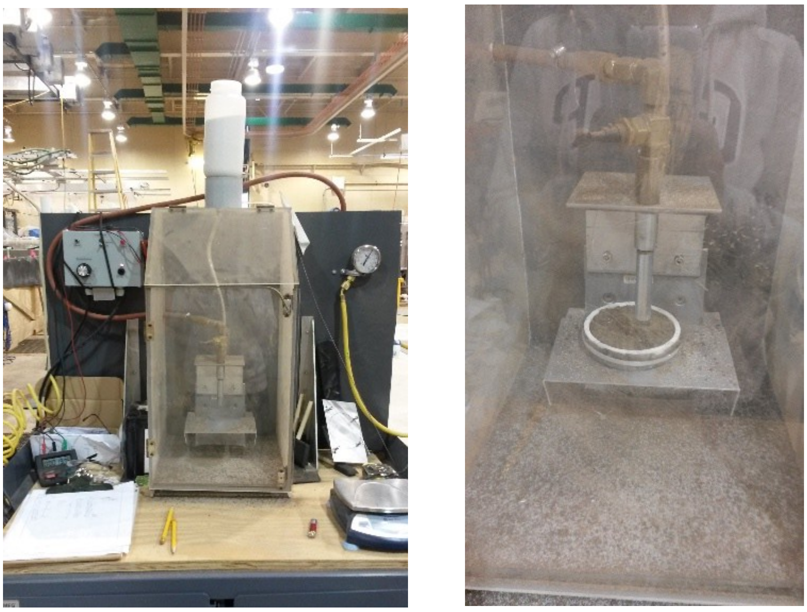

Figure 2. Views from sand blaster tool and experiments (photo by Selen Deviren Saygın, USDA-NSERL Laboratory, 2014)

Results and Discussion

Figure 3 shows the obtained detachment rates of the two soil samples. The crust formed on the Palouse soil showed a resistance of about 15 seconds under applied air pressure conditions. However, the Nansene soil has not broken until the 20 seconds. The sand contents of the soils are approximately similar, but the differences in the distribution of sand sizes have affected the removal rates at different levels. Moreover, although the Palouse soil has higher soil organic matter content and water-stable aggregate percentage than the Nansene soil (Table 1), its crust is considered as weaker in terms of resistance.

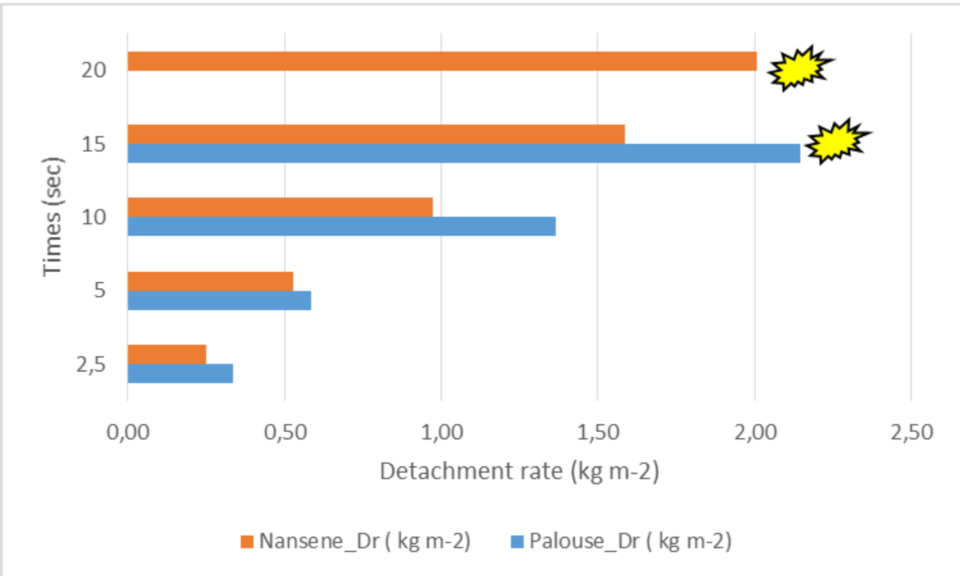

Figure 2. Comparative results of the detachment rates and blowing times of the soils

Soil crust formation and its effect on wind erosion processes have been taken into the consideration for a long time by different researchers (Chepil, 1953, 1958; Zobeck, 1991, Hagen et al., 1992; Fryrear et al., 1998; Rajot et al., 2003). All these studies clearly indicate that crust resistance is the important subject to take into the consideration in erosion prediction models with other soil properties such as soil organic matter, soil clay contents, and soluble salts etc effect on the crust formations. The finding also indicates that several variations in soil structures can be different effects on soil detachment rates.

Conclusion

In this study, we tried to test a simple procedure (named as sand blasting technique) to measure the strength of dried soil crust provides the benefits of implementing more effective precautions to the risk of wind erosion for these fragile ecosystems. Results showed that the technique very sensitive to cropping and management history despite the bulk soil properties are very similar. Thus, the technique is considered to be useful both for evaluating soil crust strength against wind erosion processes. In addition, the technique used has the potential to be developed in different wind angles, with only vertical blasting conditions being created within the scope of this study.

Acknowledgments

The authors would like to special thanks to B. Hofmann and all the staff at the USDA-ARS National Soil Erosion Research Laboratory for their kind technical assistance.

Funding

This work was conducted with funding provided by the Turkey Higher Education Council [grant YOK/PostDoc/2547-39/19508].

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Soil Cohesion of Two Similar Silt Loam Soils

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Abstract

Soil cohesion is a measure of the external forces necessary to separate soil particles and aggregates, hence it is an indicator of the inherent soil strength against erosive forces. Mechanical soil cohesion measurements were performed in two similarly textured soils (Palouse and Nansene) with a fluidized bed approach in order to investigate the variations and soil cohesion under saturation condition which is identified as one of the most important deficiencies of in process-based water erosion assessments. The fluidized bed approach is based on the principle of applying a gradually increased hydrostatic pressure at the bottom of a soil mass until the point when the soil mass fluidizes, i.e., the upward fluid stress on the soil particles or aggregates overcomes the weight of the soil and cohesion that holds the particle/aggregate together. The study was conducted in the United States National Soil Erosion Research Laboratory and assessed the validity of the method on two silt loam soils. Findings indicate that the Palouse soil has a cohesion value about 5.5 times higher than the Nansene soil. This difference may be attributed to the difference in soil organic carbon as the Palouse soil is much higher (3.91%) then the Nansene soil (1.93%), although these two soils have very similar textural composition. Results showed that soil organic matter have very important implications on mechanical soil cohesion development and fragmentation mechanics against external forces.

Key words: Aggregate stability, fluidized bed approach, mechanical soil cohesion, soil erosion, soil organic matter.

Introduction

The soil cohesion points to the physicochemical forces holding the particles together and is mechanically considered as a complementary component of the friction forces in the soil (Das, 2008). In general, it is mentioned as a general expression of the entire force corresponding to the breakage of particles from the mass of soil (Nouwakpo et al. 2014). Although the behavior of cohesive material in water is extremely important for predicting sedimentation and disintegration, studies on this point have indicated that the roles of these physicochemical forces affecting erosion, fragmentation, and transport of soil cohesion are not yet fully understood (Simon and Collison, 2001).

Particularly in the formation of rill and gully, soil particles broken by the decrease of soil cohesion by the effect of increasing water pressure tend to move depending on the density and velocity of the water passing through. Studies on the effect of water pressure on the soil aggregates have reached to the conclusion that there is a considerable effect on the concentration of sediment transported along with the amount of surface water flow increased under the surface (Römkens et al. 2001).

The methods and approaches to evaluate cohesion are very limited, as well as being an important parameter in predicting soil erosion resistance or determining erodibility. The general trend is to estimate with the help of other soil parameters affecting the cohesion and to determine the soil with various indices on the shear strengths. The most important variable that can give an idea about cohesion is the soil aggregate stability (Nouwakpo et al. 2014). Although it is known that the mechanism of aggregate formation is very complicated, it is widely known that soil organic matter is extremely important influences for the formation of aggregates from the primary soil particles (clay, silt, and sand) in cohesive form (Tisdall and Oades, 1982, Amezketa, 1999, Chenu et al. Deviren Saygin et al. 2012).

The success of this method is, of course, closely related to the fact that other processes affecting cohesion in soil or affected by cohesion change are accountable. For example, rainfall simulation experiments and flume studies are carried out in order to evaluate the erosion sensitivities of soils. However, these experiments are both a strong infrastructure and long-time and labor-intensive work. Nouwakpo and Huang (2012) reported that there is a strong correlation between the critical shear stress value used to determine the rill erodibilty in the "Water Erosion Estimation Project (WEPP)" model (Foster and Lane, 1987, Lane and Nearing, 1989, Nearing et al. 1990, Flanagan and Nearing, 1995) used in the process-based evaluation of water erosion, and the value of cohesion achieved with this approach.

Rill erosion is one of the most important land degradation causes encountered in agricultural areas (Parlak and Çanga, 2007). In the erosion studies, there is no general evaluation of subsoil hydrology in general terms. Studies are mostly focused on the assessment of sediment concentrations carried by rills under different management and terrain conditions. Determination of the changes in the hydraulic conditions will give a different direction to the erosion studies, allowing faster detection of the erosion threat and increasing the effectiveness of the measures to be taken against it (Erpul et al. 2013).

Within the scope of the study, it is aimed to determine the mechanical soil cohesion conditions of the two different soil types (silt loam) with the help of fluidized bed method proposed by Nouwakpo et al. (2010) and to assess the effects of changes in soil organic matter on aggregate strength in terms of mechanical soil cohesion variations.

Materials and Methods

Study area

The soil samples used in the research in the USDA-ARS National Soil Erosion Research Laboratory were obtained from two different soil series called Palouse (silt loam) and Nansene (silt loam) in the ARS Research Station in Whitman Country, Pullman, USA. Some physical and chemical properties of these soils are given in Table 1 (Deviren Saygin et al. 2018). Leco TruMac CNS Macro Analyzer was used to determine the soil organic carbon contents; and, the Malvern Mastersizer 3000 instrument was used to extract particle size distributions. The water-stable aggregate contents of the soils were determined by Yoder's wet sieving set reported by Kemper and Rosenau (1986). Soil pH (1:1) and cation exchange capacity (by ICP) were done at A & L Great Lakes laboratories. The semi-arid climate conditions are dominant in the area where the soil sampling is made and the annual minimum and maximum temperature values are 2.8 °C and 14.6 °C and the annual average total rainfall is 518 mm.

Table 1 Some chemical and physical properties of the research soils (derived from Deviren Saygin et al., 2018)

Soil Series	VCS[a]	CS[b]	MS[c]	FS[d]	VFS[e]	S[f]	C[g]	TC[h]	pH[i]	SOC[j]	CEC[k]	WSA[l]
Palouse	0	2.3	4.6	6.4	12.3	64.8	9.7	Silt loam	4.7	2.27	16	74.1
Nansene	0	0.5	2.5	4.9	15.6	67.1	9.5	Silt loam	5.0	1.12	16.6	56.9

[a,b,c,d,e,f,g] is the % of very coarse sand, coarse sand, medium sand, fine sand, very fine sand, silt and clay contents of samples, respectively. [h] is the texture classes; [i] is the pH value; [j] is the soil organic carbon content (%); [k] is the cation exchange capacity (meq (100 gr^{-1}); [l] is the water stable aggregates (%)

Fluidized bed approach and analysis

The fluidized bed approach has been used in the evaluation of mechanical soil cohesion (Nouwakpo et al., 2010). In this approach, when a pressurized fluid enters the pore space of a solid particle bed, the bed is forced to act as a fluid and forms a fluid bed. When the solid-bed used here is thought to be soil, which is a cohesive material, when the water pressure applied to the soil mass is gradually increased, the cohesive force between the particles is transferred from mass to water. This approach is based on observing changes in the cohesion force between the particles as a result of the gradual increase in the water pressure passing through a particular mass of soil and measuring the decrease in water pressure as the cohesion drifts away. For this purpose, pressure drops (Pa) formed as a result of gradually increasing the water level in 20 mm long soil mass is transferred to the computer by sensors and transducers placed in the upper and lower part and over time the pressure change inside the soil mass is monitored as a function of time on the graph. A schematic view of the apparatus used in the working method is given in Figure 1 (cited from Nouwakpo and Huang, 2012).

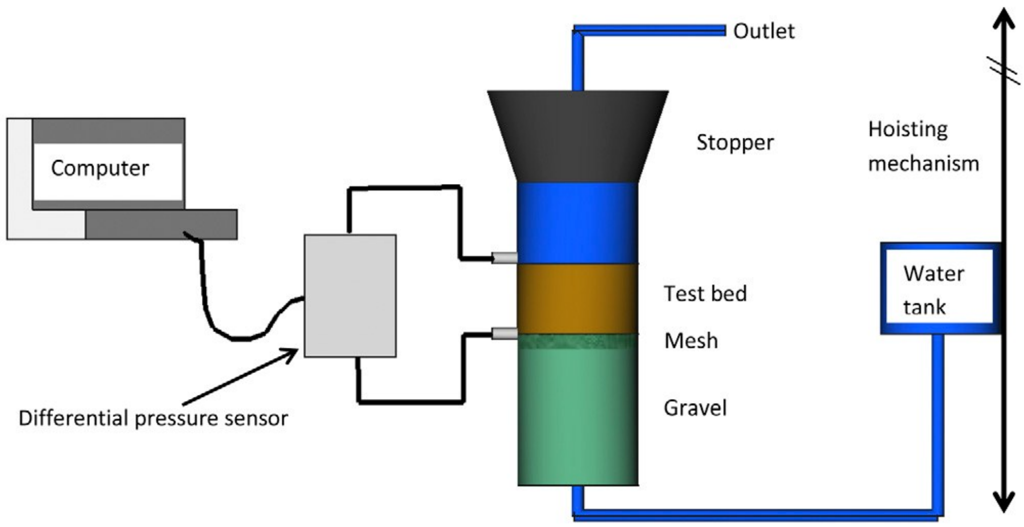

Figure 1. Schematic view of the tool used in fluidized bed experiments (cited from Nouwakpo and Huang, 2012)

The cylinder tube is 30 mm in diameter and 0.11 m in length and is connected to the water tank by means of a flexible pipe 5 mm in diameter. The manual lifting mechanism associated with the water reservoir allows the hydraulic pressure at the bottom of the test tube to be increased or decreased by moving it up and down. The water entering the test tube reaches up to 10 mm thick synthetic filter by moving upward from the gravel layer with a thickness of 50 mm. Gravel and synthetic filters are used to ensure that the water reaching the soil mass forms an even pressure at the bottom of the upper test bed. Just above the filtration is a 25 mm deep soil layer. For this purpose, a 2 mm sifted soil sample was used and placed in the sample test tube to reach the natural volume weight. Pressure transducers (PX26-005DV, Omega Engineering) were installed to measure the pressure difference at the top and bottom of the soil layer and computer connections were established (Nouwakpo et al. 2010). At the same time, the cohesion is terminated, it can be observed both graphically and visually. With the emergence of cohesion in the soil mass, the soil in the test bed passes through to the outlet of the test tube. Once this point has been reached, the system is shut down and the mechanical soil cohesion value (C_o) is expressed in units of Pa m^{-1} or N m^{-3}.

According to the basic principle on which the method is based, the particles only move under the flow conditions and the water flow, which reaches the soil mass as a cohesive material, decreases during the motion of the mass in the effect of pressure on the cohesion. The linear relationship between the water flow velocity V (m s^{-1}) and the pressure drop is based on Darcy's law (Darcy, 1856) (Equation 1).

$$\Delta P = \Delta P_m - \Delta P_0 = a.V \tag{1}$$

Where ΔP_m is the measured pressure drop, ΔP_0 is the minimum pressure drop, a constant value to initiate a measurable flow in unit length.

After the hydraulic pressure is increased by the lifting mechanism, the amount of water exiting the test tube is measured and recorded within a certain period of time. These values are used to obtain the pressure drop recorded in the unit length during the flow at which the float is actuated, that is, ΔP_f. Decrease flow rate of the water pressure through the soil is closely related to the size of soil particles packed with the specific weight of soil and water. The difference between the measured pressure drop (ΔP_f) and the specific gravity of water and soil when soil mass passes to the stream under increasing pressure gives the value of mechanical soil cohesion as C_0 (Pa m^{-1} or N m^{-3}) (Nouwakpo et al. 2010, Nouwakpo and Huang, 2012, Nouwakpo et al. 2014).

$$C_o = \Delta P_f - (\gamma_t - \gamma_s) \tag{2}$$

Where C_0 is the pressure drop in unit length (Pa m^{-1} or N m^{-3}); γ_t and γ_s are the specific gravity of soil and water.

Fluidized bed experiments

For each soil sample used in the study, the experiments were made to be 10 replicates, each of which was completed within 60 to 90 minutes according to soil characteristics and packing conditions of soil samples. The fluidized bed experiment shown in Fig. 2 provides connections between the soil samples placed after the 2 mm sieve is sieved and the water tank. Once the flow has been started, it is gradually raised (2 mm) by the hydraulic load lifting mechanism, which is at the same level as the test bed at the start. For ascending water load, water samples are taken for the determination of the water flow rate (V, m s^{-1}) of the test apparatus from the outlet mouth and weighed and recorded on the computer.

Figure 2. A view from the fluidized bed experiments (photo by Selen Deviren Saygın, USDA-NSERL Laboratory, 2014)

As an example, the pressure difference-time graph obtained for Nansene soil is given in Fig. 3. Due to the increase in the instantaneous water pressure, the difference between the water pressures entering and leaving the soil mass increases primarily and the pressure difference is increasingly rapidly decreasing despite the increased water pressure when the fluidization point, where the soil coincides with the emergence of cohesion. When this point is reached, the soil moves into the water and reaches the exit of the test tube. The flow rate values measured immediately after each increase in the pressure during the test are transferred to the computer system and the mechanical soil cohesion values are obtained as shown in Equations 1 and 2.

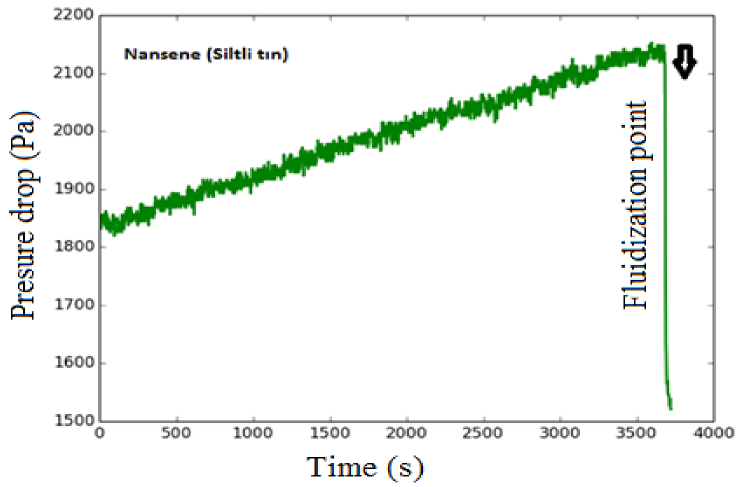

Figure 3. Representative pressure difference-time graph of Nansene soil

Results and Discussion

As a result of the fluidized bed experiments made for the Palouse and Nansene soils, cohesion values were obtained by means of Equation 2 between the flow velocity and the drop pressure values in unit length as shown in Figures 4 and 5. As expected, the decrease in measured pressure values per unit length (ΔP, Pa mm^{-1}) within the time period up to the moment of flow (fluidization) increased as the flow rate increased. Here the ΔP values explain the work done to overcome both the weight of the water and the cohesion (C_0) between the particles.

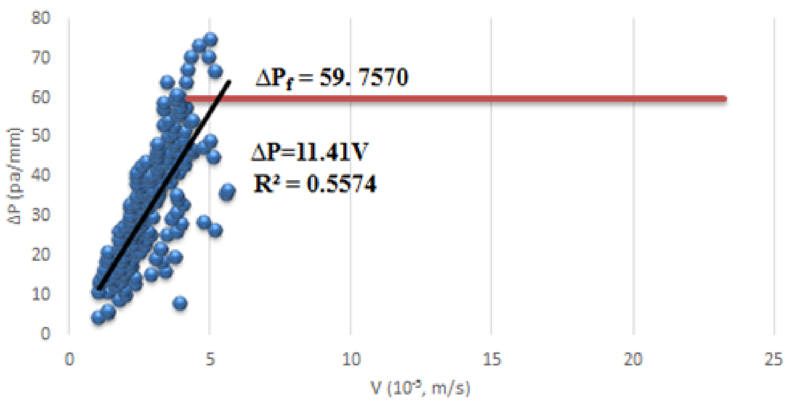

Figure 4. The relationship between measured pressures drop (Pa mm-1) and flow velocity (m s^{-1}) f or Palouse soil

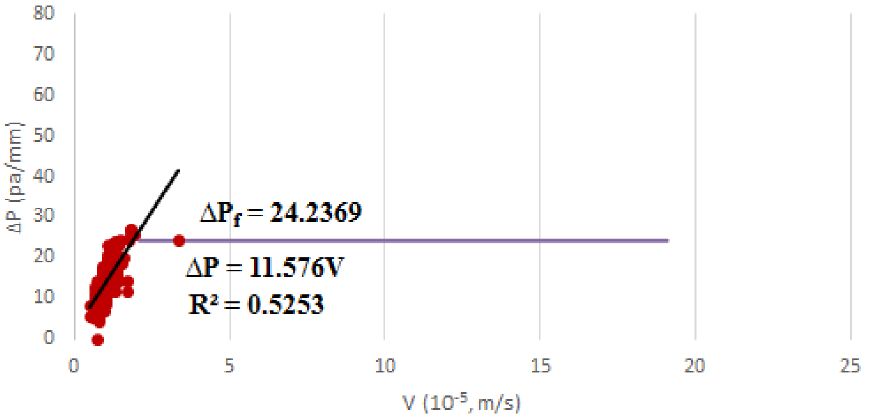

Figure 5. The relationship between measured pressures drop (Pa mm^{-1}) and flow velocity (m s^{-1}) for Nansene soil

From this, the mechanical cohesion values (C_o, N m-3) of the soil can be calculated from the pressure values (ΔP_f, Pa m^{-1} or N m^{-3}) with Equation 1, Equation 3 and 4 as shown below. ΔP_f value indicates the pressure that the soil can pass under the applied water pressure and is considered as a very important variable in explaining the erosion sensitivities of the soil under the infiltration conditions and getting the critical shear stress values of soils for rill initiation processes (Nouwakpo and Huang, 2012).

$$C_o(Palouse) = \Delta P_f - (\gamma_t - \gamma_s) = 59757 - (25970 - 9800) = 43587 \tag{3}$$

$$C_o(Nansene) = \Delta P_f - (\gamma_t - \gamma_s) = 24236.9 - (25970 - 9800) = 8066.9 \tag{4}$$

Specific gravity values of water and soil were obtained as shown in Equations 5 and 6.

$$\gamma_t = q_t \times g = (2.65 \times 10^3) \times 9.8 = 25970 \tag{5}$$

$$\gamma_s = q_s \times g = (1 \times 10^3) \times 9.8 = 9800 \tag{6}$$

Where γ_t and γ_s are the specific weights of soil and water respectively (N m^{-3}), the density of grains (qt, kg m^{-3}) and water (qs, kg m^{-3}), and gravity (g, N kg^{-1}).

As can be seen from the results obtained, the Palouse soil has a cohesion value of about 5.5 times higher than the Nansene soil. This suggests that the Palouse soil has a stronger structure in terms of the mechanism of aggregate formation. Considering some of the physical and chemical properties given in Table 1 for the soil samples used in the experiment, it seems the Palouse (3.91%) has almost twice organic matter content than the Nansene (1.93%). As stated in the relevant literature, the results are positive correlations between the positive effect of organic matter on the aggregate formation mechanism and the high aggregate strength and the susceptibility of soils to erosive forces (Amezketa, 1999; Angers and Caron, 1998; Barthes and Roose, 2002; Cerda, 2000; Cerda et al. 2016; Emerson and Greenland, 1990; Le Bissonnais, 1996, Six et al. 2000; Peng et al. 2015; Tisdall and Oades, 1982). In summary, the effect of organic matter on the wettability-reducing effect on aggregate strength has led to an increase in aggregate strength and, consequently, cohesion development (Deviren Saygin et al. 2012; Deviren Saygin et al. 2017).

The hydraulic conditions of subsurface soils, especially in erosion studies, are overlooked in many studies and models. On the other hand, it is known that the ability of the sediments,

which are broken by the influence of erosive forces, to flow to the surface is closely related to the sub-surface conditions (Bryan, 2000). In this respect, the mechanical cohesion values of the subsurface soil hydrology can be simulated for rill initiation and channel development in a practical way (Simon and Collison, 2001; Fox et al. 2007; Nouwakpo et al. 2010).
As a result, performed early studies show that relations between the rill erodibility and the mechanical cohesion obtained by this method can be established for silty soil. For example, in a study of Palouse series, in Nouwakpo and Huang (2012), a linear positive correlation of 82% was obtained between the critical shear pressure used to evaluate rill erodibility and the mechanical cohesion value determined by fluidized bed method. Undoubtedly, it is extremely important and necessary to test the relationships between erosion sensitivities by investigating the fluidized bed method with different soil textures so that these relationships can be improved.

Conclusion

Water erosion studies, which are considered to be one of the most important species of soil degradation, are of great importance in determining the efficacy of water velocity and weight on soil cohesion in determining the effectiveness of measures to be taken in terms of rill and channel development. For this purpose, the fluidized bed method, which is a much unknown method yet, was used to evaluate the mechanical cohesion of soils in the National Soil Erosion Research Laboratory of the United States by using a fluid bed approach for two similar silt loam soil (Palouse and Nansene). According to the findings, there is a close relationship between the aggregate strength of the soil, organic matter content and soil cohesion. In particular, the effect of soil organic matter on the development of cohesion of two different soils with similar textural composition was found to be extremely important. Finally, it is believed that testing of the method for different soil types will make a significant contribution to understanding and simulating subsurface soil hydrology in soil erosion studies.

Acknowledgments

The authors would like to acknowledge the scientific guidance of Dr K. Nouwakpo. Also a special thanks to B. Hofmann and all the staff at the USDA-ARS National Soil Erosion Research Laboratory for their kind technical assistance.

Funding

This work was conducted with funding provided by the Turkey Higher Education Council [grant YOK/PostDoc/2547-39/19508].

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Phosphorus Aging Impacts on Sorption-Desorption Features of Lead (Pb) in Soils

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Abstract

This research examined the effects of artificially aging of phosphorus in soils on sorption-desorption characteristics of lead (Pb). Nine soil samples covering a wide range of relevant properties were collected from north and north-west of Iran. The soils were treated with 0, 50 and 500 mg P kg^{-1} from Ca $(H_2PO_4)_2.H_2O$ at field capacity and incubated at 25±0.3° C for one day and at 35 ± 0.3° C for 30 days. Thereafter, Pb sorption experiments were performed using a series of 0.01 M KNO_3 solutions containing different concentrations (1-5mM) of Pb (as $Pb(NO_3)_2$).The desorption experiments were performed immediately following the sorption completion. Results showed a huge impact of soil native pH (ranging from 3.7 to 8.9) on all features of Pb sorption-desorption reactions. The acceleration of equilibrium establishment following phosphorus application disappeared with decreasing soil pH. Phosphorus increased both sorption parameters of Freundlich model (K_F and N) only at the highest level of treatment. The K_F parameter increased but the N parameter decreased by aging of phosphorus in the acid soils, while the reverse was observed in the near-neutral and alkaline soils. Soil pH and organic carbon content showed strong positive correlations with K_F parameter in all treatments. The phosphorus aging process in the soil significantly decreased the hysteresis index values ($HI=N_{sor}/N_{des}$) for Pb in an acid and particularly in a calcareous soil, while increased that of a near-neutral non-calcareous soil. Moreover, this process decreased the influence of contact time between soil and Pb.

Key words: contact time, Freundlich model, hysteresis index, soil pH.

Introduction

Lead (Pb) is known as a relatively immobile heavy metal and believed to accumulate for many hundreds, even thousands, of years in the upper layers of soil (Miretzky and Fernandez-Cirelli, 2008). Really, high concentrations of Pb have been reported in the surficial horizons of shooting range soils from shotgun pellets (Lin et al., 1995). Mobility and bioavailability of soil Pb are mainly controlled by its chemical forms and solubilities (Shahid et al., 2012). Although, other factors such as pH, cation exchange capacity, organic matter content, and redox may have considerable impact potential (Zimdahl and Skogerboe, 1977). It has been reported that the metallic lead in the pellets has been converted to hydrocerussite $[Pb_3(CO3)_2(OH)_2]$ associated with Cerussite ($PbCO_3$) and anglesite ($PbSO_4$) in shooting range soils (Lin et al., 1995; Yoo et al, 2017). Unfortunately, these precipitates have high enough solubilities to release Pb into the environment (Crysochoou et al., 2007). Also, many researches have demonstrated that the non-residual forms of Pb (including exchangeable, carbonate-bound, oxide-bound and organic-bound) pose a high risk environmental pollution (Yin et al., 2010). Cong et al. (2016) even observed the transport of residual Pb along the soil profile in a mining region in north China. Among different Pb forms, the exchangeable plus carbonate forms had the highest correlation with Pb bioaccessibility (Li et al., 2015). The same result has been reported for availability to plants (Chlopecka, 1996).Therefore, it is of great theoretical and practical importance in the contaminated soils to transform all mobile or fairly mobile forms of Pb into geochemically stable forms. This can be achieved through the use of phosphate-induced Pb immobilization technique. The Pb phosphates are at least 44-fold less soluble than aforementioned naturally-occurring Pb minerals (Traina and Laperche, 1999). Remediation of

Pb-contaminated soils via phosphate additives has been extensively studied and characterized in the literature (Miretzky and Fernandez-Cirelli, 2007). Three main mechanisms may be responsible for phosphate-induced Pb immobilization: 1) precipitation of Pb-phosphates like pyromorphites with the extremely low solubility products ranging from $10^{-84.4}$ to $10^{-71.6}$, 2) adsorption of Pb on negatively charged iron oxides, 3) rhizosphere acidification (Zeng et al., 2017). Most of previously published reported have described the role of recently added phosphate on Pb immobilization in the contaminated soils, but little is known regarding how ultimate fate of Pb is affected by residual phosphate. This research examined the effects of artificially aged phosphate on sorption-desorption of added Pb.

Materials and Methods

Nine soil samples covering a wide range of relevant properties were collected from 0-20 cm depth of agricultural lands located in north and north-west of Iran. The soils were air dried and then sieved to less than 2 mm. Some soil properties including $pH_{1:1}$ (Lierop, 1990), texture (Gee and Bauder, 1986), field capacity moisture content (FC) (Cassel and Nielsen, 1986), electrical conductivity ($EC_{1:1}$) (Rhoades 1996), organic carbon (OC) (Nelson and Sommers, 1996), cation exchange capacity (CEC) (Chapman, 1965), calcium carbonate equivalent (CCE) (Allison and Moodie, 1965) were determined.
The soils were treated with 0, 50 and 500 mg P kg^{-1} from monocalcium phosphate [$Ca(H_2PO_4)_2.H_2O$] at FC and incubated in incubator at 25±0.3^o C for one day and at 35 ± 0.3^o C for 30 days, separately . For this, 2 mL of monocalcium phosphate solution at concentrations of 500 and 5000 mg P L^{-1} was mixed with the required amount of distilled water to bring the soils to FC and was added to 20 g of the soils (based on oven dry weight) in polyethylene bottles. The bottles were incubated under two aforementioned conditions. The soils with an incubation period of 30 days were also subjected to 15 cycles of wetting and drying. Thereafter, sorption experiments were performed using a series of 0.01 M KNO_3 solutions containing different concentrations (1-5mM) of Pb (as $Pb(NO_3)_2$). The desorption experiments were performed immediately following the sorption completion.
Before sorption and desorption experiments, the equilibration times were determined for upper limit of Pb concentration. Finally, the Freundlich equation was fitted to the sorption as well as desorption data:

$$q = K_F C^N \quad (1)$$

where, q is the amount of Pb adsorbed (mg g^{-1}), C is the equilibrium concentration of Pb (mg L^{-1}) and K_F and N are the equation parameters. Moreover, the values of hysteresis index ($HI=N_{sor}/N_{des}$) were determined (Celis et al., 1997).
To assess the effect of sorption incubation times longer than the traditional 24 hours, the Pb sorption experiments were conducted over one week of shaking in three soils, under aforementioned conditions.

Results and Discussion

General properties of the studied soils are presented in Table 1. The soils sampled show a wide variation in their physicochemical properties such as texture, pH and organic carbon content.

Table 1. General properties of the studied soils

No.	pH	EC (µS cm^{-1})	Texture	OC ($g\ kg^{-1}$)	CCE ($g\ kg^{-1}$)	CEC ($cmol_c\ kg^{-1}$)
1	3.7	460	CL	25.5	nil	23.8
2	4.3	332	SiC	18.1	nil	26.1
3	5.7	332	SiC	11.7	nil	32
4	6.1	306	SiL	16.6	nil	26.4
5	7.1	2610	SiL	14.6	nil	28.8
6	7.5	1347	C	25.4	110	27.7
7	8	1499	L	12.7	196	29.2
8	8.3	240	SL	8.3	117	14.5
9	8.9	751	L	3.9	231	11.3

Equilibration time: Almost all of the added Pb to a near-neutral non-calcareous soil (soil 5) and particularly to a calcareous soil (soil 8) was retained during the time of experiment. However, only 27.5% of the added Pb was retained by an acid soil (soil 1) (Figure 1). The acid soil showed a fast reaction with Pb in both phosphorus treatments, while the slowest reaction was observed in the calcareous soil at control. Formation of Pb precipitates as various pyromorphites can be hindered in strong acid soils. This is a result of proton release during the formation of these minerals (Mavropoulos et al., 2002). The slower rate of Pb sorption in near -neutral and calcareous soils may be due to the slow formation of pyromorphites in soils with higher pH values. As it can be seen, the acceleration of equilibrium establishment following phosphorus application disappeared with decreasing soil pH. Based on the sorption kinetics, 24 hours was considered to be the equilibration time for Pb sorption in the subsequent experiments as previously reported in the literature (Vega et al., 2009). Strawn and Sparks (2000) reported that sorption incubation times up to 32 days had no effect on Pb desorption behavior. Also, the time required for equilibrium establishment in desorption experiment was found to be 2 hours. Although, longer times (up to 24 hours) have been reported in the literature (Sovelo et al., 2007).

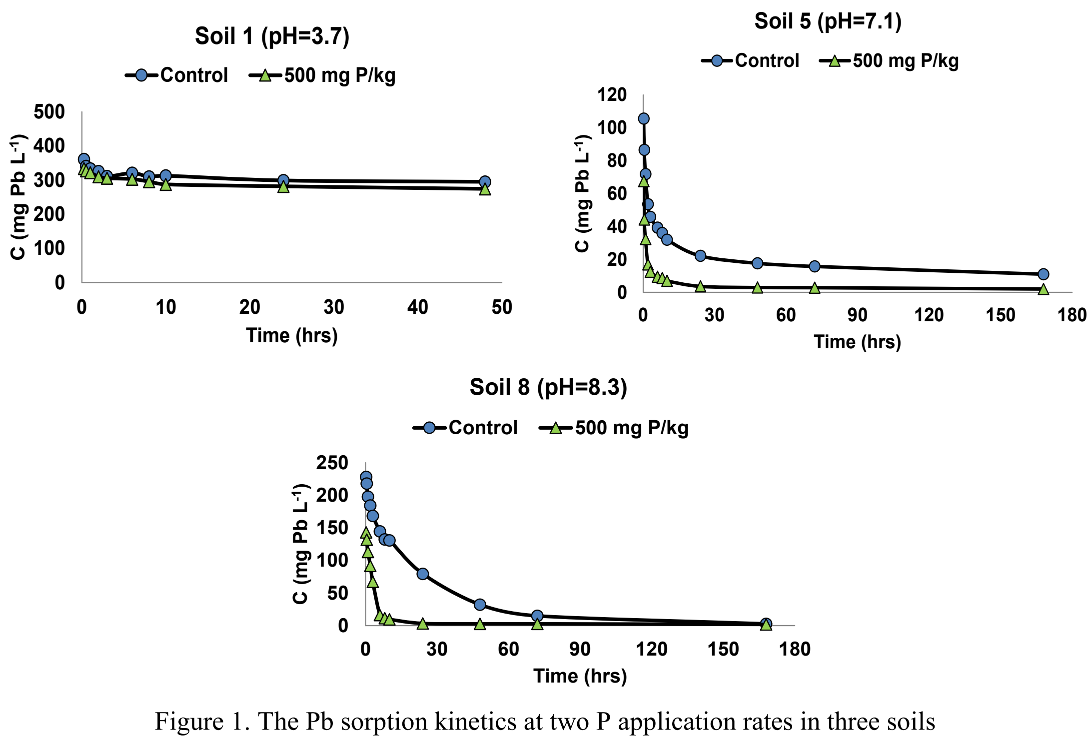

Figure 1. The Pb sorption kinetics at two P application rates in three soils

Sorption isotherms: Sorption isotherms for the two phosphorus-soil contact time and at three P application rates in three out of nine studied soils are shown in Figures 2 and 3. The highest Pb sorption values in all isotherms were lower than the respective CEC values of the soils, however it is difficult to conclude that the electrostatic forces are responsible for the P sorption. Although, from the CEC obtained, Martinez-Villegas et al. (2004) concluded that the outer-sphere surface complexes may explain Pb sorption in their studied soils. For both phosphorus-soil contact times, there is a clear shift of the Pb isotherm curves to higher sorption with increasing soil native pH at 500 mg P kg^{-1}. However, the respective curves at control and 50 mg P kg^{-1} almost overlay each other and no effect of pH was detected. Moreover, increasing pH from 3.7 to 8 led to a shift of isotherms toward a lower Pb concentration. The isotherms shifted again to higher Pb concentrations at higher pH values (i.e. 8.3 and 8.9). For a phosphorus-soil contact time of 30 days, in comparison to a phosphorus-soil contact time of one day, an slight upward shift of the curve at 500 mg P kg^{-1} was observed in soil 1 (an acid soil). Also, the isotherm shifted to lower Pb concentrations. A same trend was observed for acid soils 2, 3 and 4. In contrast, a shift of the isotherm to higher Pb concentrations after a long phosphorus aging was detected in soil 5 (a near-neutral non-calcareous soil) and soil 9 (an alkali calcareous soil). A same trend was observed for soils 6, 7 and 8 (calcareous soils). Based on results, phosphorus aging results in a decline in Pb mobility in acid soils and an increase in alkaline soils.

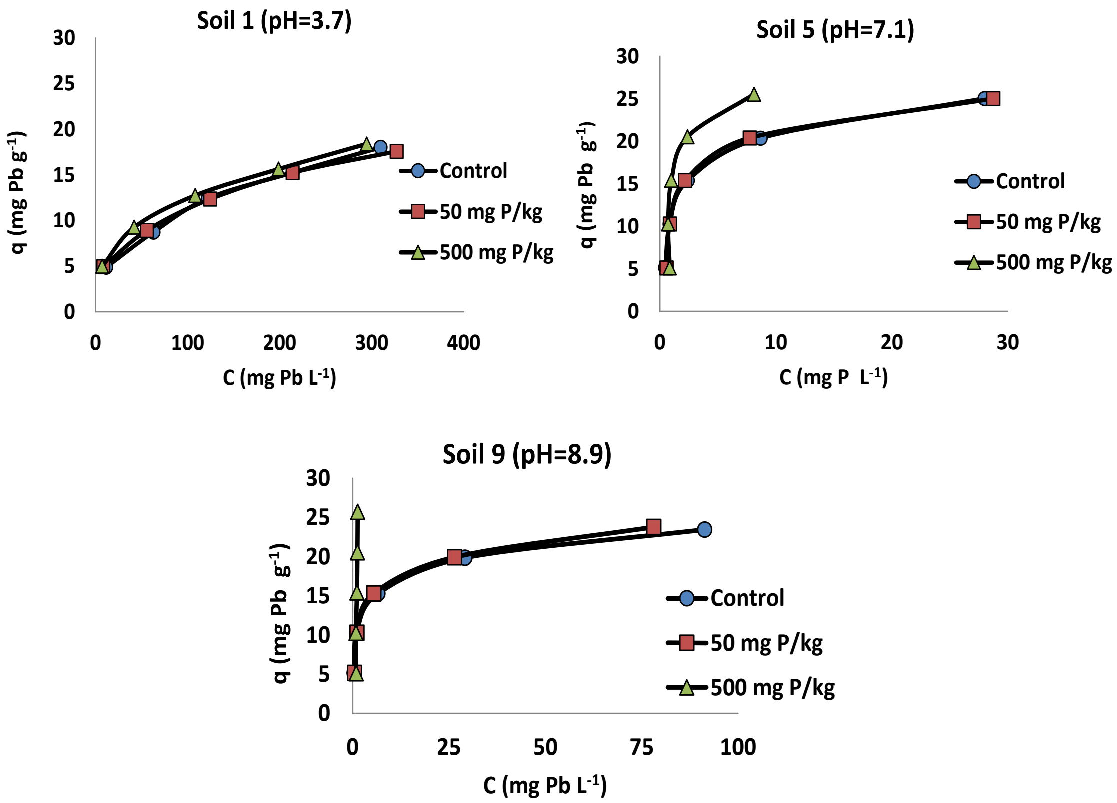

Figure 2. The Pb sorption isotherms for a phosphorus-soil contact time of one day and at three P application rates in three soils

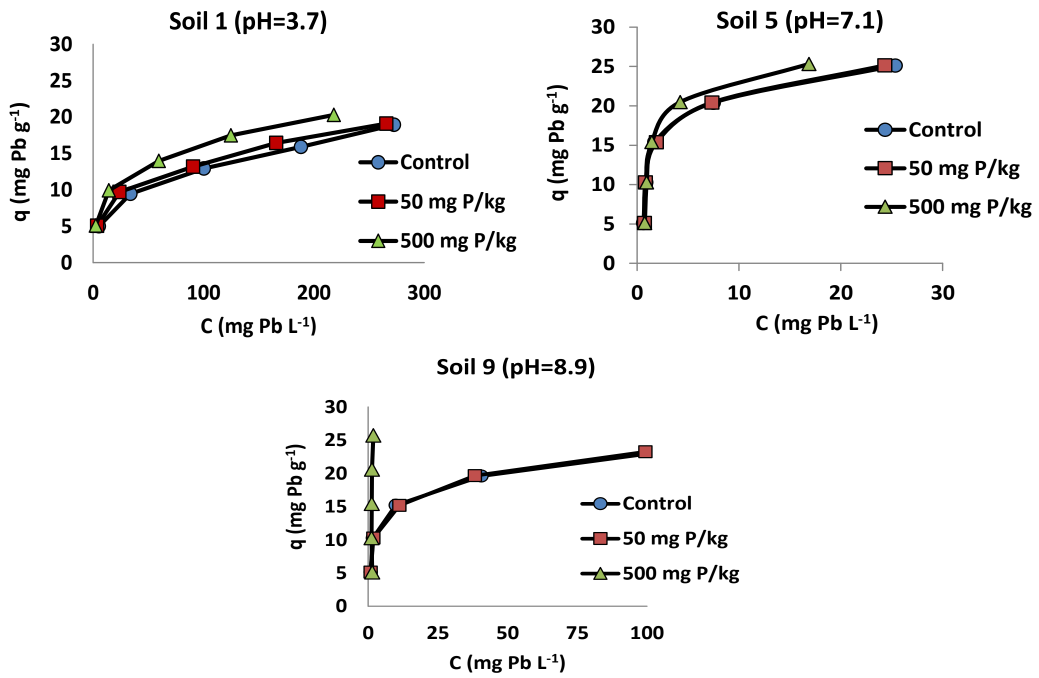

Figure 3. The Pb sorption isotherms for a phosphorus-soil contact time of 30 days and at three P application rates in three soils

Sorption model fitting: The Freundlich equation was fitted to the sorption data and the average values of K_F and N parameters for different treatments are presented in Figures 4, 5 and 6. All N values were less than 1 which implies the reversible nature of sorption (Elbana et al., 2013).

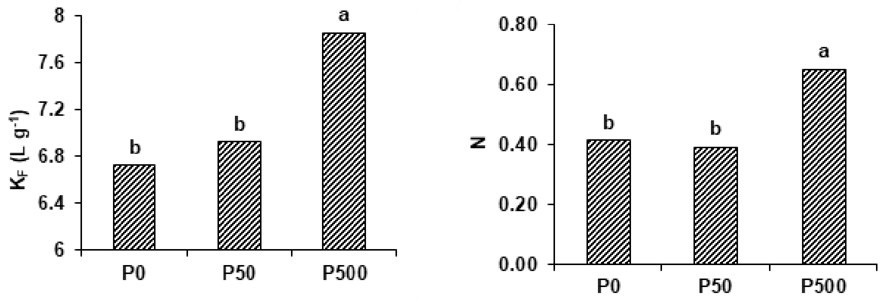

Figure 4. Comparison of mean values of K_F and N parameters at three phosphorus application rates (P0: Control, P50: 50 mg P kg^{-1}, P500: 500 mg P kg^{-1})

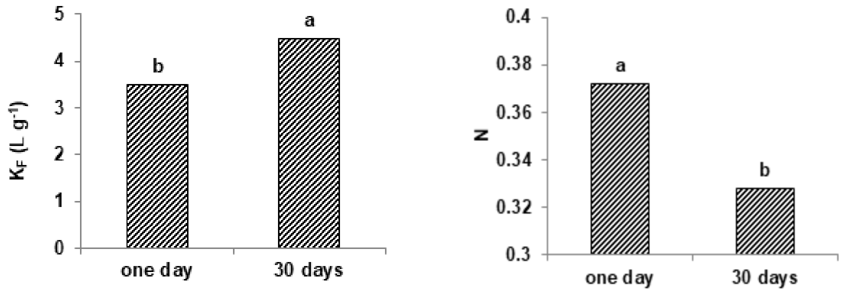

Figure 5. Comparison of mean values of K_F and N parameters for two phosphorus-soil contact times in four acid soils

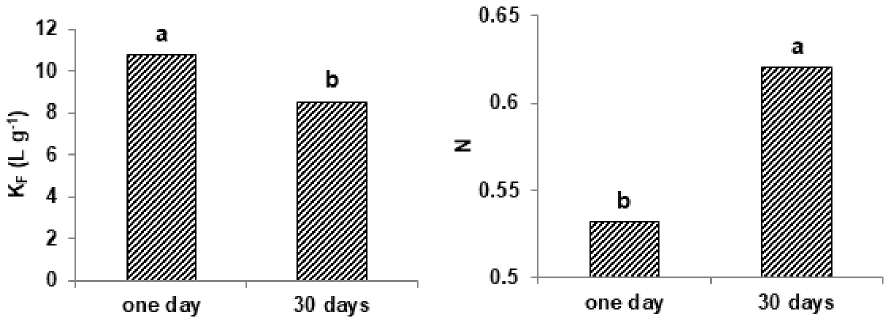

Figure 6. Comparison of mean values of K_F and N parameters for two phosphorus-soil contact times in five near-neutral and alkaline soils

As it can be seen in Figure 4, addition of phosphorus significantly increased both parameters of Freundlich sorption equation (K_F and N) only at 500 mg P kg^{-1}. Aging of phosphorus had two different effects on Freundlich parameters, depending on the reaction of the soil. In acid soils, the aging process caused an increase in K_F parameter and a decrease in N parameter (Figure 5). While, a decrease in K_F parameter and an increase in N parameter was observed in near-neutral and alkaline soils (Figure 6).
The K_F parameter had a significant direct relationship with soil native pH (P<0.05) for both phosphorus-soil contact times and at three phosphorus application rates (Figures 7 and 8). The highest value of correlation was observed for a phosphorus-soil contact time of 30 days and at 500 mg P kg^{-1}. Soil pH plays a major role in the sorption of heavy metals as it directly controls the solubility of metal precipitates. Soil pH also has an effect on metal hydrolysis, formation of metal–ligand complexes, organic matter solubility as well as surface and edge charges of soil constituents (Yang et al., 2004). Martinez-Villegas et al. (2004) observed an increase in Pb sorption by the soil in response to an increase in pH.

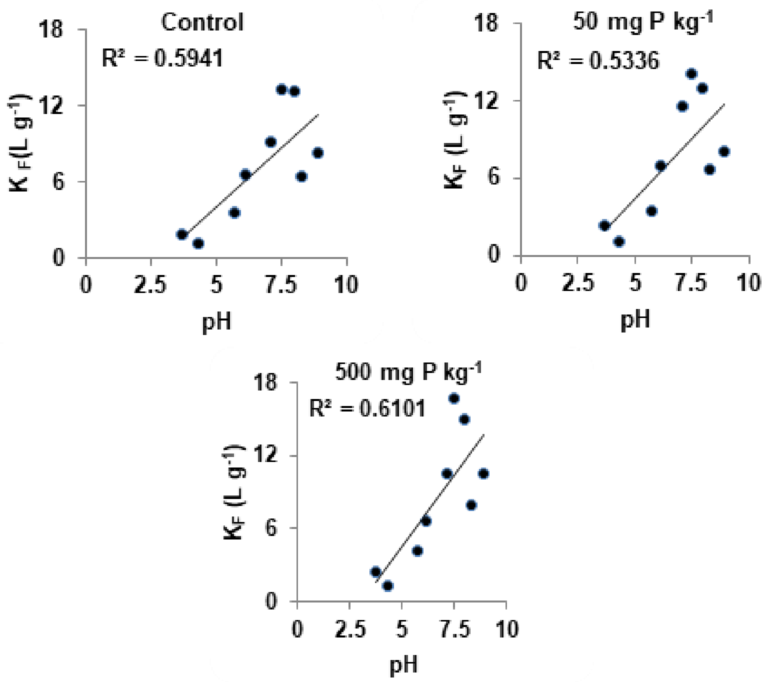

Figure 7. Relationship between K_F and pH values for a phosphorus-soil contact time of one day in nine studied soils

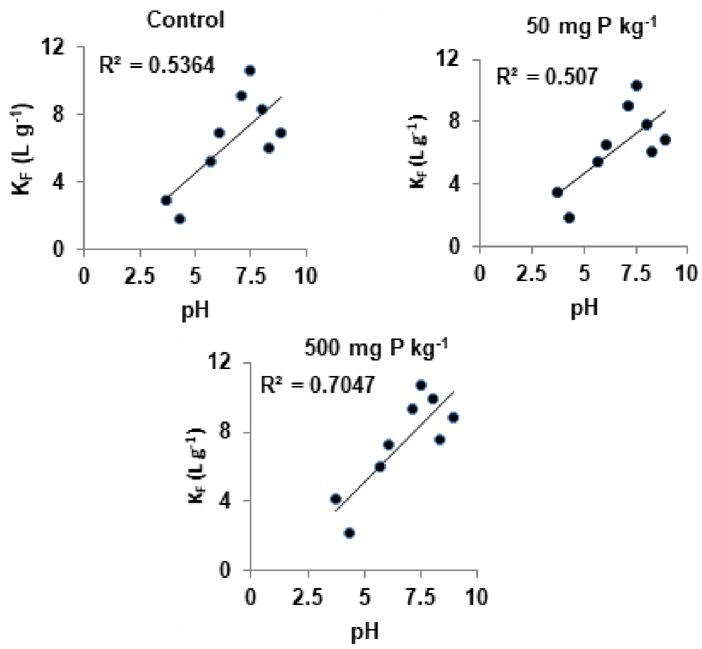

Figure 8. Relationship between K_F and pH values for a phosphorus-soil contact time of 30 days in nine studied soils

Multiple linear regression analysis using stepwise method showed that when soil organic carbon variable was entered in the regression equation, the strength of the aforementioned relationship increased as follows:
For a phosphorus-soil contact time of one day:

$$K_{F0} = -19.01 + 2.96\ pH + 4.21\ OC \quad (2)$$
$R^2 = 0.87$
SE= 1.81

$$K_{F50} = -20.52 + 3.12\ pH + 4.79\ OC \quad (3)$$
$R^2 = 0.92$
SE= 2.1

$$K_{F500} = -23.96 + 3.67\ pH + 5.30\ OC \quad (4)$$
$R^2 = 0.96$
SE= 1.81

For a phosphorus-soil contact time of 30 days:

$$K_{F0} = -9.83 + 1.84\ pH + 2.68\ OC \quad (5)$$
$R^2 = 0.81$
SE= 1.43

$$K_{F50} = -8.71 + 1.69\ pH + 2.56\ OC \quad (6)$$
$R^2 = 0.89$
SE= 1.35

$$K_{F500} = -8.14 + 1.85\ pH + 2.12\ OC \quad (7)$$
$R^2 = 0.94$
SE= 1.13

According to the results, the presence of soil humic substances increases the sorption of Pb by the soil. Formation of Pb–ligand complexes on sorption sites can enhance the Pb sorption (Xiong et al., 2018). It has been demonstrated that the fraction of desorbed Pb from the soil decreased with increasing the amount of soil organic matter in the soil (Strawn and Sparks, 2000). Perelomov et al. (2011) have been also reported a positive role of organic acids (citric and oxalic acids) to increase the sorption of Pb by goethite.

Sorption-desorption isotherms: The Pb sorption-desorption isotherms were determined for three out of nine studied soils and two of them are presented in Figures 9 and 10.

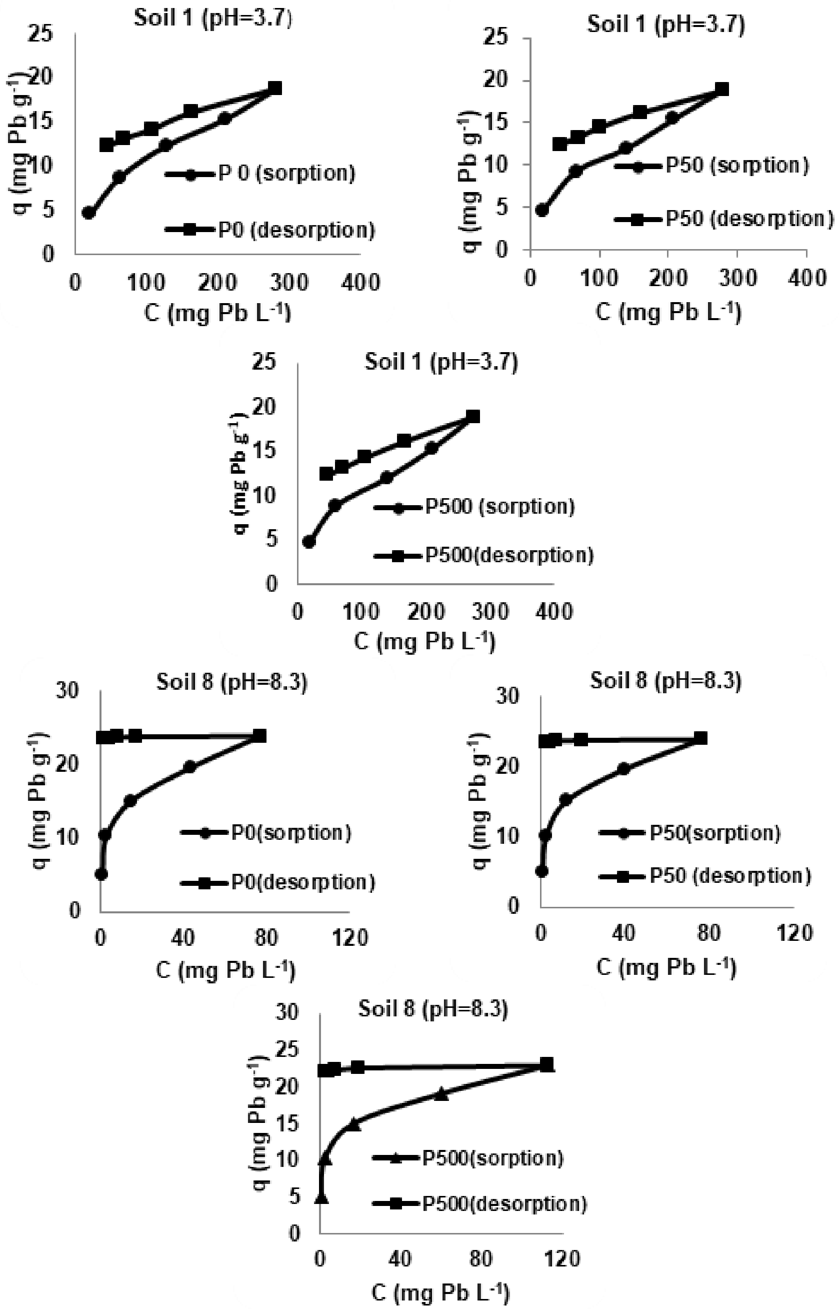

Figure 9. The Pb sorption-desorption isotherms for a phosphorus-soil contact time of one day and at three phosphorus application rates in two studied soils (P0: Control, P50: 50 mg P kg^{-1}, P500: 500 mg P kg^{-1})

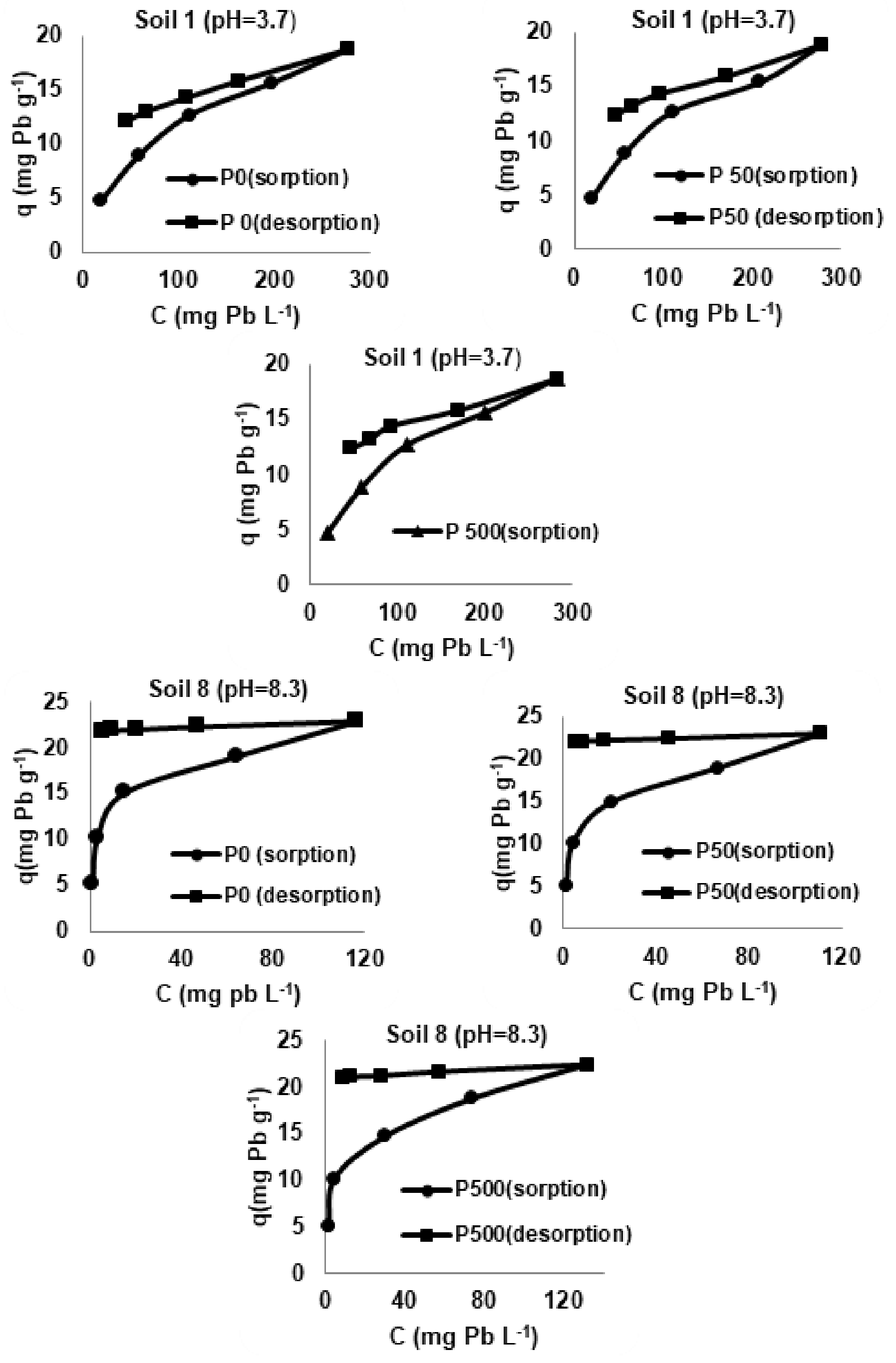

Figure 10. The Pb sorption-desorption isotherms for a phosphorus-soil contact time of 30 days and at three phosphorus application rates in two studied soils (P0: Control, P50: 50 mg P kg^{-1}, P500: 500 mg P kg^{-1})

Figures 9 and 10 indicate a significant hysteresis between sorption and desorption branches of the isotherms in both acid and calcareous soils (soils 1 and 8, respectively). However, degree of hysteresis in the calcareous soil was greater than that in the acid soil. Findings imply more reversibility of Pb sorption reactions in acid soils than in calcareous soils. The phosphorus aging process in the soil significantly decreased the hysteresis index values ($HI=N_{sor}/N_{des}$) in an acid soil and particularly in a calcareous soil (soils 1 and 8, respectively), while increased that of a near-neutral non-calcareous soil (soil 5) (Table 2). As HI values increase, desorption affinity decreases (Celis et al., 1997). The reason for this observation is likely to be that extremes in soil pH values can lead to precipitation of Pb added, while Pb adsorption may be a dominant mechanism in neutral pH mediums. Therefore, phosphorus aging in acid and calcareous soils may promote Pb precipitation reactions that provide slightly soluble precipitates, while this process cause a conversion from a monodentate to bidentated surface complexes, of which the latter is less desorbable than the former (Tan, 2010).

Table 2. The values of hysteresis index for two Phosphorus-soil contact time and at three phosphorus treatments in three studied soils

Soil No.	Phosphorus Treatment (mg P kg^{-1})	Phosphorus-soil contact time of one day	Phosphorus-soil contact time of 30 days
1	0	1.7	1.4
	50	1.6	1.3
	500	1.5	1.4
5	0	38.8	71.8
	50	39.3	52.4
	500	37.3	52.3
8	0	88.3	18.3
	50	78.3	22.1
	500	18.1	11.7

Effect of shaking period on Pb sorption: The Pb sorption isotherms were also determined over a one-week shaking period. Comparison of isotherms obtained for 24 hours and one-week shaking periods are shown for soil 1 in Figures 11 and 12. As it can be seen, prolonging the contact period between Pb ions and soil from 24 hours to one week increased P sorption values only for a phosphorus-soil contact time of one day. As a result, phosphorus aging process in the soil decreased the influence of contact time between soil and Pb. When a major portion of the phosphorus added is present in soil solution or in a non-equilibrium state, it is important to know the contact period between Pb ions and soil.

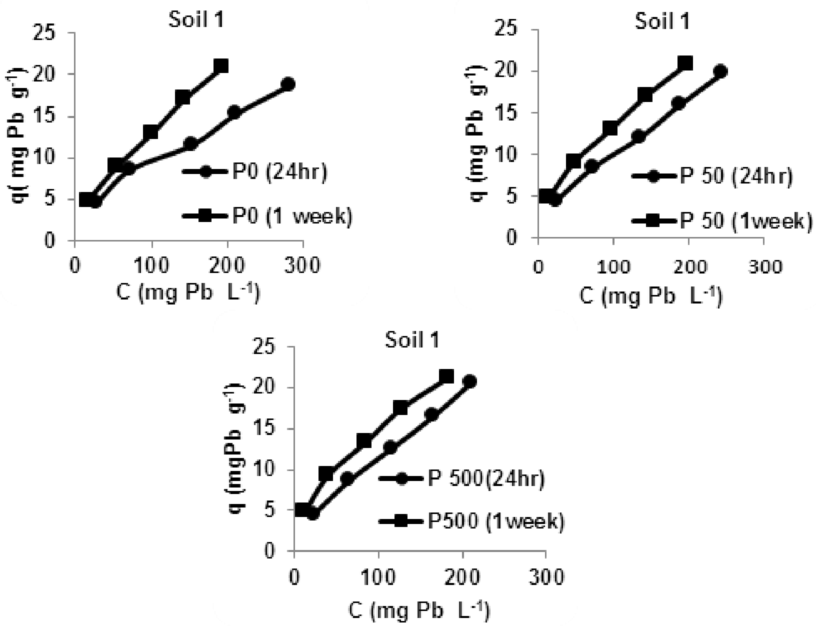

Figure 11. Comparison of Pb sorption isotherms for a phosphorus-soil contact time of one day and at three phosphorus application rates (P0: Control, P50: 50 mg P kg^{-1}, P500: 500 mg P kg^{-1})

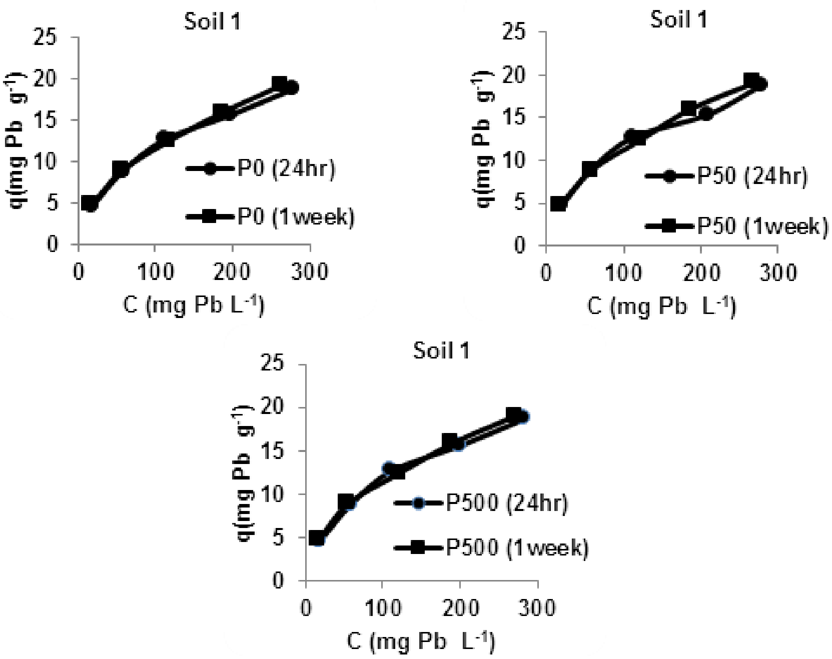

Figure 12. Comparison of Pb sorption isotherms for a phosphorus-soil contact time of 30 days and at three phosphorus application rates (P0: Control, P50: 50 mg P kg^{-1}, P500: 500 mg P kg^{-1})

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Soil constructions: their functioning, transformation and natural analogs

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Abstract

Research of functioning and transformation of soil constructions, with different structures in different climatic conditions and formed for the purpose of reclamation of lands in the extraction of minerals, and also for the purpose of creating a soil cover in the greening of the city, was held. Objects of the investigation were the soils, created under remediation of the oil-contaminated tundra gley soils of the North of Russia (the Komi Republic), under remediation of an iron ore pit of the Kursk Magnetic Anomaly (the Belgorod Region) and soil constructions with different structure located in Moscow. The general characteristic of these soil constructions distinguishing them from natural analogs was existence of the layered profile, that leads to specificity of their hydrological regime, transformation of properties of solid phase and pore space of soils.
Key words: soil constructions, physical properties of soils, soil structure, scanning electron microscopy, pore space of soils, rheological characteristics of soils, solid phase of soils
This research was financially supported by Russian Foundation of Basic Research (the project No. 16-04-01851).

Introduction

The modern soil science is characterized by emergence of a large number of artificially created soils from layers of non-native soils. Requirement of soil construction formation is caused by anthropogenic influence that destroys a soil cover of territories, or makes impossible to use it. Layers, usually used for creation of soil constructions, have sharply contrast physical and chemical properties and are united in the general system. It inevitably leads to gradual transformation of the soil constructions' properties. The high demand of creation of similar objects, specifics of their structure, clear target orientation lead to requirement of studying of their stability under new conditions and opportunities of performing of soil functions in the present and future. The aim of this research was to study features of functioning and transformation of different soil constructions, depending on their structure and to compare them with natural analogs.

Materials and Methods

The first object of the research was the soil cover of the oil contaminated site in 1994, located near the "Vozei - Headworks" oil pipeline (66 ° 25'N, 57 ° 18'E) in Usinsky district in the north of the Komi Republic. In this work, investigations of one of the methods of reclamation carried out with the replacement of the contaminated layer with sand and placement of soil enriched in sewage sludge on its surface with a layer of 15-30 cm are presented. Two variants of soil (automorphic and hydromorphic regions) were chosen. A comparative analogue was the background tundra gley peaty soil, with a sharp division of the profile into organic and mineral layers. The next object of the research was soil land reclamation constructions, created 20 years ago in the open-cast ore mining of the Kursk Magnetic Anomaly (the Belgorod Region) and have been under agricultural use since that time. Land reclamation consisted in creating 60-cm soil chernozem layer above the thick sand layer. Its natural analogue was virgin chernozem typical of the Central-Chernozem State Natural Biosphere Reserve named after prof. V.V. Alekhin under the relic oak forest of the Dubroshin tract (coordinates 51 ° 33'55.2 "N 36 ° 05'15.4" E). One more object of the research was complex of soil construc-

tions, created on the territory of Lomonosov Moscow State University for the purpose of greening of the city. There were 2 variants with follow profile's structure: variant 1 – A arable (0-6cm) - lowland peat (6-12cm) – sand (12-18 cm) – A arable (18-30 cm); variant 2 - construction mixed from 3 components (A arable, peat, sand, mixed in the same proportions as in the layered construction). The background was the soil of the same territory (Urbic Anthrosol), the upper horizon, which is represented by horizon A arable.
Data were obtained on the water-physical properties of soils (filtration coefficient, water retention curves, breakthrough curves and properties of the solid phase (granulometric composition, structure, porosity), model filtration experiments were carried out using moisture transfer labels.

Results and Discussion

The layered structure of the profile with the formation of sharp boundaries for the transition of horizons along the granulometric composition is characteristic for all soil structures. Thus, sand layer is located at a depth of 30 cm in the construction of the recultivated territory in the Republic of Komi. However, at a depth of 10-20 cm the filtration almost drops to zero, due to the morphologically and experimentally evolved residual oil contamination and the sharp boundary of the layer transition. In the background soil, waterproof was found in the mineral horizon at a depth of 70-80 cm [1].
Determination of water retention curves revealed the importance of the location of soils along the slope, which determines the degree of their hydromorphism (Fig. 1).

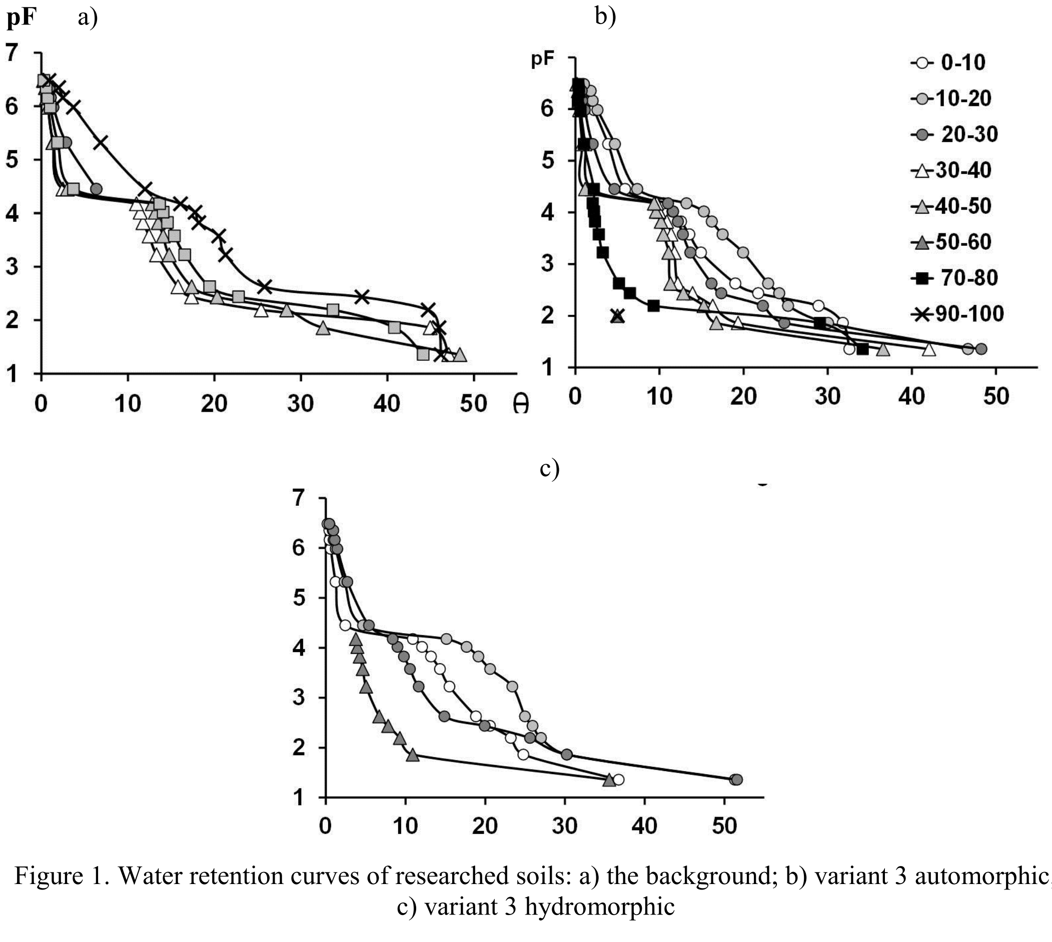

Figure 1. Water retention curves of researched soils: a) the background; b) variant 3 automorphic; c) variant 3 hydromorphic

Water retention curves (WRC) were determined for mineral horizons of background soils and soils with different degree of hydromorphism. It was found, that the mineral horizons of the background soil have a very close water-retaining capacity, with the exception of the 90-100 cm layer, which consistents with the granulometric composition and the presence of gleying. There is a gradual decrease in water retention in the sorption and capillary ranges with depth in the soil of automorphic positions. The maximum water retention was detected at a depth of 10 cm, which is consistent with the reduced filtration in this variant. In the samples of the lower part of the profile the shape of the WRC changed, indicating a less pronounced thin pore space. The differentiation of the water retention profile was more pronounced than in the automorphic in hydromorphic soils. It also has a depth of 10-20 cm with maximum values. And the layer, with the smallest values, analogous to the lower horizon of the automorphic soil, was located closer to the surface - at a depth of 50 cm. Thus, the presence of distinct boundaries of soil layers and soil, which create conditions for the formation of suspended moisture, was revealed, especially with increasing automorphy of the soils.
A technogenic soil (technozem) of the Kursk Magnetic Anomaly was created on the surface of the former sludge pond of the iron-ore quarry in the course of land rehabilitation [2, 3]. The upper chernozemic layer in the technozem was underlain by the sandy or loamy layers. Field studies of water flows in this soil with the use of starch label and laboratory experiments on infiltration of salt solutions though the soil columns with determination of breakthrough curves demonstrated the existence of preferential water flows in technozem. Rapid infiltration of water through preferential water paths in chernozemic layer after abundant rainfalls and during the snowmelt season leads to the development of perched water above the textural boundary. The water regime of these soils differed from the water regime of background automorphic natural soils and was characterized by the periods of water stagnation at the boundary between the two layers. In 20 years this type of water regime resulted in the development of a columnar structure in the lower part of the chernozemic layer.
Transformation of soil properties in the process of soil constructions' functioning was studied in detail on a complex of soil constructions with different structures, specially created in 2012 in the territory of Lomonosov Moscow State University [4]. It turned out that after four years of functioning in soils with a sharply differentiated profile (variant 1) at the sand horizon-A arable horizon boundary a horizon with very low water permeability was formed. According to laboratory experiments on obtaining breakthrough curves of chloride and potassium ions, the most heterogeneous and uneven migration of moisture and dissolved substances were observed in layered constructions.
Thus, the conducted researches of soil constructions with different purpose, which were consisted from soil horizons of different genesis, located in different climatic zones, showed a high degree of differentiated profile in terms of physical properties. It leads to periods of waterlogging on the boundary of the layers. This, in turn, is the reason for the transformation of the solid phase of soils, expressed in a changing of the soil structure.

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Efficacy of using trace elements for cotton in meadow-gray soils under the conditions of the Mugan steppe

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Abstract

The article is devoted to the study of the application and influence of microelements (Mn, Zn, Cu) on the growth and development of cotton on meadow-gray soils of the cotton zone of Azerbaijan. Meadow-gray soils are fairly widespread in the cotton zone of Azerbaijan. The development of these soils takes place underground moistening conditions, which occur at depths of groundwater from 2,5 to 3,0 m, depending on the water-physical properties of these soils and on the nature of the soil-forming rocks. The process of humus formation in meadow-gray soils is very intensive. The humus content is 1.8-2.2%. The reaction of the soil medium is neutral or strongly alkaline. The pH varies from 7,2 to 8,2. The profile of the soils described by the granulometric composition is well differentiated. The soils described are heavily clayey or clayey. The results of soil analyzes on the agrochemical characteristics of the experimental section show that the content of humus in them varies from 1,85-2,0%, as well as total nitrogen 0,16-0,18%, absorbed ammonia 12.07-7231 mg/kg, mobile phosphorus 32,5-41,2 mg/kg, exchangeable potassium 114-155,4 mg/kg. Accor-ding to the agrochemical characteristics of the soils of the experimental area, it can be noted that they differ in lower fertility, both in the reserves of the humus and in the content of nutrients.As microfertilizers, Mn, Zn and Cu are taken. To avoid leaching of trace elements by irrigation and atmospheric precipitation, microfertilizers were introduced into the cotton budding phase together with nitrogen and phosphorus fertilizers, i.e. - into the first fertilizing.Based on the data obtained, we can say that the introduction of manganese, zinc and copper against nitrogen, phos-phorus, and potassium promotes not only an increase in the yield of raw cotton, but also an improvement in the nutrient regime of the soil.

Key words: microelement, macroelement, microfertilizer, soil, cotton, fertilizer, nutrient.

Introduction

Meadow-gray soils are fairly widespread in the cotton zone of Azerbaijan. More significant areas are concentrated in the Kura-Araks lowland.

Soil-forming rocks for meadow-gray soils are deluvial-alluvial loams and young saline alluvial layered loams. The development of these soils takes place under conditions of ground moistening, which occur at depths of groundwater from 2.5 to 3.0 m, depending on the water-physical properties of these soils and on the nature of the soil-forming rocks. The process of humus formation in meadow-gray soils is very intensive. The humus content is 1.8-2.2%. The composition of humus is predominantly humate-fulvate. The reaction of the soil medium is neutral or strongly alkaline. The pH varies from 7.2 to 8.2. The profile of the soils described by the granulometric composition is well differentiated. The soils described are heavily clayey or clayey. It should be noted that materials on the effect of macroelements on the growth and development of plants growing in meadow-grey soils are sufficiently abundant, but materials on the study of the effect of trace elements on agricultural crops are quite rare.

Materials and Methods

On the basis of the studies carried out on the agrochemical characteristics of the soils of the experimental site, it can be noted that these soils are characterized by lower fertility, both in terms of humus and nutrient content.

It is known that nitrogen for the growth and development of plants is of primary importance, since it is part of the protein and is 16 to 18% of the weight of the ash, and is also a part of chlorophyll, the content of which depends on the process of photosynthesis. With excess nitrogen and one-way nitrogen nutrition of cotton, an excessive vegetative mass develops and the development of reproductive organs is weakened.

With a large lack of nitrogen in young plants, there is a slight growth, reduced fruit formation and a small weight of the boxes.

Phosphorus directly, in contrast to nitrogen, is not part of the protein, but is an integral part of nucleic acids, which in combination with a simple protein form complex protein-nucleoproteins. In contrast to nitrogen, abundant phosphorus nutrition of cotton strengthens the development of reproductive organs, accelerates the development of plants and maturation of the boxes.

Potassium is found mainly in leaves, buds and growing shoots. A sharp lack of potassium causes the death of old leaves, while the young leaves still remain healthy. With a lack of potassium, plants are more affected by fungal diseases. Usually, potassium in plants contains 30-50% of the weight of ash [3].

It should be noted that in the ashes of plants on a number of macro elements (N, P, P) also contain micro elements. The amount of microelements entering the plants is different, it depends on the type of plants and soil-climatic conditions.

It should be noted that the main sources of microelement supply to the soils of the cotton-growing zone of Azerbaijan are their parent rocks.

As is known from the literature data, microelements, including manganese, zinc and copper, are necessary for plants, since they enter into the composition of enzymes [1].

It is established that manganese plays an important role in the respiration of plants and in the processes of photosynthesis. It increases the respiration rate of plants and the intensity of assimilation of carbon dioxide, plays the role of a catalyst in the assimilation of nitrates by plants. When manganese is introduced, the yield is increased and the quality of raw cotton is improved, the number of fallen reproductive organs in cotton is markedly reduced. Excess manganese is harmful.

Copper in plants contains a small amount, it is necessary as a catalyst in the formation of chlorophyll. The average content of copper in the soil is $1 \cdot 10^{-3}$% and it is present in all varieties of soils. The lack of copper in the soil causes serious functional diseases of plants, in the raft before their death.

According to the literature, it is known that the greatest amount of copper is found in the generative organs of plants. In addition, the content of copper in plants depends on the phase of their development. With a lack of copper in the soil, the development of cotton deteriorates sharply.

Zinc is necessary for plants in small quantities. The average content of zinc in soils is 5.10^{-3}%. Despite the fact that the value of zinc for higher plants was proved by K.A. Timiryazev in 1872, attention to the physiological significance of zinc in the life of plants drew only in the fifties of the twentieth century. The amount of zinc absorbed by the plants is very small, regardless of the dose and source of nutrition. Depending on the specific features of plants, the content of zinc in them varies between 17-66 mg/kg dry matter. Despite the numerous materials devoted to the study of the influence of zinc on various agricultural crops, relatively little research has been conducted on cotton in this respect [2].

To study the effectiveness of introducing microelements for cotton, field experiments were conducted, as mentioned above, in meadow-gray soils. The size of the plot is 50 m^2 with triplication and 4 irrigations.

For agricultural practice, the establishment of the gross content of microelements will make it possible to justify the need for soils of microelements of migration phenomena, etc. In determining the reserves of trace elements to be studied, soil samples were taken in the soil and manganese, copper and zinc were determined in them. The analysis data show a well-marked accumulation of these elements in the upper humus horizons. The total content of manganese in the humus horizon is 430-520 mg/kg, copper 12.5-18.5 mg/kg, zinc 16.0-28.2 mg/kg and correlates well with the humus content of the soils of the experimental site.

Results and Discussion

The results of analyzes of soils according to the agrochemical characteristics of the experimental plot show that the content of humus in them varies from 1.85-2.0%, as well as total nitrogen 0.16-0.18%, absorbed ammonia 12.07-22.31 mg/kg, mobile phosphorus 32.5-41.2 mg/kg and exchange potassium 114-155.4 mg/kg. Also, analyzes showed that the presence of mobile microelements ranged from: manganese 16-22 mg/kg; copper 1-1.8 mg/kg; zinc 1,2-2,4 mg/kg.

According to the data obtained, it can be said that the soils of the experimental site need both macro and micro elements.

For the purpose of field experiments on the study of the most effective doses of microelements, the task was also set by the definition of more rational periods for the introduction of microfertilizers for cotton.

Experiments were laid on the background of nitrogen and phosphorus fertilizers. In our experiments, doses were taken that were equated with the nitrogen used for meadow-grey soils, 60 kg and phosphorus - 90 kg per 1 hectare. At the same time, 60% of the total dose of phosphorus was applied for basic plowing and 40% of additional fertilizing. 50% of the total dose of nitrogen fertilizers was applied to the soil before sowing, and the remaining 50% to fertilization.

Despite the fact that potassium fertilizers against the background of nitrogen and phosphorus favorably influence the growth and development of cotton plants in the experimental plot, they were not used due to the fact that meadow-gray soils are more or less provided with potassium.

On the experimental plot, against the background of macroelements, microelements - manganese, zinc and copper - were applied to cotton. As a microfertilizers, zinc sulphate, copper and manganese are used. In order to avoid leaching of microelements by irrigation and atmospheric precipitation, microfertilizers were introduced by us into the cotton budding phase together with nitrogen and phosphorus fertilizers, etc. into the first fertilizing.

Data on the increase in the yield of raw cotton from various doses of microelements confirmed the advantage of root fertilizing of plants, which is introduced to a depth of 10-15 cm after mixing with nitrogen and phosphorus fertilizers, at the beginning of the cotton budding phase. Almost all three microelements when applied at medium doses at the beginning of the cotton budding phase gave the best results. For example, the addition of manganese (2 kg/ha) gave an increase of 23.6%, copper (2 kg/ha) 13.9%, zinc 17.4% compared to the background (16.5 c/ha). Based on the data obtained, it can be said that the introduction of manganese, zinc and copper against nitrogen, phosphorus, and potassium promotes not only an increase in the yield of raw cotton, but also an improvement in the nutrient regime of the soil.

Conclusion

From the above studies on the use of microelements it follows that trace elements such as manganese, copper and zinc play a large direct and indirect role in physiological processes, increasing the yield of plants and improving its quality. Therefore, in the case of a lack of meadow-grey soils of these elements, they must go into the system of feeding crops, especially when cultivating cotton.

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Content of labile organic matter in irrigated meadow-chernozem soils as an indicator of their agroecological state

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Abstract

The labile pool of soil organic matter is an informative indicator of an agroecological state of soils of agro-landscapes at their intensive use in agriculture. Labile humus substances are a direct source of nutrition and energy for living organisms, participates in the formation of water-soluble aggregates and have a protective function in respect of a conservative part of organic matter. The aim of the study was to determine the level of content of labile organic matter in continuous irrigated lugovo-chernozem soils, used in vegetable and grain-grass crop rotations, to assess the degree of their depletion and resistance to anthropogenic loads.

Under conditions of continuous irrigation the content of labile organic matter (LOM) and energy reserve accumulated in it increase in the row: vegetable crops – cereals – annual grasses – perennial grasses. Minimum reserve of energy, very low and low content of labile humus substances establish in the soil, intended for the cultivation of vegetable crops. With the development of the grain-grass crop rotation, the amount of LOM in the soil increased to the middle and high values, and reserves of energy – to low and middle values. The regular application of mineral fertilizers against the background of irrigation contributes to the increase in the LOM content and energy reserves in it.

Key words: labile organic matter, irrigation, humic acids, fulvic acids, reserves of energy.

Introduction

Labile organic matter (LOM) performs protective functions with respect to a conservative part of organic matter; it also accumulates energy available to living organisms. When there is a deficit of LOM, more stable components of an organic part of soil are destructed, which is accompanied by the development of processes of its chemical and physical degradation. LOM is most sensitive to changes in the level of agricultural technology, farming systems, crop rotations, doses and fertilizer types and can serve as an early indicator of a diagnosis of changes in soil fertility. In soils of agricultural landscapes, especially under conditions of an extensive farming system, the volumes of incoming plant biomass are sharply reduced, a deficit of fresh organic matter is observed, which causes a decrease in LOM quantity. The main factor influencing its content under conditions of regular irrigation is additionally incoming moisture, which contributes to the creation of favorable hydrothermal conditions for the microorganism development during arid and hot periods. With a lack of fresh organic matter, they begin to utilize mobile organic substances, some of which are also capable to migrate with irrigation water to the lower part of a soil profile.

The aim of the study was to determine the level of content of labile organic matter in long-irrigated meadow chernozem used in vegetable and grain-grass crop rotations, the level of energy reserves accumulated in it, to assess the degree of depletion (ploughing-out) of soils and their resistance to anthropogenic loads.

Materials and Methods

The objects of the research are meadow chernozem soils formed in the southern forest-steppe zone of Omsk region on the territory of the Siberian Research Institute of Agriculture (SibRIA) and Novoomskoe irrigation system (IS). The soil of the experimental plot of the

Siberian Research Institute of Agriculture is meadow chernozem, medium thick, heavy loamy with middle humus content; it is used in the grain-grass crop rotation. Irrigation is carried out with the waters of the Om River during more than 35 years. The average irrigation rate for annual crops is 300 m^3/ha, for perennial grasses – 450 m^3/ha.

The soil cover in the territory of the Novoomskoe IS is represented by meadow chernozem, medium thick, low-humus, heavy loamy soil, used for the cultivation of vegetable crops. Irrigation is carried out with the waters of the Irtysh River during more than 30 years.

In 2016–2017 the study of the LOM content and energy reserves in it was conducted for the soil layers of 0–20 and 20–40 cm in the following variants of the experiment: 1) beans, the background without fertilizers, the background with $N_{30}P_{60}$; 2) grass mixture of brome and alfalfa of the 6th year of life, the background without fertilizers, the background with $N_{60}K_{60}$; 3) sorghum, the background without fertilizers, the background with $N_{60}P_{60}$.

On the territory of the Novoomskoe IS there were three fields: 1) beet; 2) beet; 3) potato.

The following parameters were determined:

- humus content according to the Tyurin's method in the modification of Simakov V.N.;
- mobile organic matter (MOM) content by the extraction with 0.1N NaOH and water;
- energy reserves in mobile humic acids and organic matter according to the methodology of the All-Russian Research Institute of Farming and Soil Protection from Erosion [5];
- the degree of depletion (ploughing-out) of soils according to a 15-point scale developed for chernozems of the forest-steppe and steppe zones [1] and gradations for the Siberian region [6].

Results and Discussion

MOM is a group of substances that are part of the labile organic matter of soil, which include nonspecific organic substances, the products of vital activity of living organisms, prohumic substances, newly formed humus compounds, humic acids that are loosely associated with the mineral part of the soil [2]. The content level of substances of this group in the soil depends on the crop rotations used, cultivation systems, organic and mineral fertilizers, and a number of other factors [3]. A high content of MOM (Table 1) was determined in the soil layer of 0–20 cm under the grain-grass crop rotation, where perennial and annual grasses (up to 50%) supply a considerable amount of fresh organic matter in the soil as plant residues.

Table 1. Content of MOM in irrigated meadow-chernozem soils

Option	C_{total}, %	Content of carbon of humus substances					Degree of depletion, score
		water soluble	alkali-hydro-lyzed	rating	water soluble	alkali-hydrolyzed	
		mg/kg			% from C_{total}		
Extensive system of bogharic farming, field crop rotation (SibRIA)							
Spring wheat	3.84 3.56	400 400	6561 6252	high	1.04 1.12	17.2 17.7	0
Extensive system of irrigation farming, grain-grass crop rotation (SibRIA)							
Beans	4.21 3.69	600 400	4804 4297	high medium	1.43 1.08	11.4 11.7	3.6 3.3
Sorghum	4.01 3.63	700 600	5282 4060	high medium	1.75 1.65	13.2 11.3	1.8 3.7
Grass mixture of brome and alfalfa of the 6th year of life	4.10 3.77	700 500	6429 5232	high	1.71 1.32	15.4 15.4	0

Continuation of table 1

Intensive system of irrigation farming, grain-grass crop rotation (SibRIA)							
Beans	4.48 4.15	500 600	6576 6138	high	1.12 1.45	14.7 14.7	0.3 0.3
Sorghum	4.14 3.85	600 500	5260 4077	high medium	1.45 1.30	12.8 10.6	2.2 4.4
Grass mixture of brome and alfalfa of the 6th year of life	4.41 4.16	700 600	7342 6574	high	1.59 1.44	16.6 16.3	0
Extensive system of irrigation farming, vegetable crop rotation (Novoomskoe IS)							
Beet	2.55 2.73	600 600	3493 3455	medium	2.35 2.20	13.7 12.8	1.3 2.2
Beet	2.93 2.78	500 500	3570 3807	medium	1.71 1.80	12.3 13.7	2.7 1.3
Potato	3.44 3.41	700 700	3906 3905	medium	2.03 2.05	11.3 11.4	3.7 3.6

the numerator is the layer of 0–20 cm; the denominator is the layer of 20–40 cm.

When the plant material is decomposed, LOM forms, the content of humic acids increases due to the binding of exchange calcium to the newly formed humic substances, and as a result, the content of total carbon increases. Against the background of the regular application of mineral fertilizers, which improve the nutrient regime of the soil, plants form a large biomass, therefore, against this background there is also an increase in total carbon and a high level of MOM in the layer of 20-40 cm in relation to options with an extensive system of bogharic and irrigated agriculture.

The maximum content of substances in this group is characteristic for the soil of the bogharic area. It can be assumed that at irrigation this indicator is rather lower due to water-soluble compounds, which will be used by microorganisms first of all as the most available source of nutrition, as well as due to their migration with irrigation waters to the lower horizons. Without taking into account a readily decomposable part of organic matter, the degree of depletion of soils under annual crops (beans and sorghum) in the grain-grass crop rotation is very weak and weak.

Energy, the most available to living organisms, is also concentrated in LOM; it can be used when necessary. The fraction of mobile humic acids has the largest energy reserves, it contains from 220–375 GJ/ha (0–20 cm) to 191–304 GJ/ha (20–40 cm) of energy. The energy resources of a fraction of mobile fulvic acids are 2 times lower than that of humic acids, the energy accumulated in them does not exceed 107–174 GJ/ha in the 0–20 cm layer and 95–169 GJ/ha in the 20–40 cm layer. The energy reserves in the organic matter (OM) of the soil are set at the level of 3313–3947 GJ/ha in the case of the extensive system and of 3313–4237 GJ/ha in the case of the intensive system of farming.

Under vegetable crops, the content of MOM is significantly lower, since a significant part of biomass is alienated with the yield, and an insufficient amount of plant residues enters the soil, as indicated by a low content of total carbon and humic acids. At the same time, an increased amount of the water-soluble part of humic compounds and reduced amount of the alkaline-hydrolyzable part is observed, which can be connected with a weakening of the bond strength of humus acids with the mineral part of the soil, reduction of their availability to microorganisms and their involvement in the migration process with irrigation waters. The degree of soil depletion (without taking into account the readily decomposable part of organic matter) under vegetable crops is also very weak and weak.

In this territory, energy reserves in mobile humic acids in the soil layers of 0–20 and 20–40 cm vary from 134 to 159 GJ/ha, in fulvic acids – from 72 to 82 GJ/ha. The energy potential of soil organic matter under the vegetable crop rotation is lower by 1000–1500 GJ/ha than under the grain-grass one, and it varies from 1949 to 2606 GJ/ha.

The alienation of up to 50% or more of biomass with the yield in vegetable rotations, the critical level of energy reserves of the soil OM, the low total carbon content and the average content of carbon of LOM, with an increased water-soluble part, makes it possible to assess this agrocenosis as unstable to anthropogenic loads. The admissible anthropogenic load is typical for grain-grass crop rotations [4].

Conclusion

Against the background of irrigation, there is a decrease in the content of MOM. The content of MOM in the soil increases in the row: vegetables – annual crops – perennial grasses. Average energy reserves are characteristic for organic matter of the soil allocated for the cultivation of perennial grasses, low ones – for legumes and cereals (beans and sorghum) against the background of mineral fertilizers. The critical level of the energy potential of organic matter is established in bogharic and irrigated soil against unfertilized backgrounds under grain and vegetable crops. In the layer of 20–40 cm, the energy reserves of soil organic matter for all investigated objects are at a critical level.

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Spatial variability of soil organic matter content in a cultivated field

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Abstract

The aim of soil cultivation is generally to form a homogeneous media to supply optimum growth conditions for seeds and plants. In this study, spatial variability of soil organic matter content (SOM) in a cultivated field was determined by geostatistical method. Conventional tillage was used with a mouldboard plough at a depth of 15 cm in a field. A total number of 49 soil samples were taken from a square grid at 5 m spacing of a 30 x 30 m2 plot selected in the center of field. SOM contents of the samples varied between 2.03 % and 2.98 %. Clay content (31.48 to 43.97 %), bulk density (BD) (1.12 to 1.41 g/cm3), total porosity (F) (46.79 to 57.73 %), volumetric water content (θ) (19.64 to 43.86%), soil pH (6.47 to 7.40) and electrical conductivity (EC) (0.31 to 0.80 dS/m) values also showed variations among the sampling points. In kriging interpolation for the spatial variability of SOM, the biggest r2 (0.766) and the smallest RSS (0.0013) values were determined with Gaussian model. Spatial dependences of the SOM was strong in the field with 6.4 of nugget/sill ratio. The semivariogram of SOM showed spatial dependence with a range of 157.61 m. SOM had significant positive correlations with clay (0.365**), F (0.287*) and significant negative correlations with BD (-0.286*), θ (-0.362*) and silt (-0.429**) content. This study showed that spatial variability of SOM in arable fields can be predicted for precision agricultural practices and monitoring organic carbon in global warming researches.
Key words: Soil organic matter, cultivation, soil properties, spatial variability, kriging.

Introduction

Spatially variables influencing crop yields are usually soil related, anthropogenic, topographic, biological, and meteorological factors (Tanji, 1996; Corwin, 2012). Knowledge of the spatial variation of soil properties is important for crop production in precision agricultural management systems. It has been known that most soil properties are spatially variable in a field (Burrough, 1993). Iqbal et al. (2005) reported that spatial variability of soil properties in any field position is inherent in nature due to geologic and pedologic soil forming factors, but some of the variability may be induced by tillage and other management practices. Benefits from soil tillage are known as i) improvement of soil-air-water relations in seedbeds, ii) control of undesired vegetation, and iii) reduction of the mechanical impedance to root growth (Gardner et al. 1999). Soil tillage practices causes changes to soil structure and hydraulic properties dynamically in space and time (Mueller et al., 2003; Strudley et al. 2008). The ordinary kriging is one of the most common methods in spatial interpolation of soil properties after estimating semivariogram parameters of soil properties using geostatistical tools (Goovaerts, 1998; Utset and Greco, 2001; Castrignano et al., 2003; Zhao et al., 2009). Strudley et al. (2008) reviewed tillage effects on soil hydraulic properties in space and time. They have found little work on small-scale spatial variability in soil hydraulic properties resulting from tillage practices. The objective of this study was to determine changes in spatial variability of soil organic matter content in a cultivated field by geostatistical method.

Materials and Methods

This study was carried out on Vertic Haplustoll in the Experimental Field having a 4% slope north to south (41º21´ N, 36º10´ E) direction in Samsun-Turkey. Conventional tillage in 4 ha field was used with a mouldboard plough at a depth of 15 cm. Soil properties were measured in a randomly selected small-scale plot near the center of the field 20 days after soil tillage.

The measurements in 49 different soil sampling points were made in a square grid at 5 m spacing in the 30 x 30 m2 plot. After determining the bulk density (BD) by undisturbed soil core method (Demiralay, 1993), total porosity (F) was calculated using the equation; F=1-(BD/2.65). Gravimetric (W) and volumetric water (θ) contents, soil pH (1:1) and Electrical Conductivity (EC) values were determined (Tüzüner, 1990). Particle size distribution of the surface soil samples (0-15 cm depth) was determined by hydrometer method (Demiralay, 1993). Organic matter contents of the soil samples were analyzed by Walkley-Black method (Kacar, 1994).
The geostatistical analyses were performed with the GS+ version 9, and the correlations among the soil properties were calculated using SPSS program. The semivarince ( ) describing degree of spatial dependence of random variable Z(xi) over a certain distance was estimated from (Trangmar et al., 1985):

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{n} \left[Z(x_i) - Z(x_i + h) \right]^2$$

Where γ(h) is the semivariance for the interval distance class h, N(h) is the number of pairs, Z (xi) and Z(xi + h) are the measured sample values at position i and (i + h), respectively.

Results and Discussion

According to the results of soil analyses, while soil organic matter (SOM) content values varied between 2.03 and 2.98%, bulk density (1.12 to 1.41 g cm-3), clay (31.48 to 43.97%), silt (14.49 to 36.38%), sand (30.11 to 47.57%), volumetric water content (15.19 to 32.56%), pH (6.47 to 7.40) and EC (0.31 to 0.80 dS m-1) values showed variations among the sampling points at the cultivated field (Table 1). Ogunkunle (1993) reported that soil properties having a coefficient of variation (CV) between 0 and 15 % are considered least variable, 15 and 35%, moderately variable, and bigger than 35% highly variable. The CV values of the soil properties indicated that the most soil properties are least variable while EC values having 22.41% of CV was more variable than the other soil properties at the field.
Skewness and kurtosis values and frequency distributions for clay, BD, SOM, θ, pH and EC indicated that the soil properties usually showed normal distribution (Table 1, Figure 1). Therefore, the original values of soil properties were not transformed. Warrick and Nielsen (1980) reported that the spatial variability of the static soil physical properties is commonly fitted to normal probability distributions; whereas the dynamic properties, related to water or solute movement, are usually lognormally distributed. Veronese-Junior et al. (2006) reported that moisture content values for Brazilian Ferralsol showed normal distribution. Utset and Greco (2001) found that BD in 30 x 30 m2 plot of Rhodic Ferralsol are normally disturbed.

Table 1. Descriptive statistics for the soil properties

	Minimum	Maximum	Mean	Std. Dev.	CV, %	Skewness	Kurtosis
Clay, %	31.48	43.97	38.31	2.92	7.62	0.030	-0.785
Silt, %	14.49	36.38	22.54	3.42	15.17	1.266	4.907
Sand, %	30.11	47.57	39.15	3.74	9.55	0.209	-0.463
BD, g cm^{-3}	1.12	1.41	1.27	0.067	5.28	0.016	-0.109
W, %	15.19	32.56	24.32	3.24	13.32	-0.069	0.681
Θ, %	19.64	43.86	30.87	4.70	15.22	0.223	0.625
SOM, %	2.03	2.98	2.52	0.23	9.13	-0.254	-0.419
pH(1:1)	6.47	7.40	6.84	0.184	2.69	0.446	0.851
EC, dS m^{-1}	0.31	0.80	0.531	0.119	22.41	0.151	-0.476

OM: organic matter, BD: bulk density, W: gravimetric water, Θ: volumetric water.

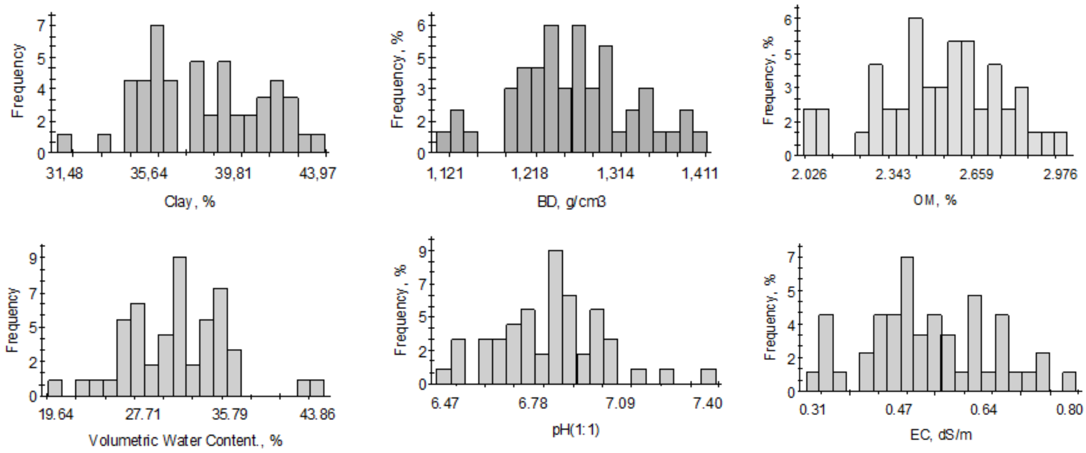

Figure 1. Frequency distribution of the soil properties

To evaluate the spatial variability of the soil properties, the exponential model for clay content and BD and the Gaussian model for SOM and θ were selected with their biggest r2 values and the smallest residual sum of squares (RSS) values using the GS+9 package program (Table 2). The semivariograms of the soil properties indicated that the range in spatial correlation varied among soil properties. The range indicates the distance in a field where measured properties are no longer spatially correlated. Measured properties of the samples at a distance less than the range become more alike with decreasing distances between them (Tabi and Ogunkunle, 2007). The shortest range (19.67 m) was observed for BD and the longest range (157.61 m) was observed for SOM content.

The nugget effect, which represents random variation caused mainly by the undetectable experimental error and field variation within the minimum sampling space (Cerri et al., 2004; Aşkın and Kızılkaya, 2006), was higher in θ content than in the other soil properties. Generally, the nugget values close to zero for the physical properties revealed that all variances of the soil properties were reasonably well explained at the sampling distance used in this study by the lag. A variable has strong spatial dependency if the ratio of nugget/sill is equal or less than 25%, moderate spatial dependency if the ratio is between 25 and 75%, and weak spatial dependency if the ratio is greater than 75% (Cambardella et al., 1994; Bo et al., 2003). Generally, strong spatial dependency of soil properties is related to structural intrinsic factors such as texture, parent material and mineralogy, and weak spatial dependency is related to random extrinsic factors such as plowing, fertilization and other soil management practices (Zheng et al. 2009). The ratios of nugget/sill in the soil physical properties, except BD, were less than 25% in Table 2. Therefore, spatial dependence values for SOM and the other soil properties were strong. Spatial dependence of BD was moderate due to having 44.91% nugget/sill ratio. This indicated that soil plowing as an extrinsic factor weakened spatial dependency of BD in the field. Cressie and Horton (1987) found that there was a strong spatial dependence (12 m lag distance) in infiltration rates for a silty clay loam undergoing moldboard plowing.

Table 2. Models and parameters for the soil properties

	Model	Nugget, (C_0)	Sill, (C_0+C)	$C_0/(C_0+C)$	a	r^2	RSS	Cross Val. r^2
Clay	Exponential	3.750	28.490	13.16	80.19	0.723	16.20	0.541
BD	Exponential	0.00269	0.00599	44.91	19.67	0.786	7.68E-7	0.122
SOM	Gaussian	0.0320	0.4990	6.40	157.61	0.766	0.00131	0.292
θ	Gaussian	12.90	76.80	16.80	79.07	0.750	276	0.040

(SOM: soil organic matter, BD: bulk density, volumetric water content)

Block-kriged maps of the soil properties were created by GS+ 9 program (Gamma Design, 2010), using 0.32 x 0.32 m2 grid system with 8836 points (Figure 2). While the SOM content values increased from the east to the west part of field, the lowest SOM content values were obtained at the northeast part of field. Similarly, clay content in soil generally increased in the east to west direction of the plot. On the contrary, high BD is found in the eastern part of the plot. It is known that the variation in bulk densities is the result of differences in soil texture, organic matter contents and management practices (Wolf and Snyder, 2003).
Soil OM content had significant positive correlations with clay (0.365**) and total porosity (0.288*), while it gave negative correlations with BD (-0.286*), silt (-0.429**), W (-0.288*) and θ (-0.362*) contents (Table 3). Organic matter increases the soil's capacity to hold water by direct absorption of water and by enhancing the formation and stabilization of aggregates containing abundance of pores that hold water under moderate tensions (Weil and Magdoff, 2004). Volumetric water content had a significant positive correlation with BD (0.480**).

Table 3. Correlation matrix among the soil properties

	Clay	Silt	Sand	BD	F	W	θ	pH	EC
SOM	0.365**	-0.429**	0.157	-0.286*	0.288*	-0.288*	-0.362*	-0.034	0.178
Clay		-0.495**	-0.313*	-0.358*	0.362*	-0.347*	-0.431**	0.176	0.007
Silt			-0.671**	0.139	-0.127	0.211	0.232	-0.139	0.007
Sand				0.153	-0.170	0.066	0.114	0.002	-0.013
BD					-0.995**	0.159	0.480**	-0.138	0.018
F						-0.144	-0.466**	0.134	-0.015
W							0.942**	0.067	0.087
θ								0.019	0.082
pH									-0.602**

**correlation is significant at 0.01 level, *correlation is significant at 0.05 level. (SOM: soil organic matter, BD: bulk density, W: gravimetric water content, θ: volumetric water content,)

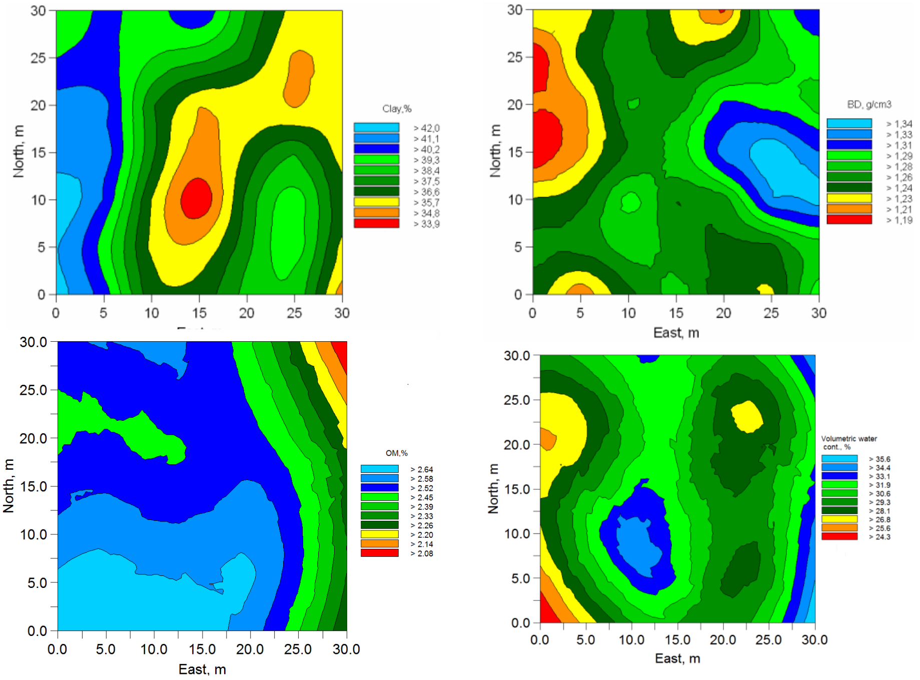

Figure 2. Block kriged maps for clay content, bulk density (BD), soil organic matter content (OM) and volumetric water content

Conclusion

According to the CV values, SOM and the other soil properties, except clay content, showed less variation in the field. Generally, the range or the distance of spatial dependence for the soil physical parameters, except BD, varied between 79 m and 157 m. These are the distance between two sample-collecting points for soil properties in the field. While the BD had moderate spatial dependence, the other soil physical properties had strong spatial dependence with having lower nugget/sill ratio less than 25%. Strong spatial dependency of the soil properties may be attributed to clay content, and moderate spatial dependency of BD can be attributed to effect of soil tillage. There were strong relationships among the soil properties. Kriged maps illustrated positional similarity between the SOM content and related with other soil properties along the small scale plot of cultivated field.

As a result, SOM showed high spatial variability even if in the small-scale plot cultivated for preparing suitable seed bed and plant growth soil conditions. Therefore, in precision agricultural, heterogeneity and variation of soil properties such as, SOM, BD and water content in a field due to soil plowing should be taken into consideration for a successful site specific management. The spatial variability of SOM in cultivated fields can also be predicted for monitoring organic carbon in global warming researches.

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Ecoethic problems of saline and salty soils in Azerbaijan

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Abstract

Salinization of plain soils in our Republic has a special place within the ecoethic problems. Saline soils spread widely in Azerbaijan. Approximately about 60% of the Kur-Araz lowland soils whose total area is 2.2 million hectares, became medium and strongly saline soils. In addition, saline soils are spread in Siyazan-Sumgait, Jeyranchol areas, in the Nakhchivan Autonomous Republic and other areas of Azerbaijan. In general, moderate and intensive saline soils in the territory of our Republic consist of 1.3 million hectare total area. About 670 thousand hectares of irrigated soils in the country (46.4%) are situated in Kur-Araz lowland. The irrigation herein has an ancient history. In Mill plain and in the south of Mughan plain the traces of irrigation canals are found and remain even today. The main issue of sail washing is removal of salts from soil where plant roots spread. Plant roots spread layer implies one meter upper layer of the soil as most of the agricultural crops or their root systems are in whole or partially spread under one meter. Light and medium mechanical composition soils are easy to clean as their water-leakage ability is great. The soils with weak water leakage have some typical features like poor water absorption capacity, unstructured condition, crusting over, difficulty in water and salt secretion. The existence of these features makes the melioration of soils more difficult; for preparation of soils with heavy granulometric composition for sowing; additional ameliorative measures are required, unlike light soils. The main objective on application of agro-biological complex in melioration of saline soils is to attract calcium salts to planting layer of soil and loosen hardened edges of the saline layer. In this case, the gaps increased in all soil profile, arises in good conditions increasing the depth of precipitation and irrigation water absorption, increases moisture reserves in soil, physical and chemical processes are accelerated and melioration of hazardous sub-stances from soil with washing process easily.
Key words: salinity soils, mineralization, granulometric composition, soil fertility, humus.

Introduction

The more aggravated global problems mankind faces at present time, the more complex their comprehension in new way and reveal of the ways of their solution becomes. One of these global problems is the ecological situation of the world. With the lapse of time the mankind becomes more comprehensive of that while traditional views and methods in use of the nature, existing for thousands of years, remain unchanged. In addition the prevention of the approaching ecological crisis will be not only impossible, but its fast growing scale and damaging influence will be attracted also in global social-economic development. If in 70-80th of XX century, the condition of the global ecology and protection of the natural wealth was considered the second big problem happening to mankind after the war and peace problems, the end of "cold war" period and elimination of the global danger of heat-nuclear war become urgent and the top problem. During thirties-fifties of the past century fast integration of scientific-technical revolution into human society and start of the wide scale interferences in nature under the slogan "don't wait for mercy from the nature, subordinate it to yourselves" expedited the crisis in global ecology and brought its complications from local and regio-nal levels up to the global level. Pollution of the water basins and atmosphere, destruction of the tropical forests that are considered "the lungs" of our planet, the problems related to widening of the ozone flues, global climatic changes, global desertification, decrease of global biodiversity reached undesired extent. During the last ten - year destruction of the thousands of vegetation and animal species, the rare landscape and ecosystems started becoming more wide scale. In U.N.O. annual report concerning the environment, it is said that "During 1984-1994 the industrial reserve of 5 fish species in Atlantic Ocean decreased by 95%”. At the present time more than 15 million vegetation and animal species exist in the world. The research shows that about 100 species of them are destroyed every day. But their destruction in most cases occurs to be unknown for people. The danger that these losses will create for biosphere in the future has not been studied yet. But one truth is known that the mankind will have to suffer very great troubles due to these losses in the future [4, 5].

Results and Discussion

In the XX century increase of population in Republic also created some ecological problems and resulted in intensification of anthropogenic factors in natural ecosystems. The population of Azerbai-jan Republic was 8 million 141 in the beginning of 2002. We should notice that this increase is not connected just with natural growth. The number of population has increased by approximately 1 mln persons that is 12,5% in comparison with 1990. It was caused also by immigration of about 250 thousand refugees in Azerbaijan as a result of deportation of Azerbaijanians living in Armenia. The other reason is the occupation of 20% of territory of the Republic by armed forces of Armenia which resulted habitation of more than 700 thousand people living in those territories in other regions of the Republic as forced refugees. Thus one more ecological problem was created as a result of Armenian occupation. In general, the fact that approximately 12% of the territory of republic is refugees and forced migrants and approximately 20% of its territories are under occupation affected not only the economy of the country and life condition of the population but also the ecological situation. Though the sources polluting the atmosphere are assembled in local territories in our republic (Baku, Sumgayit, Ganja, Ali Bayramli, Mingachevir), regarding the geographic position of these points and great amount of wastes, the influence of pollution is observed to some extent in 50-60% of the territory of the republic. At the end of 1980s, in the beginning of 1990s when the heavy industry, especially chemical, oil-chemical, black and non-ferrous metallurgy enterprises were working with full power, 2635 ton waste materials or 376 kg waste per capita were thrown in atmosphere annually in our Republic. This indicator in Ali Bayramli was 2000 kg, in Mingachevi r – 1300 kg, in Baku – 800 kg, in Sumgayit – 480 kg, Ganja – 380 kg. The content of these wastes consisted of a number of gases (sulphur antihydride, carbon oxide, nitrous oxide, sulphur gaze, flor, chlorine compounds) and heavy metals [6, 7].
In our republic pollution degree of water basins is sobering and worrisome. We should especially indicate the condition of the Kur River where 200-250 thousand cube meters of 1 mln. cube meters of wastewater, the share of the Kur river, poured in the Caspian Sea every day, let alone the collector-drainage water measured by big figures, we can get the correct estimate scale of pollution in the Kur river. The researches show that pollution of the Kur in part till Shamkir and Mingachevir reservoir storages is because of the countries where it passes through namely Turkey and Georgia and in the lower currents because of wastewater poured from a number of centers of population and waste bro-ught by Araz. In twenty settlements in Kur basin the installations cleaning biologically of the wastewater is operated, and just in thirty settlements there are sewer systems. In settlements where there is not a canalization system, the wastewater is poured in ponds, aryks, ditches and pit areas. Being absorbed in soil and mixing with groundwater this water worsens sanitary-hygienic condition of the settlement. It is a constant danger for health of the population [2, 3]. Natural aridization processes generated because of farm activity of the people, expansion of residential communities, as well as global climatic changes. On top of that due to some other reasons the bottom border of these forests raised up in all natural-geographic territories from 100 m to 400 m. Reduction of territories of mezophile forests functioning as water protector and soil protector in middle and high mountainous territories cause more anxiety. Use of the territories of the border of these forests with alpine and subalpine grassland and grassland-steppe landscape zones, of

summer pastures in intense graze and conduction of sowing works here, from time to time, has weakened restoration mechanism of the forests, and this caused the fall of border of high mountain forests at the average for 150-200 m (200-300 m in some places) [2, 10, 11].

Salinization of plain soils in our Republic has a special place within the ecoethic problems. Saline soils spread widely in Azerbaijan. Approximately about 60% of the Kur-Araz lowland soils, whose total area is 2.2 million hectares became medium and strongly saline soils. In addition, saline soils are spread in Siyazan-Sumgait, Jeyranchol areas, in the Nakhchivan Autonomous Republic and other areas of Azerbaijan. In general, moderate and intensive saline soils in the territory of our Republic consist of 1.3 million hectare total area. It means that 15% of the territory of the Republic has suffered this ecoethic problem. As a result of carried investigations, it was defined that, 565481 hectares of the 1444.9 thousand hectares or 47.6% of total irrigated suitable for agriculture soils of the country became saline in different degrees (152898 ha or 27% of this less saline, 146235 ha or 25.9% average saline, 223838 ha or 39.6% intensive saline, 42510 ha, or 7.5% salty soils), 508.3 thousand hectares (29.0%) of the different saline degrees (385037 ha or 75.8% of the low saline, 102110 ha, or 20.1% average saline, 21123 ha or 4.1% intensive saline). In the result of assessment of irrigated soils it was defined that 385.1 thousand hectares of soil is insufficient; in addition 103.4 thousand hectares of soil where the level of ground water is near the surface, 115.1 thousand hectares of intensive saline soil, 166.6 thousand hectares are shown as the main reason for the combined effect of both factors. Soils of this category are considered to be useless and a complex measure on their melioration is required. About 670 thousand hectares of irrigated soils in the country (46.4%) are situated in Kur-Araz lowland. The irrigation herein has an ancient history. In Mill plain and in the south of Mughan plain the traces of irrigation canals are found and remain even today. However in XIX century, in Azerbaijan the primitive methods of irrigation had been implemented and irrigated soils – were in the Kur-Araz lowland, in the lower part of the Shirvan and Karabakh river flows, located along the banks of the Kur and Araz rivers. Buried in the areas of flood waters of the Kur and Araz rivers, the soil surface cracks formed due to drying and then the seeds (barley and cotton) were sown, though there have not been vegetation watering, the product was relatively high. In these conditions in 1960s of the XIX century, the Tsarist government had implemented some measures for irrigation of these areas and had started the construction of irrigation canals for the production of cotton to Mugan-Salyan zone in 1900.

Thus, in 1901-1917 the consumption of the main channels of 130 m^3/sec and 209 km in length were built four irrigation systems. Thus, 169 thousand hectares of land had been provided with irrigation water. Back then, the plain areas of Salyan irrigated directly from the Kur River water. Water-lifting irrigation devices were used working with animals. The main defect of irrigation systems was irrigation networks rarity and non-existence of water-throwing network. Therefore, salinization of arable lands began to be observed in the early years, and the population started to use a new area every year. As a result of the irrigation with landfill method 15-20 m^3 irrigation water spent per hectare, ground water level became closer to the surface of the earth, a large scale salinization process spread out. As a result of current situation population and even the service staff began to leave Mughan for other regions. During the First World War irrigation systems had been damaged, hydraulic devices were destroyed, and salinization process accelerated. As a result, the northern region of Mughan suffered from salinization 96%, land fields of Salyan 98% [3, 8, 10]. A similar process occurred in other regions, too. For example, along the left bank of the Kur River the area from Yevlakh to Hajigabul "Black water" swamp was formed and the surrounding area has been exposed to salinization. In the early 1990s, with the collapse of the Soviet Union, former Soviet Republics, including Azerbaijan got their independence. In the first years of the country's economic difficulties, especially lack of funds and financial means due to Armenian aggression, maintaining irrigation systems and reclamation measures were impossible to continue. Silting of the collector-drainage systems, their fully deterioration in some places resulted in the formation of favorable conditions for secondary salinization.

This process manifested itself especially, in Shirvan plain areas even more obvious than where the collector-drainage systems and irrigation facilities were not well developed. In addition, the investigations show that, despite being in stagnation condition for some period, increase in rate of repeated salinization areas is not very high. In recent years, cleaning and other measures in Salyan, Mughan plains collector-drainage systems has created a hope on salinization or secondary salinization which is the most serious challenge to prevent the possibility of Ecoethic problem. Although there is enough experience in the struggle against salinization in the country, there is a need to develop water technologies and scientific-researches. It should be noted that different parts of the Kur-Araz lowland differ from each other for their natural conditions. Therefore, to apply a universal method in restora-tion of saline soils all over the area of the plain is impossible. Individual approach to each case is necessary. According to the amount and type classification of the soils of our country defined by G.Azizov [3] the soils were divided into saline, soda, chloride, sulphate-chloride, chloride-sulphate and sulphate types. Despite of the fact that this classification differs from other classifications proposed for our Republic [9, 10], it generally reflects the real situation correctly.

Degree of salinization is characterized with poison indicators. Salines NaCl, Na_2SO_4, $MgCl_2$, $CaCl_2$, $MgSO_4$, Na_2CO_3, $Na(HCO_3)_2$ are more harmful for plants [9]. The main issue of sail washing is removal of salts from soil where plant roots spread. Plant roots spread layer implies one meter upper layer of the soil as most of the agricultural crops or their root systems are in whole or partially spread under one meter. This layer is called a report layer. Light and medium mechanical composition soils are easy to clean as their water-leakage ability is great. Therefore, based on these factors, taking into account the characteristics of the soil melioration measures, the soils in the Kur-Araz lowland are conditionally divided into three specific groups [1, 3, 10]:

1. Soils with light granulometric composition, capable of high water leak, easily soluble salts (chloride, sulphate-chloride). The soils in the northern and central Mugan, Salyan plain, south -eastern zone of the Kur River in Shirvan and Shirvan plain from administrative point of view cover Sabirabad, Salyan, Netfcala and Zardab administrative districts. To prevent water loss and soil washing is very important to ensure a high yield of soil. In this regard, stripes and periodically washing technology proved its effectiveness and was confirmed. The essence of the strip wash technology is the area defined to be washed is divided into parallel 3-5 lines depending on among-drain distance. The width of the central section 100 m, but the edges of the strips are separated into 50 meters. Washing the first begins with burial of the central zone with water, in the second stage middle strips, and in the third stage the burial of the edge strips continues. The area is prepared for washing generally in intermittent wash. Beds buried with water should be waited for absorption of the water up to depth 1.5-2.0 m. Then the area is to be watered again. By this way washing continues up to reaching required report norm. As a result of the application of both methods, wasting of the consumption water for washing is prevented, the area is cleaned from salts in equal degree, and washing efficiency will be high.

2. Soil salinization with heavy granulometric composition, poor water leakage ability, chloride-sulphate and neutral sulphate type. These soils are mainly spread in the north-west of Karabakh (Ganja, Tartar, partially Barda), excluding the Kur River coastal zone in Shirvan plain (Aghdash, Ucar, Kurdamir, Aghsu regions) and South Mugan (Bilasuvar and Jalilabad). The soils with weak water leakage have some typical features like poor water absorption capacity, unstructured condition, crusting over, difficulty in water and salt secretion. The existence of these features makes the melioration of soils more difficult; for preparation of soils with heavy granulo-

metric composition for sowing; additional ameliorative measures are required, unlike light soils. Heavy washings in the second group soils whose water leakage ability is weak, water passing layer is thick and its location, washing norm volume and other features, below technologies are used.
- In soils where filtration coefficient is 0,10-0,30 m/day, report washing volume rate is 10 m^3/ha the washing should be carried out in the usual way – watering the beds; In soils where filtration coefficient is 0,10-0,30 m/day, report washing volume rate is 10 m^3/ha the washing should be carried out in applying shallow drains; In soils where filtration coefficient is 0,05-0,10 m/day, depth of weak water leakage layer less than 0,6-0,7 m, report washing volume rate is 10 m^3/ha the washing should be carried out in the usual way, by applying prior loosening; In soils where filtration coefficient is 0,05-0,10 m/day, depth of weak water leakage layer more than 0,6-0,7 m, not depending from report washing volume rate the washing should be carried out by applying temporary shallow drains and deep loosening; In soils where filtration coefficient is 0,05-0,10 m/day, depth of weak water leakage layer more than 0,6-0,7 m, not depending on report washing volume rate, the washing should be carried out by applying temporary shallow drains and deep loosening; In soils where filtration coefficient is 0,05-0,10 m/day, depth of weak water leakage layer more than 0,6-0,7 m, report washing volume rate is 10 m^3/ha the washing should be carried out by applying temporary shallow drains and deep loosening; In soils where filtration coefficient is less than 0,05-0,10 m/day, depth of weak water leakage layer more than 0,6-0,7 m, together with applying temporary shallow drains and deep loosening the washing should be carried out by giving chemical ameliorants or permanent power supply; horizontal washing is carried out in deep loosened soils with weak mineralization and salinization level of ground water, and located in the upper layer of soil.
3. Saline and salty soils with heavy granulometric composition, weak water leakage ability, salt which includes soda within composition. Usual washing methods are not rational in soils located in Karabakh and Mil (Barda, Agjabedi, and Imishli regions). Therefore, on these soils the 2nd group of washing is recommended and in addition to washing technology, the application of chemical melioration must also be considered.
Salinization is one of the factors influencing productivity of agricultural plants in irrigated agricultural areas of the Republic. As salinization plays an active role in the ecology of soils in our Republic, it was partially taken as an ecoethic problem by us. Negative effects of salty soils on agricultural plant growth and productivity are associated with existence of sodium in soil composition and sodium within absorbent complex and magnesium captions. V.R.Volobuyev [11] has shown four ways of salinization in the Kur-Araz lowland: Soil formation and soil erosion processes occurring as a result of the alluvial soil salinization enrichment with sodium ions; Salinization emerged as a result of weakly mineralized soil surface water drainage, and with dealluvial way; Salinization before becoming salty as a result of the groundwater capillary impact; Salinization emerged as a result of becoming unsalted of soils. When the amount of magnesium in the soil absorbing complex is less than 20% of the total absorbed bases, such soils are magnesium non-saline, weak magnesium saline if 20-30%, average magnesium saline if 30-40%, magnesium saline intensive case if 40-50% and >50%. Productivity of plants also varies depending on the saltiness. As seen on the table, wheat productivity in weak saline soil is about 30 %, in average saline is 50%, in intensive saline is 75%, in salty soil it is less than 90%. These soils are found in Araz coastal zone, Karabakh plain, Mugan plain of the Kur-Araz lowland zone. Taking into account the formation conditions and characteristics of saline soils to improve and increase their fertility, the following methods are briefly used to solve their ecoethic problems.

Conclusion

1. Chemical melioration method. In this case, the chemical meliorants are given equivalent to their amount of sodium ions in the soil and the alkalinity of soil absorbing complex;

2. Agro-biological method. In this case, agronomic and biological measures complex (through deep plugging and trenching the layers of gypsum and calcium carbonate are used, their solution is provided) is to be applied.
Melioration of saline soils with chemical method is carried out in two phases: In the chemical phase of melioration chemical meliorants of equal amount is given for removal of alcality of soil solution and replacing sodium ion with calcium ion in soil. After that, the favorable soil structure is formed, a water-physical property of the soil improves significantly, and fertility begins to grow gradually as intensive soil microbial processes continue; In the physical phase of melioration – tin the result of ex-change between given calcium salt and sodium cation compressed from absorbent complex, the excessive amount of harmful salts (mainly Na_2SO_4) for agricultural plants within soil solution washed out through water.

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The impact of tillage on soil organic carbon accumulation in clay loam in Lithuania

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Abstract

The research was carried out at the Joniskelis Experimental Station (56°21′ N, 24°10′ E) on a clay loam in the experiment, established in 2006, in order to evaluate the long-term effect of tillage intensity as well as its combinations with practices for soil improvement on soil organic carbon (SOC) in different soil layers. The following tillage systems were investigated: deep mouldboard ploughing (DP); ploughless tillage (PT); ploughless tillage with lime sludge incorporation (PT+LS); cover crop for mulch without autumn tillage (PT+M). Compared to DP the applied reduced tillage systems have led to an increase in SOC content in the 0–10 cm layer, but the trend of SOC declining was observed in deeper layers. In addition, a higher content of clay fraction (CF) C was found in 0–20 cm layer, which indicates an increase in SOC stability due to reduction of tillage intensity. The significantly higher water-extractable organic carbon (WEOC) content in the 0–20 cm layer in PT and PT+M systems shows that reduced tillage maintains soil productivity. The use of lime sludge led to accumulation of SOC in the form of humic substances bounded with calcium in 0–20 cm layer, while the use of PT and PT+M had the opposite effect. More than 50% of humified SOC was accumulated in the fraction strongly bound with soil clay minerals, and tillage did not have an appreciable impact on this soil quality indicator.
Key words: reduced tillage, humified carbon, mobile humic substances, water-extractable organic carbon, clay fraction.

Introduction

The Thematic Strategy on Soil (COM 231, 2006) obliges EU states to monitor and analyse the state of the soil, and to seek to use the soil in such a way that its physical, chemical and biological properties are not reduced, quality and overall productivity will not decrease. Recently, in many countries of the world, including the EU, emphasis has been placed on the decline of agrarian soils area and the deterioration of soil quality. The quality, productivity and sustainability of soil as well as other terrestrial ecosystem renewable components (vegetation, fauna, microbiota) is determined by the ability to accumulate organic matter. The accumulation of soil organic matter (SOM), the main element of which is carbon, is the long-term fixation of atmospheric CO_2 in the soil in durable stable organic forms. Soil organic carbon stocks are affected not so much by climate change, but by changes in land use (Brovkin et al., 2013). The tillage intensity reducing can improve soil quality (Van Groenigen et al., 2010), increase the carbon content in top soil layer (Ogle et al., 2005), result in greater soil biological activity and increase humus content (Slepetiene et al., 2010), but at the same time cause the loss of carbon in deeper soil layers (Blanco-Canqui, Lal, 2008). In order to preserve and increase soil organic matter content in clay loam soils, it is worth to use lime materials (Hontoria et al., 2016), and cover crops for green manure or for mulch (Velykis, Satkus, 2018). It is believe that land use practices with various carbon inputs (such as crop residues, root production, etc.) and losses (through decomposition of organic matter via soil disturbance) would influence on the quantity and quality of SOM (Benbi et al., 2015). The aim of the research is to evaluate the impact of soil tillage intensity and additional improvement measures on organic carbon compounds, depending on their quantitative and qualitative characteristics.

Materials & Methods

Research was carried out at the Joniskelis Experimental Station of the LRCAF, located in the northern part of Central Lithuanian's lowland (56°21′ N, 24°10′ E) on a clay loam soil in the long-term experiment, established in 2006. The effect of reduced tillage as well as the combinations of reduced tillage with practices for soil improvement on soil organic carbon was investigated following the design: 1) deep ploughing (DP); 2) ploughless tillage (PT); 3) ploughless tillage with lime sludge incorporation (PT+LS); 4) no-tillage with cover crop for winter mulch (NT+WM). The soil samples were collected annually after the main crop harvest, eight sub-samples per plot were taken randomly and each soil sample was separated into 0–10, 10–20 and 20–30 cm depth and combined across sub-samples by depth for each plot. All samples were air-dried, visible plant residues were removed, than samples were crushed and sieved through a 2-mm sieve. For SOC, WEOC determination and chemical fractionation an aliquot of the samples was passed through a 0.25-mm sieve. Soil pH was determined by potentiometric method in 1M KCl (1:2.5; w:v). The content of SOC was determined by the Tyurin method modified by Nikitin (1999). WEOC was measured by IR-detection method after UV-catalysed persulphate oxidation. The clay-sized fraction (CF) was isolated according to Schulz (2004); carbon content in CF was determined by Dumas method. SOM was fractionated into three humic acid and four fulvic acid fractions according to the Ponomareva and Plotnikova (1980) version of the classical Tyurin method.

Results & Discussion

It is widely believe that soil disturbance by tillage was a primary cause of the loss of SOC, and that substantial SOC sequestration can be accomplished by changing from conventional ploughing to less intensive tillage. Lime sludge was used three times during the period 2006–2014 to improve soil physical properties and structure, but the soil acidity in the plough layer reached the level of neutral and alkaline soils (pH=7.2) and the upper value of the optimum pH range for agricultural crops (Velykis, Satkus, 2018). The residual lime sludge effect on SOC investigated in this research, without further insertion. Soil pH was significantly higher in PT+LS compared to other treatments, although 6 years after the last liming (Fig. 1). The data presented in Fig. 2 shows that SOC accumulation in the 0–10 cm layer has increased in reduced tillage systems, but only PT and PT+LS showed a significant increase of SOC, however, the deep mould-board ploughing has homogenized soil, and organic carbon is evenly distributed throughout the 0–30 cm layer.

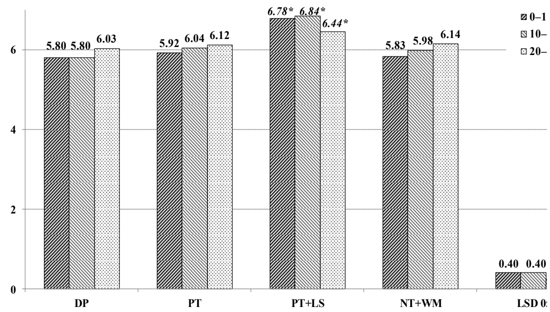

Figure 1. Soil pH (mean data 2015–2017)

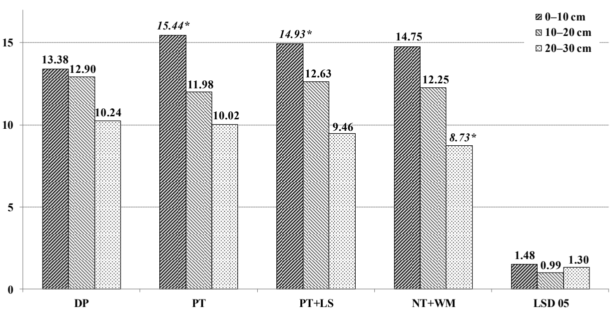

Figure 2. Soil organic carbon content, g kg^{-1} (mean data 2015–2017)

The changes in SOC due to management are difficult to detect whereas these changes are minor and occur very slowly. Labile fractions of SOC, such as WEOC, are more sensitive to soil management. Being a direct reservoir of readily available nutrients, the WEOC affect soil fertility (Popov et al., 2004), and is an appropriate indicator of soil quality. Our study showed that the application of reduced intensity tillage led to an increase in the concentration of easy-mineralized WEOC in 0–20 cm soil layer, and WEOC concentrations decreased with increasing soil depth (Table 1).

Table 1. Distribution of soil organic carbon in fractions of different stability (mean data 2015–2017)

Tillage	Layer, cm	WEOC	CF (<2μm) C	Humic substances (HS)		
				mobile	bound with calcium	bound with clay minerals
		g kg^{-1}		% SOC		
Deep ploughing (DP)	0–10	0.260	8.126	13.07	15.86	31.22
	10–20	0.243	7.520	13.03	16.78	31.17
	20–30	0.218	7.423	12.88	17.70	31.16
Ploughless tillage (PT)	0–10	*0.307**	*8.764**	12.85	16.11	30.94
	10–20	0.251	7.770	12.59	16.55	30.76
	20–30	0.212	7.115	12.05	17.20	30.60
Ploughless tillage with lime sludge (PT+LS)	0–10	0.272	*8.771**	*11.50**	*16.98**	31.79
	10–20	0.245	7.827	*11.59**	*17.97**	31.42
	20–30	0.205	7.096	*11.82**	18.46	30.97
No-tillage with winter mulch (NT+WM)	0–10	*0.305**	8.700	13.36	15.42	30.98
	10–20	*0.279**	7.584	13.16	16.41	30.73
	20–30	0.205	6.732	12.96	17.83	30.55
LSD_{05}*	0–10	0.0257	0.628	0.868	0.961	1.230
	10–20	0.0323	0.410	0.873	0.934	1.394
	20–30	0.0291	0.418	0.890	0.942	1.295

The stable pool is mainly determined by site conditions, representing the primary products of mineral–organic interactions (Schulz et al., 2011). The abundance of clay particles <2μm in the plough layer of clay loam soil led to a high sorption capacity. This may explain the increase in carbon content in the CF in the upper soil layer, when the organic carbon of the labile compounds is stabilized due to interaction with clay particles.

The humified C represents the most microbially recalcitrant and thus stable reservoir of organic carbon in soil. The applied tillage systems changes content of humus-forming agents, soil acidity, the content and composition of exchangeable cations, and these factors directly affect the humification. The evaluation of the humus substances fractional composition showed that use of the lime sludge (PT+LS) caused a significant decrease of mobile humic substances percentage in SOC in all plough layers, and simultaneously increase percentage of the humic substances bound with calcium. More than half of humified SOC was accumulated in the fraction strongly bound with soil clay minerals, the applied tillage system influence on this fraction percentage was not essential.

Acknowledgements.

The research findings were obtained through the project “The influence of long-term contrasting intensity resources management on genesis of different soils and on other agroecosystems components" (SIT-9/2015) funded by the Research Council of Lithuania. Part of this study was conducted under the research programme "Productivity and sustainability of agricultural and forest soils" implemented by Lithuanian Research Centre for Agriculture and Forestry.

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Meliorative techniques of the development of soda-salted saline soils in green zone of Astana city

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Abstract

As a result of application of technology of reclamation of soda-salted saline soils by experimental studies proved the effectiveness of reclamation of soda-salted saline soils on the experimental plot of land EPU-2012 RSE "Zhasyl Aimak" near Astana and shows the possibility of scaling this technology for reclamation of soda-saline soils in the North of the Republic of Kazakhstan. High levels of alkaline salts in the EPU-2012 and exchangeable sodium of the soil-absorbing complex (40-70 %) required for reclamation of high doses of meliorants. Two variants of meliorants application were included in the scheme of experiments: half of the calculated dose of phosphogypsum (30 t/ha) + ash of Shakhtinsk sity during coal combustion of the Karaganda mine (15 t/ha) and the total calculated dose of phosphogypsum (60 t/ha) + ash (30 t/ha) against the background of agrotechnical soil treatment. As a result of such treatment, the solonets of this area were transformed into dark chestnut medium-saline soils for the third year after the precipitation. In both variants of experiments, there was a decrease in salinity of the arable reclamation horizon due to the change of toxic salts of bicarbonate and normal carbonates to non-toxic salts of sodium and calcium sulphates. The main technical and operational indicators of this technology are high speeds and levels of reclamation effect. Laboratory model experiments were carried out and pilot tests on reclamation of soda-salted saline soils were laid.
Key words: soda-salted saline soils, meliorants, phosphogypsum, ash.

Introduction

Greening is recognized worldwide as an important and effective means of environmental protection and improvement of urban design. The actual problem in the rapidly developing capital of Kazakhstan Astana is a modern environmental study and securing green building on sodic soils. The purpose of the research is to develop methods of reclamation of soda-salted saline soils in the forest zone of Astana city and their development to increase the survival and productivity of forest crops.

Materials and Methods

The object of research is the soil cover of the forest protective zone of Astana city, in particular, soda-salted solonets. In the process of work, the technology of using a new reclamation product in the North of the Republic of Kazakhstan on the basis of phosphogypsum and ash waste of thermal power station during special agricultural technology was introduced.

Results and Discussion

As a meliorant, a mixture of phosphogypsum (Stepnogorsk) and ash from the Shakhtinsk thermal power station from burning coal from the Karaganda basin was used. Field experiments on the development of methods of reclamation of soda-salted solonetzs were carried out on the experimental production area of 0.15 hectares.the soil cover in the virgin soil state was represented by saline meadow medium-columned in complex with highly saline meadow soils up to 30%. The area of plots is 150 m^2, repeatability is 3 times.
The following options for determining the effectiveness of chemical meliorants were tested:

1. Control.
2. Phosphogypsum 30 t / ha + ash 15 t/ha
3. Phosphogypsum 60 t / ha + ash 30 t / ha.

In the scheme of the experiments also incorporated a variant of agrotechnical tillage. Reclamation work in 2012 was conducted in the following sequence:

1. Moldboard plowing to a depth of 20 cm.
2. The layout of the surface plot planner P-4.
3. Introduction of ash waste at a dose of 15 and 30 t / ha.
4. Application of phosphogypsum at a dose of 30 and 60 t / ha.
5. Deep moldboard plowing to a depth of 40-45 cm
6. Filling of meliorants with heavy disk tillers in two tracks to a depth of 10-15 cm.

After application of phosphogypsum and ash, of the reclamation techniques on technology "Method of reclamation of soda-saline solonetzes" (Akhanov et al., 1989). In the fall of 2012 and spring of 2013 in may, there was a cycle of studies on the morphological changes of state meliorism lick EPU-2013. The exchange reaction ameliorants with PPK lick was slow due to low temperatures in winter. The morphological status of solonetzes by their appearance of solidity about it, a thick crust has changed slightly. Reclamation processes have accelerated significantly after heavy precipitation of the summer period. The morphological description of the structure of reclaimed solonetzs addition and analytical data on the content of water-soluble salts and the composition of PPK confirm the reclamation state of EPU-2012 soils.

Solontsy in the soil cover of EPU-20112 were transformed and transformed into dark chestnut medium-saline soils in the third year after heavy precipitation. When phosphogypsum (30 t/ha) and ash (15 t/ha), as well as phosphogypsum (60 t/ha) and ash (30 t/ha) were introduced, there was a decrease in salinity of arable reclamation horizon due to the replacement of toxic salts of bicarbonate and normal carbonates with non-toxic sulfates of sodium and calcium.

Analyzing the composition of water-soluble salts in the EPU-2012 salt flats before and after reclamation, it can be concluded that the technology of reclamation of soda-salted salt is successfully operating in the North of Kazakhstan. The saline horizon of soda-saline soils is completely reclaimed-by neutralizing the alkalinity of the soil solution and displacing the absorbed sodium from the PPK. The newly formed non-toxic salts represented by $CaSO_4$, $MgSO_4$ and Na_2SO_4. From very strongly saline soil of soda chemistry with a degree of toxic ions, more than 9 are converted to medium-saline sulphate with a total effect of 3 and 4.47.

The content of exchangeable sodium soils described belong to highly sodic or highly sodium (more than 40% exchangeable sodium on the capacity of the exchange).

The content of the exchange sodium is reduced from 40 to 70 % of the exchange capacity to 2-8 % when making a full dose of meliorants. In the implementation of reclamation half norm of meliorant neutralization is unstable and the amount of absorbed sodium is 10-45 %, the reaction of exchange to Ca in the PPK in the variants varies widely.

The availability of phosphorous (up to 100 mg/kg) and potassium (230-240 mg/kg) nutrients to the reclaimed solonetzs of the experimental site was high, as phosphorus and potassium were introduced with meliorants.

The humus content in the solonetzs was in the range of 0.4-0.8% and gradually decreased with depth. Almost all humus (70-90%) acquires high mobility and under the influence of alkaline soda soil-ground solutions is washed out of the soil profile.

Conclusion

The high content of alkaline salts in the saline soils of EPU-2012 and content in SPC exchange sodium (40-70 %) highly sodium salt licks demand for reclamation of high doses of ameliorants. Solontsy in the soil cover of EPU-20112 under the influence of meliorants were transformed into dark chestnut medium-saline soils in the third year after heavy precipitation.

When using the introduction of the mixture of phosphogypsum (30 t/ha) and ash (15 t/ha) and phosphogypsum (60 t/ha) and ash (30 t/ha) showed a decrease in salinity reclamation of arable horizon due to the change of toxic salts from the bicarbonate and normal carbonate to non -toxic sulphates of sodium, calcium. The saline horizon of soda-saline soils was completely reclaimed as a result of neutralizing the alkalinity of the soil solution and displacing the absorbed sodium from the PPK. The newly formed non-toxic salts were $CaSO_4$, $MgSO_4$ and Na_2SO_4. From very strongly saline soil of soda chemistry with a degree of toxic ions more than 9 is converted to medium saline sulfate by the total effect of 3 and 4.47. The content of the exchange sodium is reduced from 40-70% of the exchange capacity to 2-8 % when making a full dose of meliorants. In the implementation of reclamation half norm neutralization is unstable and the amount of absorbed sodium is 10-45 %, the reaction of the exchange of Ca in the PPK in the variants varies widely.

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Biotechnological method of production and application of biomineral fertilizer "BIOMINECO" in increasing the fertility of soils of the Republic of Kazakhstan

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Abstract

The method of modification of natural zeolite in order to obtain on its basis of biomineral fertilizers of a new type of prolonged action. For the modification of zeolite was used baseline a two-component solutions of fertilizer type nitroammophosphate, humic and microbial preparations and stimulants of the new generation.
The matrix of modified zeolite at different levels of redistribution from 1 to 5 is more productive (3-7.5 times) and functional as a result of optimization of life activity of nitrogen-fixing microorganisms on water supply and nutrition.
In vegetation experiments the greatest number of nitrogen fixators was found out at use of the modified zeolites processed by humic and microbial biopreparations. When using biopreparations MERS, Gumi, Gumi-30 and Nanobiosensor G significantly increased the number of microorganisms in several times.
Economically justified doses of biomineral fertilizers based on modified zeolite for the soil of grain, vegetable crop rotation is the norm of 1-2 t / ha.
Modified natural zeolites in the treatment of various nitrogen, bioorganic fertilizers and cultures of nitrogen-fixing microorganisms increase the effective productivity of soils up to 100%. Modification products have optimal physical and chemical parameters, are technological and economical when used for rice, vegetable and industrial crops.
On the methods of obtaining biomineral fertilizers on the basis of modified zeolite obtained patents of the Republic of Kazakhstan № 20621, № 27379, № 31348.
Key words: zeolite, biomineral fertilizers, fertility of soils.

Introduction

At present, natural minerals zeolites are components for obtaining organo-mineral fertilizers of prolonged action, as they contain significant amounts of elements of mineral nutrition of plants (Ca, Mg and K). However, the most valuable macronutrients such as nitrogen (N), phosphorus (P), and important trace elements zinc (Zn) and manganese (Mn) are generally absent. In the Republic of Kazakhstan in Almaty region has Chankaragai's deposit of zeolites is that the content of clinoptilolite (85%) are considered the best in the EAEU.
The purpose of scientific research since 2002 is to develop a new physical and chemical meliorant and complex organo-mineral fertilizer of multifunctional and prolonged action on the basis of natural zeolite.

Materials and methods

The absorption of zeolites is associated with the phenomena of adsorption and sorption- concentration of a substance from an aqueous salt solution or a gas phase on the surface of a solid (adsorbent) or in the volume (sorbent). The granule of any adsorbent is penetrated by channels whose diameter in conventional broad-porous adsorbents (aluminum or silicon oxides) reaches 10 nm or more, and in the volume during sorption cavities of various configurations are formed. The set of channels and cavities creates a system of pores, the surface of which (the inner surface of the adsorbent) and can be hundreds of square meters per 1 kg, and the sorption bulk capacity of zeolite pores is much higher. But the absorption capacity of natural zeolites in normal conditions is small (2 mg*equ). On this basis the concept of modification of natural zeolite by batteries and microorganisms is based. We have developed a method of physical and mechanical treatment of natural zeolite of the Chankaragai' deposit in order to increase its sorption volume by 10 times (know-how), which allows to create volumes and reserves of absorption by nutrients, stimulant preparations and strains of effective soil microorganisms.

Results and Discussion

The first stage of the work was to develop a method for producing a modified zeolite, which had an increased cationic-exchange capacity and contained the missing macro - and microelements. It is possible to obtain biomineral fertilizer of a new type BIOMINECO" on the basis of natural zeolite. Application in field vegetation experiments biomineral fertilizers BIOMINECO for 10 years in doses of 1 to 2 t/ha in the cultivation of rice, soybean and potato in arid zones of the Republic of Kazakhstan has shown high effectiveness of this drug (increasing the yield to 100%).

At the second stage of research, a technology was developed using a complex organic-mineral biofertilizer based on modified zeolite. To do this, the matrix of modified zeolite was inoculate useful soil effective microorganisms (nitrogen fixers, phosphate- and potassiumsoluble, oil-oxidizing microorganisms and others), as well as humic substances and some types of plant growth stimulants. This allowed to obtain new types of complex organic-mineral fertilizers for ecology-bioremediation of oil-contaminated lands in Western Kazakhstan in the regions of oil production.

Currently, three patents of the Republic of Kazakhstan were obtained for the methods of obtaining biomineral fertilizers of a new type (Kan, 2009; Titov et al., 2013; Titov et al., 2016).

Conclusions

The method of modification of natural zeolite in order to obtain on its basis of biomineral fertilizers of a new type of prolonged action. For the modification of zeolite was used baseline a two-component solutions of fertilizer type nitroammophosphate, humic and microbial preparations and stimulants of the new generation.

The matrix of modified zeolite at different levels of redistribution from 1 to 5 is more productive (3-7.5 times) and functional as a result of optimization of life activity of nitrogen-fixing microorganisms on water supply and nutrition.

In vegetation experiments the greatest number of nitrogen fixators was found out at use of the modified zeolites processed by humic and microbial biopreparations. When using biopreparations MERS, Gumi, Gumi-30 and Nanobiosensor G significantly increased the number of microorganisms in several times.

Economically justified doses of biomineral fertilizers based on modified zeolite for the soil of grain, vegetable crop rotation is the norm of 1-2 t / ha.

Modified natural zeolites in the treatment of various nitrogen, bioorganic fertilizers and cultures of nitrogen-fixing microorganisms increase the effective productivity of soils up to 100%. Modification products have optimal physical and chemical parameters, are technological and economical when used for rice, vegetable and industrial crops.

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Evolution and adaptive use of soil cover in Kazakhstan agriculture

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Abstract

The aim of the research is agroecological assessment of the Kazakhstan soil cover and the design of adaptive landscape farming systems using the example of a test farm – "Bayserke-Agro" LLP, Talgar District, Almaty Oblast.
Key words: soil fertility, humus, nitrogen, phosphorus, potassium, group composition of humus, exchange cations, soil density, soil structure, soil cultivation, crop rotation, agronomical evaluation of soils, elementary soil area, geoinformation system, technology, farming system.

Introduction

The protection of agrarian landscapes from degradation, which cover more than 1,5 billion ha of the world's soil, is a primary priority among the macroecological problems of nowadays [7].
The growing environmental threat is also evident in Kazakhstan. Humus losses amounted to 19.0-22.5 on chernozems, 20-30 chestnut soils and 30-50% irrigated syrozemes in more than 50 years of using soils in the plowland [5]. It need to transform the zonal systems of farming into adaptive landscaping systems (ALS), the development of which is very relevant in many countries due to their high production, market and environmental potential. These systems of agriculture more fully correspond to agroecological requirements of crops, their environment-forming influence and agroecological features of soils, have a specific ecological address, which is not present in zonal systems of agriculture, provide adaptive differentiation of agro-technologies and any of their elements, crop placement, application of fertilizers, means of protection, achievements with previously completed projects of zonal systems of agriculture ahead of their time, to build models of farming systems with accounting (market) needs, agro-ecological requirements of crops and parameters of lands, production and resource potential, levels of intensification, economic structures, social infrastructure, etc. [2].

Materials and Methods

Methods of researches. Studies of the evolution of soils used for more than 50 years in the country's agriculture were carried out in stationary field experiments, laboratory-agrochemical and agrophysical analyzes of soils were carried out according to Kiryushin V.I., Ivanov A.L. (2005) [2]. The design of technologies for the application of fertilizers and soil cultivation was carried out on the basis of materials of soil and landscape mapping in M = 1: 50000 and the development of the AgroGIS test facility, which is a set of electronic maps reflecting the agroecological factors taken into account when designing ALS. This is a new type of research, the objects of which were elementary soil areas and soil structures, that is, the soil components of the elemental range of the agrolandscape. Agroecological groups of lands were allocated according to the leading agroecological factors determining the direction of their agricultural use, and the types of land and their ranking according to the degree of suitability for agricultural crops - by the category of micro-combinations of the soil cover. The use of GIS technologies in soil-landscape mapping was primarily due to the digitization of the topographic basis using GPS. All these studies were conducted according to V.I. Kiryushin (2015) [7].

Results and Discussion

More than 38 years have passed since the beginning of the formation in Kazakhstan of zonal systems of agriculture by A.I. Barayev. The experience of their development already in the middle of the 1980th showed the need for a deeper differentiation of these systems in relation to various agroecological conditions, and primarily to soils.

When soil is involved in agricultural using, changes occur in their genetic properties. The formed arable horizon becomes lighter in comparison with the upper horizons of virgin soils.

The thickness of the humus horizons (A + B) increases insignificantly, the depth of occurrence of carbonates and gypsum decreases. There are loss of humus content in soils. If its reserves in the 0-50 cm layer of virgin typical chernozems are, an average of 364.8; ordinary - 337.8; southern - 263.1; dark chestnut soils - 173.5 and gray serozem - 68.2 t / ha, in cultivated chernozems they decreased by 46.3-73.7 t / ha or by 17.6-20.1%, dark chestnut soils Soils - 29,0 t / ha or 16,7%, serozem ordinary - 9,2 t / ha or 13,5% [3].

In the group composition of humus, there is also a marked decrease in the carbon content and slightly unhydrolyzable residue - in chernozem within 2.6-3.5, in dark chestnut soil and in serozem, 4.1 and 3.3% in total carbon, respectively. Simultaneously, in all soils there is a tendency of relative accumulation of humic acid carbon, which leads to an increase in the ratio Cg.k./Cph.k. in chernozems by 0.28-0.40, in dark chestnut soils and in serozem ordinary by 0.27 and 0.04, respectively. The content of loosely bound humic substances is higher than in virgin analogs by 1.1-1.8 times.

In accordance with the content of humus, the content of total nitrogen in soils decreases. Its reserves in the semimetre layer fluctuate in virgin soils from 4.6 to 21.3 t / ha, and are minimal in common serozems (4.6 t / ha), and maximal in chernozems typical (21.3 t / ha). For more than 50 years of their use in agriculture, black soils have lost 16.9-18.8% of total nitrogen, its losses were higher compared to dark chestnut and gray soils, on which they accounted for 16-13%.

Old-arable soils, on the contrary, are provided with more than virgin, easily hydrolyzed nitrogen. In the conditions of the northern and southeastern regions, losses of the nitrate form of nitrogen are noted [1]. So, in chernozem nitrates moves to a depth of 4 m, in dark chestnut soil - up to 3 m, in serozem (on the bogar) - up to 5-6 m.

In old-arable soils, in comparison with virgin soils, the reserves of total phosphorus decrease insignificantly. In the chernozems of Northern Kazakhstan, its losses from the half-meter layer amounted to an average of 7.3%, in dark chestnut soils and ordinary gray soils - 6.5-6.1%. At the same time, arable soils contain 1.1-1.2 times more mobile phosphorus than virgin soils, but remain mostly low- and medium- provided with this element, which indicates the extreme need to increase its content in all soils. The content of total potassium varies from 1.3 to 2.6%.

Moreover, chernozems are high, dark chestnuts are increased and serozems are medium-moderately provided with exchange potassium, the content of which in old-tilled soils is not inferior to virgin analogues. There is also a decrease in the absorption capacity, which is due to a decrease in the content of exchangeable calcium and less magnesium. The most significant losses of calcium are observed on chernozems and dark chestnut soils - 18.7%, on serozem - 15.0%, magnesium - 7-8%.

AgroGIS was developed for the test farm, which represents a set of electronic maps reflecting agroecological factors taken into account when designing ALS the forms of fields, forms and elements of mesorelief, the exposures of slopes, the slopes of slopes, the granulometric composition of soils, soil-forming rocks, soil microstructure, humus content in soils, mobile elements of plant nutrition (N, P, K). On their basis, a map of agroecological groups and land types has been developed, which is the basis for designing ALS (figure 1).

The most widespread in the farm are medium-humid (semi-hydromorphous - 1250 hectares) and placer (669 hectares) agroecological groups of land. Somewhat less than the medium-moistened saline (475 ha) and strongly humidified (hydromorphic) saline (229 ha), even less placer saline (201 ha) and heavily waterlogged (61 ha) land groups.

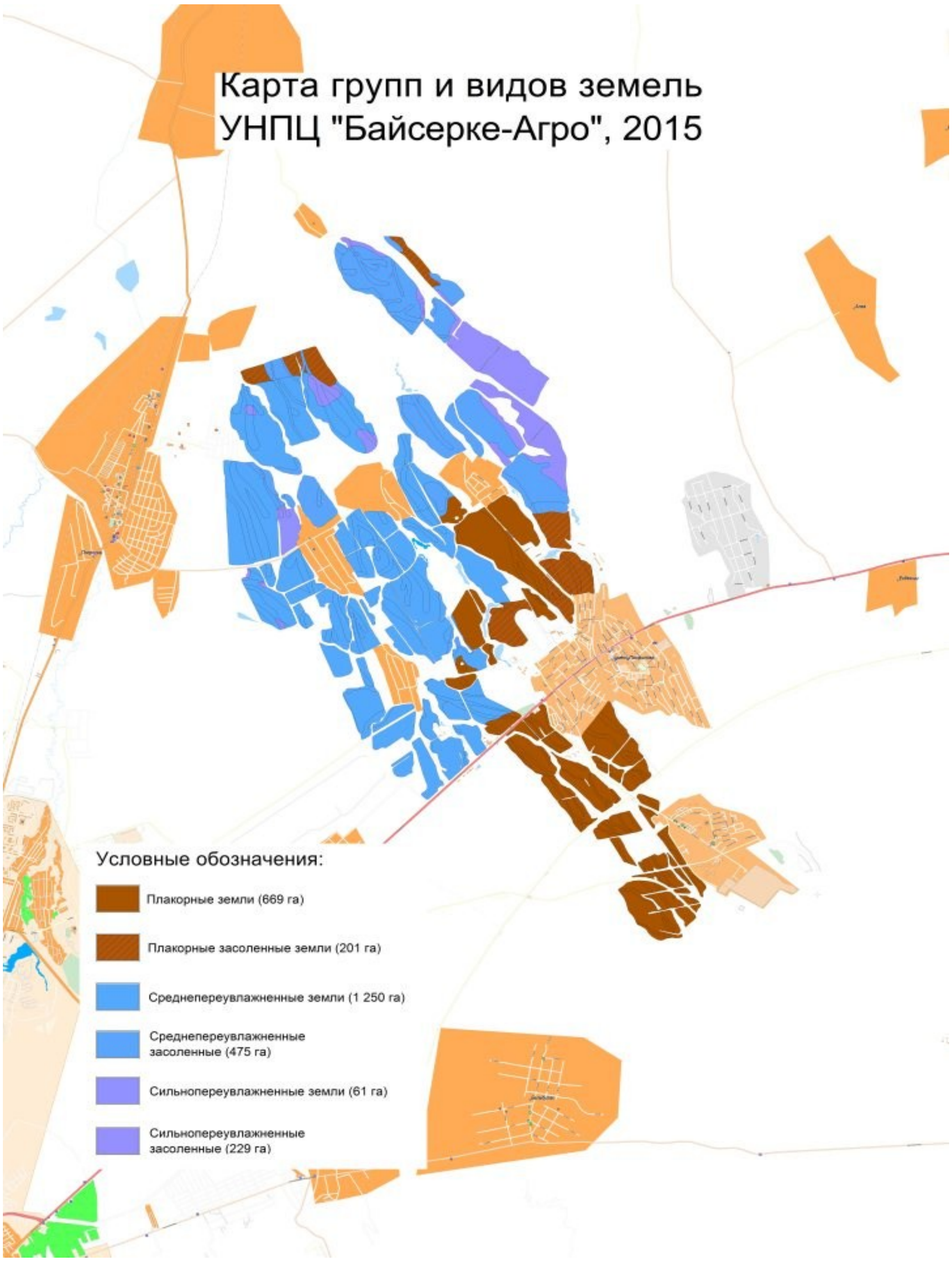

Figure 1. Map of groups and land types of Bayserke-Agro

In accordance with these conditions, land types are ranked according to the degree of suitability for the main agricultural crops grown on the farm - winter wheat, barley, soybean, maize for grain, sunflower in the form of a grouping, including their suitability categories and groups by the nature and ways of overcoming the limiting factors of cultivation [7].

So, the placer lands are automorphic soils. The structure of the soil cover is mainly represented by patches of dark and light chestnut medium loamy soils underlain by loesslike loam or

deluvial sediments from a depth of 100-130 cm. The earths are suitable for cultivation of all crops without restrictions using intensive and highly intensive agrotechnologies (1st category).
Placer saline lands are represented by spots of light chestnut carbonate and light chestnut solonchakous medium; light chestnut solonchakous and meadow-chestnut solonchakous medium and light loamy soils. Suitable for all crops with restrictions requiring regular machining due to the formation of a saline horizon, differentiated distribution of crops and agrotechnologies in accordance with the conditions of salinization, contour processing on slopes and the normal level of intensification of agricultural technologies (category II).
The medium-wetlands are a group of lands represented by spotted meadow-chestnut and meadow-chestnut medium-thick and powerful medium loamy soils. These lands are characterized by a practically constant close groundwater table from 5 to 3 m, they are capable of high yielding and are suitable for all crops without restrictions using intensive and high agrotechnologies (I category).
Medium-moistened saline lands are represented by meadow-chestnut solonchakous and meadow-chestnut solonchak medium-loamy soils with weak contrasts of individual combinations. It is necessary to differentiate crops, drain them with simple drainage devices, apply mechanical treatment to eliminate the saline horizon and organic fertilizers on low-contrast soils with a normal level of intensification of agricultural technologies (category III).
Strongly humidified lands with combinations of meadow common and meadow carbonate medium-thick and powerful medium loamy soils on loesslike deposits. Their use is associated with the selection of moisture-loving crops, a simple drainage device for eliminating excess water and a normal level of intensification of agricultural technologies (category III).
Highly humidified saline lands. The structure of the soil cover is composed of complexes of meadow carbonate, meadow saline, meadow-chestnut solonchak and meadow-chestnut solonchak, meadow-chestnut, meadow-serozem solonchak soils and meadow saline soils of medium-thick and powerful medium- and light-loamy soils. The use of these soils is associated with the selection of moisture-loving and salt-tolerant crops, the construction of systems of complex irrigation and drainage melioration, the constant cultivation of soil and the extensive level of agricultural technology (category V).
Taking into account the maps of content in humus soils, mobile plant nutrients, salinization of soils, forecrops, soil type, and levels of planned yields, we developed doses of mineral fertilizers for the above-mentioned crops and soil cultivation technologies applied to the agroecological group of placer lands (Tables 1-5).

Table 1. Recommended doses of phosphorus and potassium fertilizers for cereal crops depending on the availability of soil mobile forms of phosphorus, potassium and the level of planned harvest

Degree of soil provision	Content, mg/kg soil		Level of planned yield, c/ha							
	P_2O_5	K_2O	40		60		80		100	
			Doses of fertilizers (kg per 1 ha)							
			P_2O_5	K_2O	P_2O_5	K_2O	P_2O_5	K_2O	P_2O_5	K_2O
Very low and low	10-15	100-200	75-65	75-60	90-80	90-80	130-120	120-110	150-140	150-140
Average	16-30	201-300	60	70	75	75	90	90	120	120
High	45-60	400-600	-	-	15-20	-	30	30	60	45

Table 2. Recommended doses of fertilizer application for soybean, kg ai / ha

The content of P_20_5 and K_2O in soil mg / kg (according to Machigin)			Phosphoric			Potash		
groups	P_20_5	K_2O	basic	row	dressing	basic	row	dressing
Very Low	Less than 10	Less than 100	60-90	40	40	40-60	30	30
Low	10-15	101-200	40-60	30	30	30-40	20	20
Average	16-30	201-300	30-40	20	20	20-30	10	10
Increased	31-45	301-400	fertilizer is not required					
High	46-60	401-600						
Very high	More than 60	More than 600						

Table 3. Recommended doses of nitrogen fertilizers for maize for grain (kg ai per 1 ha)

Soils	Level of planned yield, c/ha			
	40	60	80	100
	Doses of fertilizers (kg per 1 ha)			
Light chestnut	45	60	90	120
Ordinary sierozems	60	90	120	150
Light gray soils	90	120	150	180

Table 4. Recommended doses of phosphorus and potassium fertilizers for corn, depending on the availability of soil mobile forms of phosphorus, potassium and the level of the planned harvest

Degree of soil provision	Content, mg/kg soil		Level of planned yield, c/ha							
	P_2O_5	K_2O	40		60		80		100	
			Doses of fertilizers (kg per 1 ha)							
			P_2O_5	K_2O	P_2O_5	K_2O	P_2O_5	K_2O	P_2O_5	K_2O
Low	10-15	100-200	30	30	60	60	90	90	120	120
Average	15-30	200-300	15-20	-	30	30	60	60	90	90
High	45-60	400-600	-	-	-	-	30	30	60	45

Table 5. Recommended doses of mineral fertilizers, depending on the degree of provision of soils with mobile phosphorus and exchange potassium for sunflower

Degree of soil provision	Content, mg/kg soil		Level of planned yield, c/ha			
	P_2O_5	K_2O	20		30	
			Doses of fertilizers (kg per 1 ha)			
			P_2O_5	K_2O	P_2O_5	K_2O
Low	10-15	100-200	90	90	120	120
Average	15-30	200-300	45	45	90	90
High	45-60	400-600	20	-	60	60

The system of applying fertilizers to the soil remains practically traditional, but differentiates, first of all, in order of priority, doses, compatibility with agricultural technology, depending on agroecological conditions of soils, limiting factors and measures for their overcoming. So, the use of fertilizers on saline soils is advisable after reclamation on them, on eroded - increased doses of fertilizers in combination with the application of an anti-erosion treatment system, on wetlands - after reclamation measures to drain and drain excess water from them.

In this case, the doses of fertilizers on them should be increased by 15-20%, depending on the intensity of the influence of limiting factors on the soils agroecology.

The first requirement for a soil treatment system is the maximum retention of plant residues on its surface in order to enrich it with organic matter.

In general, the processing systems are concentrated in three directions: a dump or combined processing system; a system of waste-free processing and a minimum processing system. The first is practiced in conditions of increased weediness of crops and the absence of herbicides in order to overcome the unfavorable phytosanitary situation. In intensive technologies, plowing is recommended for embedding high doses of fertilizers, especially when cultivating tilled crops.

The system of nonmoldboard or mulching cultivation is divided into three subsystems: a systematic deep (deeper than 24 cm), different depth and minimum. The former is recommended for solonets and other compacting soils, as well as for complex erosion landscapes to reduce their compactness, surface runoff and prevent erosion. The mulching depthwise tillage system provides for a periodic alternation of shallow and deep planar and other non-waste treatments at different depths, depending on the crop in the crop rotation and the state of the soil. Deep loosening is used here when compacting soils under crops sensitive to increased density.

Mulching minimal processing system is based on shallow cultivation with subsurface tiller and is recommended when switching to intensive agrotechnologies on placer soils. In the region, it is possible to further minimize processing and, in certain conditions, switch to direct seeding - with a high level of intensification and optimal provision with agrochemical resources, since the optimal soil density for specific crops relatively resistant to compaction is close to equilibrium.

When mulching, not only the moisture of the precipitations is used more efficiently, but also the moisture condensing from the air during the daytime and nighttime temperatures, which makes it possible to activate the agrocomplex by introducing more intensive crop rotations and increasing the use of fertilizers, as well as improving soil biogeneity and, in general, the ecology of farming. The value of this system is complemented by an increase in soil resistance against erosion, a decrease in the processes of mineralization of organic matter and, accordingly, loss of humus.

In the design of soil cultivation systems in adaptive agro-technologies, groups of land types are effectively used, including the above categories for suitability for cultivated crops. The more fully the culture corresponds to the agroecological conditions of the land plot, the greater the possibilities for minimizing soil cultivation, reducing the costs of means, labor and time for carrying it out.

Conclusion

An assessment of the evolution of the fertility of the soils used in the zonal systems of agriculture testifies to the deterioration of their chemical, physical and chemical and physical properties, the poor adaptability and differentiation of these farming systems to the agroecological conditions of the soil cover and low productivity and the low overall production potential, the need for their transformation into adaptive- landscape farming systems that provide a specific agroecological address, deeper differentiation, conservation and rational reproduction of soil fertility, increasing crops yielding only thanks to adaptation in 1,4-1,6 time and ecology of farming.

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Change of groundwater mineralization and location in irrigated soils in Mugan-Salyan massif

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Abstract

The study of the depth of groundwater and their mineralization in the research areas is one of the factors required for determining the meliorative regime in those areas.Studies show that the average price of groundwater in the vegetation period in calcareous soils varies between 3.0-5.0 g/l and their optimum depth is between 2.5-3.0 m. In general, ground water is mainly deposited at a depth of 1-5 m above the ground surface and at a depth of >10.0 m in the mou-ntainous part. In the intensively irrigated areas, the amplitude of their level varies between 1.0-1.5 m in the season and sometimes It is observed to be 2-2-2.5m. If the ground water is deep, its amplitude is 0.5-1.0 m; the river breaks down to 1.0-3,0m in alluvial depths.
The cost of their minerals in the shingles is 0.5-1.0 g/l, near the river and large irrigation canals - 2.0-5.0 g/l to varying degrees. Their price starts to rise to the center of the plains and from there to the Caspian Sea.Their low mineral content is 10-50 g/l and in some places is 100g/l, and their prices are slightly lower.
The main types of ground water are divided into three main types: hydrocarbonate, sulphate and chlorine. Hydrocarbonate waters are mainly concen-trated in plains, along the Kur-Araz rivers and large irrigation canals (10g/l).Sulfate waters are located in the mountainous part of the plain, their minerality is slightly higher and varies between 10-20 g/l. Chlorinated waters are distributed in the central and eastern part of the Mugan-Salyan massif and their mineral content is 20-25 g/l and more.In areas where sodium and calcium-carbonate waters are frequently encountered.Sodium and calcium sulphate are less common. The reason for this is the high concentration of salts in the soil, the high level of drainage water, groundwater levels, their close proximity to the ground surface and the lack of existing drainage systems.
Key words: salinity soils, ground water, mineralization, granulometric composition, volume weight of soil, pH, humus.

Introduction

As we know, the study of the depth and the depth of groundwater in the study areas is one of the factors required for determining the meliorative regime in these areas. Depth of sediment content in the soil and the depth of groundwater, the dynamics of their mineralization, causes of salinization and their elimination , the effectiveness of drainage systems has been scientifically substantiated by aca-demician V.R.Volobuyev's extensive research. Depending on the amount and type of salts in its soils, salinity, classification of proposed groundwater mineralization and sedimentation levels are successfully used today. The dynamics of change of ground water in the soil and their mineralization in the areas we have investigated have been widely studied by many researchers [2, 4].
Ground water in nature can be different. Studies show that in some inclined areas natural groundwater flows. In such cases ground waters are less salty. However, there are areas where there is no natural flow of ground waters and it does not flow. Under such conditions, ground water is too salty for a long time because it solves the mother liquor itself. This salting increases as a result of high levels of evaporation, where the groundwater is in desperate condition. Such a situation will cause the lands to fall off in a short time and become unusable. It is possible to adjust their levels as required when the level of groundwater is close to

ground surface, irrigation of agricultural plantations in the natural (or poorly streamed) areas is carried out in the background of collector-drainage systems. Long-term researches show that the presence of autorph, hydromorph and semi-automorphic regimes in the formation of soil, depending on the level of groundwater's sedimentation in the irrigated areas, their mineralization and the composition change [3-6].

In the autorphic regime of soils, ground water is fed mainly through irrigation water, the filtration goes freely to the lower layers, their natural flow is intensely flowing, and these waters are typically 5,0-10,0m above the ground surface. In soil hydrous morphs, plants are fed into groundwater , natural drainage conditions are poor and minerals are less than 1.0-2.0 m above ground surface. In semi-automorphic regime of soils, ground water is more active in irrigation of plants, mineralized and poorly densified. In this regime, all land reclamation activities, including measures to combat water leachate from irrigation canals, drainage networks and so on. jobs are required. As we know, the optimal depth, mineralization, irrigation regime, type of drainage,type and composition of plants to be used should be taken into consideration in laying drainage systems. Studies show that the average price of groundwater in the vegetation period in calcareous soils varies between 3.0-5.0 g/l and their optimum depth is between 2.5-3.0 m. The importance of chemical composition and mine-ralization of irrigation water in desertification of soils in the lowland areas, where there is a low level of groundwater, is of great importance.

Studies show that when water is absorbed by hydrocarbonates rich in Ca and Mg ions, the waters that flow into the soil are combined with ground waters, with new sodium hydrocarbonate and sodium compounds. Generally, groundwater sources of natural nutrition include atmospheric precipitation, surface water flows, and water flows from the surrounding areas [7-10].

Materials and Methods

The researches were carried out on the territory of the Mugan-Salyan massif (871 thousand ha). Investigations and chemical analyzes have been performed using widely used methods in the Republic and abroad [1].

Results and Discussions

As we know, irrigation water in irrigated areas affects the regime of groun-dwater. Generally, the moisture, which is higher than its water-solubility in the top layer of the soil, creates free gravitational water and moves towards the lower and sides of the free water gravitational force. In the course of irrigation of the fields with the intensity of intensive water entering the surface of the soil, part of the moisture absorbs into the soil and the other part moves through the surface of the soil. The surface of the soil is less than the amount of water that flows into the soil, while the surface of the soil is less water, moisture, surface hardness is large, and the vegetation is poor, but the amount of water flowing to the surface of the earth is much higher than the amount of water that flows into the soil.

The following changes have been observed in groundwater regime in irrigated areas:

- Groundwater nourishment intensifies at the expense of watercourses, and their level begins to rise. In places with high natural discharge, watering. As a result, the process of salting the soil in the soil is observed. Where there are no artificial drainage systems in areas with poor natural drainage, the amount of salts in the soil layer and the groundwater levels in the aeration zone have been increased;
- In the irrigation canals, water is leaked to groundwater, and their regime is changed;
- In natural areas, natural plants are replaced with relatively little transpiration cultivated plants, which results in the rise of groundwater levels;

- When there are no collector-drainage systems in the areas where the discharge waters are diminished, the level of groundwater rises, the evaporation process is intensified, resulting in the increase in groundwater mineralization and the recultivation of the soils;
- The timely application of drainage systems in the affected areas prevents the level of ground water in the area and their mineralization.

One of the key issues in studying groundwater regimes in irrigated areas is the determination of their critical depth. As we know, to ensure the normal development of reclamation and vegetation, first of all, ensure that the level of groundwater does not rise above the critical depth. The depth of the ground waters is that of the gradient, structure, capillary, climatic factors of the soils.depending on the type. The critical depth of groundwater for Lyosvari soils is 1.7-2.2 m, if their mineral content is up to 3.0 g/l; 2.2-3.0 m in case of 3.0-3.5 g/l; At 3.0-7.0 g/l, 3.0-3.5 m was determined. In heavy-grained soil this indicator is increased by 20% [2, 8, 12].

V.V.Volobuyev [12] and M.G.Mustafayev [6, 7] have shown in their studies that there are no recurrent recurrences in autumn. This explains why groundwater levels are at 2.6-3.0 m at that time and show that the depth of ground water in these areas is <2.0m. According to V.Volobuyev,in the Mughan-Salyan massif,the critical (critical) depth of groundwater should not be less than 1.75-2.25 m. It has been found out that in deep and soda saline, heavier granulometric composition, this depth is relatively high, ie 2.5 - 2.8 m is acceptable. If we compared the nutritional regime with inert water flow in areas where groundwater flows naturally, the following results can be demonstrated:

- In areas with high natural discharge, ie underground water flows are more than 500 mm per year, the annual amount of irrigation water that nourishes groundwater is regulated by the amount of flowing water and their levels approach to the ground surface;
- when the amount of water drawn in the areas covered by natural drainage is 300-500 mm/year, it is discharged through the groundwater flow. However, when the level of groundwater is close to the ground surface, they climb up and affect the physical properties of the soils, resulting in their water-air regimes.

According to studies, irrigation in areas with intensive natural discharge has a somewhat weak impact on the regime of groundwater, as the speed of flowing underground flows from these areas is high. In this case, the level of groundwater increases slightly as a result of irrigation, but does not pose a danger to salinization of soils.

Ground water levels can rise up to 2.0-3.0 m in short time as a result of irrigation in areas with poor natural flows in the soil. It is associated with a small area of movement of underground waters in those areas. In subsequent periods, as a result of evaporation, partly transpiration, the level of ground water in these areas is relatively regulated, with a seasonal and perennial regime.

Groundwater levels in natural intensive and weak drain areas are desirable to provide land reclamation prior to irrigation, especially with poorly dented areas with artificial drainage. Failure to carry out land reclamation will result in land degradation in these areas and ultimately a sharp decline in productivity of agricultural crops.

The study of groundwater regime indicates that groundwater is generally low in natural areas and minor changes are observed during the season.Mineralization of groundwater is increasing in weak flow areas,these indicators are determined to be more frequent in areas with extreme conditions. At the level of ground water that is affected by the effects of the watering in these areasThe process of temporary sweetening is going on. After the water cycle is over, the fresh water is evaporated and the prevalence of ground waters, ie, mineralization, is observed.

Surveys show that the depth of ground water in the densified areas increases as the drainage approaches. Although groundwater levels begin to rise as a result of vegetation irrigation, their levels begin to decline after drilling. After 5-8 days after the end of each irrigation, groundwater level drops are 1,0-0,8 cm / day. Studies show that ground waters are found in the flat part of the ground up to 1-5 m, and in the mountainous part> 10.0 m. In general, the surface of the ground water surface is accurate to the Kura and Araz rivers and to the sea. Studies show that the largest amplitude of the change in the level of groundwater is observed in irrigated areas. In general, groundwater levels and mineral resources are continuously changing depending on the irrigation area, the irrigation effect, the amount of atmospheric precipitation, the evaporation rate, and the level of drainage. It is observed that the amplitude of their level in inthe irrigated areas is between 1.0-1.5 m and sometimes 2.0-2.5 m in the season. If the ground water is deep, its amplitude of 0.5-1.0 m; the river breaks down alluvial depths from 1.0 to 3.0 m [2, 4, 8].

Ground waters located deep in the surface of the surface of the Mugan-Salyan massif are rarely found. These ground waters are found in the foothills of the Mugan Plain along the right bank of the Azizbeyov channel. In the south-west, along the inclined plain, ground waters in deluvial-proluxic sediments are deeper.The depth of ground water is dependent on the sharp decline of relief and the small amount of food they supply. The diversity of the depth of soils in the Mughan-Salyan massif has a profound effect on their mineralization and composition change.

Generally speaking, when studying the change of mineral water in groundwater, based on the soil and climatic conditions of the population, change of their mineralization and composition of irrigation water. Research shows that in the foothills, their mineral content ranges from 0.5 -1.0 g/l to about 2.0-5.0 g/l near river and large irrigation canals. Their price goes up to the center of the plains and from there to the Caspian Sea. Their mineral content is very high in the massive part of the massive range of 10-50 g/l and in some places at 100 g/l, and their prices are slightly lower during the period of watering [9, 10, 11].

The diversity of groundwater's chemical composition is widely mentioned in V.R.Volobuyev [12]. Based on the research, 3 main types of groundwater are separated: hydrocarbonate, sulfate and chlorine.

Hydrocarbonated waters are mainly spread in the plains, along Kur-Araz rivers and large irrigation canals (Akusha, Azizbeyov, Sabir, Mugan, etc.) (10 g/l).

Sulfate waters are located in the foothills of the plain, their minerals are slightly higher and range from 10 to 20 g/l.

Chlorinated waters are distributed in the central and eastern parts of the Mugan-Salyan massif and their mineral content is 20-25 g/l and more [5, 7].

In addition to these types of water, sodium and calcium carbonate waters are often found in those areas. Sodium and calcium sulphate are less common.

Recent developments in the area of Mugan-Salyan massif as a result of anthropogenic impacts and their improvement have been conducted. As we know, one of the factors influencing the reclamation of soil is the location of mineralized ground waters near the ground surface. That is, it is located at depths of less than 1.5-2.0 meters. So, groundwater, which is less than 1.5-2.0 meters in depth, directly damages the plants, and also increases the degree of salinity of the soil.

Studies show that the mineralization of ground waters spreading in the central part of the Mugan Plain is quite high. In the west, the mineralization of groundwater in the Arazculture ranges from 10 to 50 g/l.

Ground waters along the irrigation canals and underground waters have been minimized as a result of surface water, but this is gradually increasing as far as irrigation systems are concerned. Ground water in the irrigated areas and offshore areas ranges from 10 to 25 g/l. Chlorinated waters are distributed in the central and eastern parts of the Mugan-Salyan massif and their mineral content is 20-25 g/l and more [2, 6, 9].

The ground waters are mixed with chemical composition, where hydro-carbonate ions prevail. Groundwater with such chemical composition is observed in the irrigation systems of

Mugan-Salyan massif, Aqua river and Bolqarchay. Also, the chloride-type type of ground water can be found along the channel named Azizbeyov and in the eastern part, in the form of narrow strips of sulfate-like waters.

Recent research shows that, in areas covered by the Orcanikidze irrigation system, groundwater is a sulfate-type hydrocarbonated type in the Aras River. In the north, the ground waters of this zone are gradually shifting to the chloride type. Ground waters in the south from the Saatli region and the Sarısu lake are now completely chloride-type.

Long-term research suggests that the level of groundwater availability in satisfactory condition of the modern state of collector-drainage and irrigation systems in Mugan-Salyan massif is lower than low depth and their mineral content is not high. However, in areas that are unsatisfactory, the mineralization of groundwater is high and their location is close to the ground surface. For this purpose, separate areas of the array were investigated and the results are given below.

Researches show that in the territory of Salyan region, groundwater depths of less than 1.0 m from the ground surface are 10200 ha; The area is 1,3-3,0 m and 28,950 hectares. Groundwater mineralization varies between 4,35-23,16 g/l (on average).

The scarcity of groundwater on the ground surface in the Neftchala district Areas less than 1.0 m - 2100 ha; 1.0-1.5 m-11000 ha; 1.5-2.0 m-1790 ha; 2.0-3.0 m - 5600 ha; The area of 3.0-5.0 m is 59 ha. Groundwater mineralization and varies from 3.5 to 28.25 g/l.

In Bilasuvar, these guidelines have changed as follows: areas less than 1.0 m - 1271 ha; 1,0-1,5 m - 4710 ha; 1,5-2,0 m -12715 ha; 2,0-3,0 m -17,835 hectares. Their mineralization ranges from 1.8 to 15.85 g/l.

The area of Groundwater on the ground surface of the Saatli region is less than 1.0 m. The area is 582 ha; 1,0-1,5 m -9860 ha; 1.5-2.0 m - 26887 ha; 2,0-3,0 m - 9162 ha; 3,0-5,0 m areas are 1038 ha. Groundwater mineralization ranges from 1.2 g/l to 18.78 g/l.

In the Sabirabad district, these indicators have changed as follows: areas less than 1.0 m are 14896 ha; 1.0-3.0 m - 41447 ha; The area below 3.0 m is 6261 ha. Groundwater mineralization ranges from 1.5 to 21.5 g/l.

In the Imishli district, groundwater depths of less than 1,5 m shall be 1035 hectares; 1,5-2,0 m - 16,000 ha; 2,0-2,5 m - 14900 ha; 2,5-3,0 m and below 3.0 m; 2,0-2,5 m - 14900 ha; The areas below 2,5-3,0 m and below 3,0 m are 34,000 ha. Ground water mineralization ranges from 1.2 to 24.5 g/l.

In Hajigabul region, these indicators have changed as follows: places less than 1.0 m are 65 hectares; 1,0-1,5 m - 5248 ha; 1.5-2.0 m to 11848 ha; The areas below 2,0-3,0 m and 3,0 m are 236 ha. Groundwater mineralization ranges from 1.8 to 20.9 g/l.

According to the researches, groundwater salinity is several times higher in the salinity of soils. If the amount of salts in the soil is 0.25-0.50%, the amount of groundwater is 1-3 g/l; In places with more than 0.5% this figure exceeds 3.0 g/l.

Studies show that in the Salyan district (10200 ha), and then in Neftchala region (2100 ha), groundwater depth is less than 1.0 m. This condition of ground water covers 1271 hectares in Bilasuvar, 1035 hectares in Imishy, 582 ha in Saatli and 342 ha in Sabirabad. Ground waters are close to ground surface,it is clear that the process of feeding is going to be more obvious.

One of the key issues during the study is the study of the dynamics of change of groundwater mineralization in the area. In this regard, long-term research in the Mugan-Salyan massif was grouped, ie the data for 1990-2000 and 2000-2012 were systematized and they were compared comparatively. Studies show that the mineralization of groundwater ranges from 1,309 to 45,960 g/l in those times. Salts contain mostly SO_4 ions, followed by CI and then HCO_3. Their quantity was determined to be 1,144-16,631 g/l, 0,168-12,430 g/l, 0,122-1,305 g/l. In the com-position of cations, Ca, then Mg, and then Na+K in the first place. Their quantity varies between 0.17-0.65 g/l, 0.042-0.444 g/l and 0.004-0.695 g/l respectively. In the second phase of the study, there is a relative decline in the indicators of groundwater mineralization. This process involves the cleaning of some of the collector-drainage systems, rehabilitation of some of them, the use of temporary drainage and boilers, and the use of relatively mineral and organic fertilizers. In 2000-2012, the change in groundwater mineralization in those areas varied between 0.710-43.820 g/l .

In the composition of salts, the anions still dominate SO_4 ions, then CI, and then HCO_3. Their indicators range from 0.230 to 13.261 g/l, 0.071-9.065 g/l, from 0.122 to 1.842 g/l. From cations, Na+K, then Mg, and then Ca are in the first place, and their quantities comprise 0,041-0,701 g/l, 0,036- 0,192 g/l, 0,100 -0,180 g/l.

The results show that CO_3-ion has been found in groundwater in some areas in the 1990-2000 (22) and 2000-2012 (18th) survey areas. The results of the analyzes show that while the CO_3 ion content in these areas was 0.018-0.090 g/l in 1990-2000, their number varied between 0.018-0.078 g/l in 2000-2012. As it is seen, There is no big difference in the CO_3 ion indicator change.

The reason for this is that, in addition to other factors, these areas have not been used for a long time by agricultural crops, and that the soil is kept as herbs. As a result of all these processes, it has also been observed that in these areas, there is also a drying process in the soil and at the same time, the process of worming. It seems clear in these areas that the soil is weak and in some places moderate sputtering is taking place. However, in the years to come, some agrotechnical and meliorative measures in these areas were monitored, supervised, irrigation norms were used to meet the demand of plants, and generally the use of land was a little less than theirs. Generally investigated studies show that Mughan- In areas of Salyan massif, intensively and inaccessible areas of groundwater levels are close to ground surface (1.0-2.0 m and sometimes 1.5 m) and their mineral content is high (15,85-24,5 g/l).

All of these processes are the result of worsening of the soil in these areas, rebounding in some places, and so on. and resulted in a decline in productivity of agricultural crops in some areas by 15-25%. Recent research shows that in the Mugan-Salyan massif, where the soil salinity is high, the level of groundwater levels is lower and their mineralization is several times higher. One of the main reasons why their levels are close to the ground surface is unsatisfactory functioning of the collector-drainage and irrigation systems operating in the area. Also, the amount of salts in the soil, the increase in mineral content in the soil, non-compliance with the irrigation regimes, the rules of cultivation, the poor planting of the planting system and the lack of fertilizers lead to a sharp decline in productivity in these areas.

Conclusions

1. During the research, the Mugan-Salyan massif has a special place in the study of the basis of the amount of salts in the soils and the mineral water content of the ground waters. For this purpose, based on the results of researches carried out in that area, the amount of salts in the saline, saline, saline and saline soils, the depth of groundwater depth and their minerality are grouped according to the results of research conducted in the area. According to the research, the amount of salts in the ground in saline areas is 0-100 cm 0,130-0,246%, 100-200 cm layer - 0,115-0,289%, depth of groundwater was 2,60-3,00 m, and their mineral content was 1,2-2,8 g/l. In weakly saline soils, these indicators have changed as follows: 0.265-0.448%, 0.218-0.410%, 2.20-2.62 m and 2.9-4.8 g/l. In the moderate and severe saline soils, these variables are as follows: 0.526-0.895%, 0.213-0.903%, 2.25-2.60 m and 2.5-5.2 g/l; 1,325-1,848%, 0,435-2,365%, 1,75-2,20 m and 4,5-8,6 g/l. In very severe saline and saline soils these figures are 2,107-2,884%, 1,474-1,805 %, 1.70-1.75 m and 9.2-9.9 g/l; 3,212-4,480%, 2,971-4,005%, 1,25-150 m and 20,86-29,91 g/l. As you can see, there is a certain difference between the amount of salts and the mineral waters of groundwater. Generally, there is a substantial contrast between the salinity and the salinity of groundwater in saline, weak, medium,

severe, very severe and saline soils. In all cases, correlation coefficients r=0.98-0.99 indicate that the relationship between the results is very tight.

2. Studies show that the highest water content is observed in the areas of Sabirabad, Saatli and Salyan regions. The reason for this is the high concentration of salts in the soil, the high level of drainage water, groundwater levels, their location level close to the ground surface, and the current drainage systems are inadequately functioning. All above mentioned factors include the complex agro-meliorative and agrotechnical measures can be improved as a result of joint use. First of all, it should be used to increase the efficiency of collector-drainage systems operating in the research areas, and then to increase the productivity of agricultural crops.

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Ecological conditions of the grapes growing in Ganja-Gazakh region of Azerbaijan

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Abstract

Azerbaijan is one of the ancient countries which is busy with grapes growing and its conversion. The vine-growing and wine-making agrarian branches possesses a special place, assume importance for the country economy on side economic rationality and additional value formation. The researches in a direction of the corresponding degree to an ecological requirement for the grape plant were performed by us in the Ganja-Gazakh region. According to the research purpose a mathematic-statistical scientific analysis was performed over the soil, climate and relief parameters and bonitet scores were found on the basis of the country soils fertility indices by gathering the latest research materials. The special evaluation scales were prepared according to the appearance degrees of the separate signs according to the ecological need of the grape plant on the basis of the methodical instructions over an ecological appraisal and over 20 types and subtypes of the soils good for grapes in the country zone an ecological evaluation was performed by applying these scales. Summarizing the researches we can say that the investigated zone possesses a high perspective to develop vine-growing and vine-making according to the zone ecological condition. The most favourable conditions for grape growing possess low mountainous and foothill zone of Ganja-Gazakh region of the republic, but the best soils for growing wine grapes are mountain-grey-brown dark (92 scores) and grey-brown dark (94 scores) soils.
Keywords: ecological estimation, ecological mark, fertility indicators, limiting factors.

Introduction

Azerbaijan is one of the ancient countries which is busy with grapes growing and its conversion. The archeologists discovered wine-making implements about II century BC in the Goygol zone from the Ganja-Gazakh region. A contemporary history of the wine-making in Goygol began in Yelenendorf german colony in the first-half of the XIX century, but developed from medieval of the XIX century [13].The Ganja-Gazakh zone is situated along the foothill plain zone of the Little Caucasus mountain province in the Azerbaijan west part. The height parameters fall down beginning from 500-600m above sea-level in the north-west till 100-200m of height in a south-eastern direction. This region is considered one of the large vine-culture zones in the republic and occupies the foothill and plain parts of Khanlar, Ganja, Shamkir, Tovuz, Agstafa and Gazakh administrative districts [5].
Ganja-Gazakh is situated in the central subtropical arid steppe climatic zone, possesses hot arid climate an average annual temperature is 11,5-13,1^{0}C, an amplitude is 24,4^{0}C , a temperature of the hottest month (July and August) is 25^{0}C, a maximum temperature is 38,4^{0}C, the coldest month temperature (January) is 8,6^{0}C. The yearly rainfalls quantity is 250-450 mm. A quantity of the active temperatures is 3500-4500^{0}C. The no-frost days are 240-245. The air relative humidity is 48-55% in the zone at a grape vegetation period. 10^{0}C higher temperatures which are required for beginning of the grape vegetation period are formed in the 1st ten-day of April [5]. The zone vineyards are irrigated because the yearly rainfalls quantity don't ensure a need for water at a grape vegetation period. The Kur river tributaries, subsoil waters, underground water-pipes are used for irrigation. A natural vegetation of the Ganja-Gazakh zone was mainly represented by wormwood formations keeping in the limited places. A main part of the zone soils is used under agricultural plants by ploughing.

Materials and Methods

An ecological evaluation of the grape-fruitful soils in the investigated zone was performed by applying the special estimation scales (table 2) according to the appearance degrees of the separate signs in the grape-fruitful soils grounding on the methodical instructions over G.Sh.Mammadov [6], S.Z.Mammadova [7], D.S.Bulgakov [2] and others authors' [8, 9].

Results and Discussion

The soil cover in Ganja-Gazakh zone was investigated by S.A.Zakharov, V.V.Akimtsev, H.A.Aliyev, Sh.G.Hasanov, M.E.Salayev [11] and other researchers [1]. M.E.Salayev [11] considered that the zonal soil types of the Ganja-Gazakh region are mountain-brown and grey -brown soils, gaja, solonetzificated and irrigated kinds of the grey-brown soils spread in the zone.

Stepped mountain-brown soils are between mountain-forest carbonate soils and mountain grey-brown soils in a low borderline of the forest zone in the Little Caucasus. The mathematic-statistical scientific analysis was performed, initially collecting of the latest research materials over the soil, climate and relief indices for setting up an ecological evaluation of the Ganja-Gazakh zone soils and the bonitet scores were found on the basis of these soils fertility parameters, at this time the dark mountain grey-brown soils possessing the highest fertility as a standard soil [12]. The results of ecological evaluation of the soils good for grapes of the Ganja-Gazakh zone were reflected in the following table (table 1).

Table 1. Ecological estimation of the Ganja-Gazakh zone soils

Name of soils	Height ,m	Precipitation,mm	? t>10^{0}C	Md	Bonitet mark of soil	$CaC0_3$,%	pH	<0,01 mm,%	Dry residue, %	Ecological mark
Stepped mountain grey-brown	200-600 / 90	350-450 / 90	3500-3800 / 95	0,25 / 100	89	10,27-18,16 / 100	7,8-8,1 / 100	42,92-56,64 / 100	- / 100	96
Dark mountain grey-brown	300-500 / 90	350-450 / 90	3500-3800 / 95	0,25 / 100	100	9,28-17,55 / 80	7,8-8,1 / 100	43,05-56,80 / 100	- / 100	97
Ordinary mountain grey-brown	300-400 / 100	350-450 / 90	3600-3900 / 95	0,20 / 90	80	11,23-19,56 / 100	7,8-8,1 / 100	45,68-58,12 / 80	0,05-0,07 / 100	94
Light mountain grey-brown	200-350 / 100	300-400 / 90	3800-4000 / 100	0,20 / 90	62	13,61-21,31 / 100	7,9-8,2 / 100	45,60-58,64 / 80	0,08-0,12 / 100	92
Dark grey-brown	200-350 / 100	300-400 / 90	3800-4000 / 100	0,20 / 90	85	7,57-14,05 / 90	7,9-8,2 / 100	42,92-53,32 / 100	0,08-0,12 / 100	96
Ordinary grey-brown	200-350 / 100	300-400 / 90	3900-4200 / 100	0,15 / 80	77	8,16-18,91 / 100	8,0-8,4 / 90	49,16-59,48 / 80	0,12-0,18 / 80	89
Light grey-brown	150-300 / 100	250-300 / 80	4000-4400 / 100	0,15 / 80	58	8,5-18,91 / 100	8,0-8,4 / 90	52,04-60,20 / 80	0,14-0,22 / 80	86
Caja grey-meadow	150-200 / 100	250-300 / 80	3900-4400 / 100	0,15 / 80	69	4,3-8,55 / 80	7,8-8,1 / 100	37,56-52,08 / 100	0,12-0,20 / 80	88
Meadow grey-brown	100-200 / 100	250-300 / 80	4000-4400 / 100	0,15 / 80	83	5,46-15,52 / 90	8,0-8,4 / 90	53,88-65,64 / 80	0,12-0,34 / 70	87

As is shown from the table the stepped mountain –brown soils got 90 scores for the height of the (300-600 m), a reason is the slopes sea-level, erosion, soil thinness in connection with soil washing out, and difficulties and limitations in vineyards building in the areas where micro-relief is less convenient. These soils got 90 scores for the rainfalls quantity, if we take into account that a need of the grape plant for water is 600-700 mm, this shows incomplete requirement, therefore development of the half-un irrigated vine-culture yield good consequences. A main heat provision of the grape growing got 95 scores for $\sum t>10^0C$ tons sum ($3500-3800^0C$), this shows profitability of the quick and mean growing grape sorts on the upper borderline of the foothill zone. Md index -0,25 (for A.J.Eyyubov [3]) shows placement of these soil in the semiarid climatic zone [12]. The stepped mountain-brown soils got 89 scores, the other physico-chemical indices-pH, a quantity of carbonates, physical clay, dry residue completely ensure an ecological need of the grape plant and got 100 scores. An average ecological score of the stepped mountain-brown soils is equal to 96. So the difficulties in grapevines growing in connection with the soil washing out, the erosion processes, the slopes sheerness concern the main limiting factors of the grape growing in the Ganja-Gazakh zone stepped mountain-brown soils.

*Mountain-grey-brown soils.*_The Little Caucasus arid steppe zone is on 200-500 m of height, the whole foothill zone of the Canja-Gazakh massive concern here, the main zonal soil type is mountain grey-brown soils. These soils spread among semidesert steppe (low borderline) and mountain-forestry steppe (upper borderline) zones in the province. According to the table the height indices of the dark mountain-grey brown soils are lower than optimum (90 scores), it is connected with eroding of same soils to a different degree on the upper borderline.90 scores show a need of the vineyards for irrigation (especially light mountain grey-brown soils) for the rainfalls quantity. Getting 95 scores the active temperatures render limitation of the late-ripening grape sorts on 500 m of the height. When we pay attention to the soils bonitet score we see that they are the most fertile-dark mountain grey-brown soils (100 scores). Being heavy loamy and clayey of the mechanical composition of the ordinary and light subtypes in the mountain-grey brown soils influences on bonitet score and was a reason for falling till 80 scores. As is obvious from the table the using ecological parameter scores reduced a bonitet score in the dark mountain grey-brown soils-97 scores but bonitet scores rose in the ordinary and bright mountain grey-brown soils: they changed from 80 scores (a bonitet score) to 94 scores (an ecological score) and from 62 scores to 92 scores, a reason is in connection with fitness of the environment factors and other soil indices ($CaCO_3$, pH, a quantity of dry residue) for the grape plant growing though the fertility parameters of the ordinary and bright mountain grey-brown soils are low.

Grey-brown soils are from the largest zonal soils of the Little Caucasus, they are divided into plain soils, the plain soils were formed in the more arid climatic condition in connection with transition from steppe into arid steppe and semidesert in comparison with the mountain soils [4]. These soils are found as large massives in the Ganja-Gazakh zone. If we pay attention to the grey-brown soils ecological value scores we see their change in 85-86 score limit (table). Though the bonitet scores are low these soils fertility indices (58-85 scores) the high ecological scores were got during evaluating by paying attention to the all ecological factors. The zone got 100 scores for the height and temperatures sum indices, 80 scores were got because of being less of the rainfalls quantity than optimum in the arid zone and naturally, Md parameter shows a need for irrigation in order to get the highest crop from these soils (80 scores). The dark and gaja soils for calcareous, but the ordinary and bright grey-brown soils for pH index got a low score. 90 scores were got for density on the illuvial horizon of these soils, 80 scores were got the salinization sorts of the grey-brown soils according to dry residue quantity. Generally, a total ecological score was high according to grape-fruitfulness degree of these soils because of soil indices for growing of the grape plant and grey-brown soils environment factors in the plain zone because of being high of an average ecological score over other parameters not including the bonitet score (87 scores): dark grey-brown soils got 96 scores, ordinary grey-brown soils -89 scores, bright grey-brown -86 scores, gaja grey-brown soils-88 scores. Getting 100 scores for active temperatures sum of this zone shows non-limitation to grow quick-, middle- and late growing sorts, it is necessary to grow corresponding grape sorts to produce table grape and to process high-qualitative table grape and dessert wines and grape juice [10].

Meadow-grey-brown soils are formed under high subsoil humidification on the river valleys and inclined foothill plains of the Little Caucasus. If we pay attention to the ecological value scores of the meadow-grey-brown soils, the relief indices of these soils were evaluated by 100 scores because of being good for grape, 80 scores of the rainfalls and Md index renders a need of the vineyards for irrigation. The meadow-grey-brown soils are fertile soils and a bonitet score was 83 scores over the main diagnostic parameters, the following scores were obtained over other soil indices: the soil calcareous and pH index got 90 scores because of being less than optimum for a grape, heaviness of soil mechanical structure and finding density reduced its score-80 scores. As the salinization traces are met in these soils, they were evaluate by 80 scores taking sensitivity of grape plant against salts into account. A total ecological score of the meadow-grey-brown soils is high and equal to 87. These soils have a good soil-climatic condition for grape growing, only it is necessary to pay attention to subsoil waters level during finding of density in soil mechanical structure and irrigation.

Conclusions

1. A main bonitet scale was composed by is performing of evaluation in the Ganja-Gazakh zone soils by a quality on the basis of the contemporary soil-ecological condition investigation of the zone researching as a result of generalization of the reference and fund materials and analysis; dark grey-brown soils (100 scores) possessing the highest fertility over a zone were taken as a model; enough fertile soils are stepped mountain-brown (89 scores) and dark-grey-brown (80 scores) and meadow-brown (83 scores) soils possess relatively average fertility. Bright grey-brown soils (58 scores) have the least fertility.
2. As a result of the researches the main limiting factors of the grape growing slopes sheerness, erosion processes, soil leaching for the foothill soils in the Ganja-Gazakh massive; for plain zone soils-climate aridity, heavy granulometric structure and soils salinization were determined.
3. In the end of our researches over grape-fruitful soils ecological evaluation in the Ganja-Gazakh massive of the Little Caucasus mountain province we can say that this zone possesses a high perspectiveness in vine-growing development according to the climate, relief condition. A grape-fruitful part of the zone is foothill zone. The dark mountain grey-brown (97 scores) and dark grey-brown (96 scores) soils possessing a high fertility and good water -physical characters are useful for grape growing on ecological side.
4. According to the sort selection it is advisable to grow Rkasitely, Bayanshira, Kakhet, Tavkveri, Madrasa and other technical grape sorts for production of the quantitative white, red, light table wines, undersweet wines and shampoo in the unirrigated vineyards of the investigative zone foothill part, Rkasitely, Bayanshira, Khindogny for dessert, strong and table wines, shampoo wine and grape juice production, Tabrizi, Ag Khalili, raisin grape sorts for table grapes.

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Condition, protection and reproduction of soil fertility in Ukraine

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Abstract

At state level in many countries worldwide (and Ukraine as well) are coming up to understanding a necessity of undertaking all-planetary urgent actions to prevent the global environmental crisis re-resulting from destruction, pollution and degradation of soils. The specific feature of Ukrainian soil cover is its diversity (asbout 40 types and over 800 subtypes) and heterogeneity.
Soil-degradation processes, such as dehumification, nutrients-contents-reduction, overcompaction, st-structure-loss, erosion, pollution etc. appear in a wide scope. According to calculation various agencies, total area of degraded and poorly-productive lands in Ukraine amounts to 5-6 to 10-12 million ha. Ag-Agropotential of arable lands productivity allows to receive 40-50 million tons of grain due to natural fertility and 70-80 million tons due to resource supply - fertilization, irrigation, chemical melioration and other methods. Realization of soil cover potential is hampered by moisture deficit (up to 80% of the territory), imbalance of land use, degradation processes.
The main activities for the protection and reproduction of the Ukrainian soils resource potential are aimed at eliminating to: nonoptimal correlation of land-plots and structurization of cultivated areas; low-resource input (low doses of organic and mineral fertilizers' application and supply of chemical ameliorant); inadequate level of State management of land resources; absence of State, territorial and regional soil-protection programs; insufficiency of legislative-regulatory and technical-normative pr-provisions to manage using and protection of land resources.
Key words: degradation, fertility, soil, soil protection.

Introduction

At state level in many countries worldwide (and Ukraine as well) are coming up to un-understanding a necessity of undertaking all-planetary urgent actions to prevent the global environmental crisis resulting from destruction, pollution and degradation of soils. During years of independent evolution of Law in Ukraine, a rather advanced and multi-branch land-legislation base has been created, alongside its steps to harmonization with that in Europe; however, land and soils' management still lags behind the present-day sustainable land use requirements. Environmental leverage tools are gradually being implemented in all sectors of Ukrainian economy; however still today, economic, administrative, financial and other as-aspects of State-legislation are not completely related to environmental and soil-protection laws. As a whole, Ukrainian land and soil resources' potential, beside its ability to guarantee the national food security itself, can also turn Ukraine into one of the most important players on the global food market. The present-day stage is characterized by: non-accomplishment of agrarian reforms; deficit of circulating assets; weakness of legislative and law-regulatory dr-drives; inefficiency of normative & methodology, informational, technological, sciential, pe-personnel and financial provisions, along with inertia in use of experience gained in-internationally.
The purpose of research: to assess condition and degrees of land-degradation processes of Ukrainian soil, fertility in in Ukraine and to elaborate ways of soil- fertility protection and reproduction.

Materials and Methods

At the core of the research is the implementation of multi-year integrated monitoring surveys of soil cover in Ukraine:

- the Polesye: sod-podzolic and soddy podzolized soils, over 3.8 mio ha;
- the Forest-Steppe: light-gray, gray-forest, and dark-gray podzolized soils, 4,3 mio ha, podzolized chernozems, 3.4 mio ha and typical chernozems, 5.8 mio ha;
- the Steppe ordinary chernozems, 10.4 mio ha; southern chernozems, 3.6 mio ha; podzolized and chestnut solonetzic soils, about 1.5 mio ha.
- The present-day soil-studies (including monitoring and systemic, statistical, analytical and syntheticapproaches) are a methodological basis of scientific research.

Results and Discussion

The specific feature of Ukrainian soil cover is its diversity (asbout 40 types and over 800 subtypes) and heterogeneity. Soil-degradation processes, such as dehumification, nutrients-contents-reduction, overcompaction, structure-loss, erosion, pollution etc. appear in a wide scope. According to calculation various agencies, total area of degraded and poorly-productive lands in Ukraine amounts to 5-6 to 10-12 million ha. Table-1: represents complete characteristics of types of soil degradation and their distribution, depending on degree of intensity [3]. Soils appeared vulnerable to degradation processes evolution caused by disbalanced land-use system dominating in agricultural industry that generally fails to provide positive results in issues of soil protection, nor high economic efficiency and ecological safety [1]. These phenomena are partly resultant from disturbance of environmentally balanced equilibrium between agri-lands, forests and water reservoirs, having affected the stability of agro-landscapes and increased anthropogenic burden upon the soil cover [2]. Soil degradation is a consequence of inefficient technologies and a result of poorly arranged inter-relations within the agrarian sector.

Agropotential of arable lands productivity allows to receive 40-50 million tons of grain due to natural fertility and 70-80 million tons due to resource supply - fertilization, irrigation, chemical melioration and other methods. Realization of soil cover potential is hampered by moisture deficit (up to 80% of the territory), imbalance of land use, degradation processes. Depending on the degree of degradation processes, crop yields can fall by 10-20% and even by 30-50%, while losses due only to shortage of the produce-output a year may amount to

Table 1. Propagation of Ukrainian soils' degradation processes

Types of soil degradation	Propagation (% from total area) per corresponding grades			
	weak	medium	heavy	total
Loss of humus and nutrients	12	30	1	43
Over-compaction	10	28	1	39
Soil monolith- and crust on surfaces formation	12	25	1	38
Water erosion	3	13	1	17
Acidification	5	9	0	14
Swamping	6	6	2	14
Radio nuclides pollution	5	6	0.1	11,1
Wind erosion, loss of the upper soil layer	1	9	1	11
Pollution by pesticides and other organic substances	2	7	0.3	9,3
Heavy metals pollution	0.5	7	0.5	8
Soil salinization, alkalization and solonetziciti	1	3	0.1	4,1
Water erosion, formation of ravines	0	1	2	3
Water erosion side effects (reservoirs' siltation etc.)	1	1	1	3
Reduced level of day-exposure surface	0.05	0.15	0.15	0.35
Wind-inflicted soil-surface deformation	0.04	0.23	0.08	0.35
Soils' aridization	0.04	0.18	0	0.22

At the same time, information support to condition of soils and soil cover is insufficient. Today we need sufficient, reliable and accurate information of soil condition, to determine their potential productivity, to evaluate their cost, to improve the tax policy, to implement soil monitoring, and to further introduce agrotechnologies adapted to specific soil and environmental conditions. It is only on basis of current information of soil cover condition that we can speak about formation of sustainable land management during optimization of land resources'. Due to the lack of a unified program and monitoring methods, incompatibility of indices, inactive management of the departmental network, it is necessary to change the imperfect policy of Ukrainian land monitoring into a State-ruled eco-monitoring network, with coordinated control of all environmentals (soil, water, air, groundwater, vegetation, depth resources, etc.). Analytical cartography materials on current status of lands, an Automated Information System, a Status Forecast of lands' condition with time, and a Business- case feasibility- report on prime and long- term methods of lands' protection should become the end-results of the monitoring program. The most important tasks include: revision, amendment and digitization of soil- cartography materials with respect to International FAO and WRB nomenclature base; harmonization of methodical approaches, programs and techniques with those in Europe; creation of an open-acess Information System; development of distant land-resources' monitoring techniques, such as remote sensing, air photography technologies etc.; updating the existing availabilities and creating innovative land- observation instruments.

National strategy of well-balanced soil resources use is necessary, while it is also important to safeguard lands from degradation, taking the European thematic Strategy of Soils' Protection as an example. There is a must to select and disseminate agrarian technologies with account of soil and climatic features, to introduce adaptive and landscape systems of agriculture, thereby meeting physiological needs of agricultural crops (thus obeying ecological compliance principles).

It is necessary to:

- the thought-over selection of crop rotations;
- observing a normative optimum- ratio of crop cultures;
- subsoiling the vegetable residues, straw, siderates etc.;
- keeping to rated depth of subsoiling fertilizers and vegetable residues;
- balanced field- utilization of local raw material resources;
- ensuring a stable deficit- free balance of nutritients (contrary to the present- day deficit of 30- 50 to 70- 80 kg/hectare a year);
- protect soils from erosion (because 30% arable lands are spread over slopes);
- reduce territories of ineffective arable land (to ensure lands preservation) over total area of 8-10 mio ha;
- improve the package of anti- erosion plans and procedures;
- master up and introduce innovative methods of soil tillage, including "zero" techniques (up to 5- 6 mio ha) and "surfacial" techniques (up to 12- 13 mio ha);
- employing agrotechnical approaches on moisture accumulation and preservation;
- arranging irrigation process, gradually restoring the irrigation systems;
- implementing chemical melioration of sour and solonetz soils (whose total area makes up about 10 mio ha) et al.

Environmental leverage tools are gradually being implemented in all sectors of Ukrainian economy; however still today, economic, administrative, financial and other aspects of State-legislation are not completely related to environmental and soil-protection laws. So, the main activities for the protection and reproduction of the Ukrainian soils resource potential are aimed at eliminating to: inadequate level of State management of land resources; absence of State, territorial and regional soil-protection programs; insufficiency of legislative-regulatory and technical-normative provisions to manage using and protection of land resources. In order to solve the problem of soil fertility-recovery and protecting them from degradation, Ukraine must have a clear strategy of soil- protection alongside prevention and combat land degradation that would empower: an effective functioning of relevant programs and laws; strict implementation-control hereof; soil-monitoring activities; mandatory regulation of anthropogenic burden constraints; administrative responsibilities of authority agencies and land users; observance of recommended techniques and promotion of innovative soil- protection technologies.

Conclusion

Today, one of the main problems of Ukraine is the agricultural land degradation. The total area of degraded lands in Ukraine ranges from 6-8 to 10-15 mio ha. Depending on degree of degradation processes, yielding capacity of agricultural crops may decrease by 10-20% and 30-50%, while losses only due to shortfall in produce harvested can make up over 20 billion UAH a year.

The main activities for the protection and reproduction of the Ukrainian soils resource potential are aimed at eliminating to: nonoptimal correlation of land-plots and structurization of cultivated areas; low-resource input (low doses of organic and mineral fertilizers' application and supply of chemical ameliorant); inadequate level of State management of land resources; absence of State, territorial and regional soil-protection programs; insufficiency of legislative-regulatory and technical-normative provisions to manage using and protection of land resources.

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Method of soil cultivation in the serozem zone

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Abstract

Agriculture of the South Kazakhstan region is conducted in the arid zone, where soil salinization is one of the main reasons for the low productivity of irrigated land. Therefore, soil washing and deep soil cultivation under conditions of secondary soil salinization, is an effective measure for the soil desalinization, ensuring improvement of soil and meliorative conditions and obtaining a high yield of raw cotton.
Key words: cotton, soil washing, harmful salts, deep soil cultivation, yield, economic efficiency.

Introduction

Agriculture of the South Kazakhstan region is conducted in the arid zone, where soil salinization is one of the main reasons for the low productivity of irrigated land. Salinization of soils, both initial and secondary, is a problem of irrigated land not only in the SKR, but it is a global problem. It has been proven by science and confirmed in practice that with a low degree of soil salinity the crop loss is at least 20-30%, medium 40-60%, and intensive and very intensive from 60% to total loss.
The problem of saline land reclamation in the SKR is very relevant, as salinization has spread in the areas where the most profitable crops, such as cotton, feed, cucurbits and vegetable crops are grown.
In conditions of cotton seeding of the Maktaral region, saline groundwater and a large amount of salts in the subsoil are the immediate source of secondary salinization. Salinization is associated with drainage problems, destruction of irrigation and drainage systems; inefficient use of water resources; growth in demand for agricultural products, which results in the increased stress on agricultural land; obsolete technologies that do not meet the requirements of today's production systems and many other factors.
Fighting against soil salinization is now considered in combination with other measures aimed at sustainable intensification of the agriculture, which is one of the foundations of food security.
Irrigated lands in the south of Kazakhstan are one of the most promising areas for the irrigation development and improving the efficiency of irrigated land use in the agricultural production. The successful development of lands and use of already irrigated areas is largely complicated by their unsatisfactory meliorative condition, which is caused by the conditions of insufficient outflow and close occurrence of mineralized groundwater, resulting in salinization of large areas of irrigated land. In this respect, it is very promising to wash saline soils and perform deep cultivation before washing.
Serozem soils are widespread in the territory of the Maktaral region, they are formed in conditions of shallow groundwater table (1 to 2 m). because of the close occurrence of groundwater, during irrigation intensive processes of secondary soil salinization are observed in this zone and in case of insufficient drainage their fertility decreases. When cultivating cotton crop rotation crops during irrigation, the soils are of medium saline and even of highly saline type by the end of vegetation, and require thorough washing.

Materials and Methods

Field experiments were carried out at the scientific and experimental site of LLP "the KazRI of cotton-growing", located in the territory of the Maktaral region of the South Kazakhstan

region using the methods of cotton field and vegetation experiments (ed. by A.I. Imamaliev, NIHI Soyuz, 1981).
Farm soils are mainly loamy gray soils, they are subject to salinity to a varying degree and are formed under the influence of slightly mineralized groundwater at a depth of 1 to 2 m.
The research object is a new regionalized cotton variety M-4007. Agrotechnics is generally accepted for the experimental base of the Institute.
Soil samples were taken at the experimental site and laboratory determinations were made on the content of harmful salts (dissolved solids, chlorine ion) in the soil at 3 horizons: 0 to 20 cm, 20 to 40 cm, 40 to 60 cm. Determination of the chlorine ion content was carried out by the Mohr's method by chloride titration with silver nitrate solution in the presence of a 10% potassium chromate solution as an indicator. The method for the determination of dry residue includes evaporation of some leak and taking into account the resulting residue after drying in a thermostat (weighing on analytical scales).

Results and Discussion

The results of the conducted experiments show that washing of salts from the soil increases both in case of deep cultivation and in case of the primary cultivation. On average, in case of deep cultivation the dissolved solids washing out from the meter layer during washing was 35.1%, and in case of primary cultivation it was 28.4% (Table 1).
Chlorine ion washing out was the most intensive. If during conventional plowing 43.3% of the original amount was washed out from the meter layer, then in case of deep cultivation it was up to 64.3%.

Table 1. Change in the content of salts in a meter soil layer using different cultivation methods, %

No.	Normal, m^3	Harmful salts	1-st year		2-nd year		3-rd year		average		
			before washing	after washing	before washing	after washing	before washing	after washing	before washing	after washing	%, outwash
Conventional plowing at 32 cm											
1	2.0	dissolved solids	0.351	0.248	0.368	0.261	0.389	0.283	0.369	0.264	28.4
		Cl	0.028	0.018	0.030	0.018	0.032	0.020	0.030	0.017	43.3
Deep cultivation at 55 cm											
2	2.0	dissolved solids	0.365	0.232	0.362	0.238	0.352	0.230	0.359	0.233	35.1
		Cl	0.032	0.012	0.026	0.010	0.028	0.008	0.028	0.010	64.3

Note: the numerator is the dissolved solids, the denominator is the chlorine ion.

The effect of deep cultivation on salt washing out during washing was the most effective in the first year of research. The aftereffect noticeably manifested itself in the next two years. Deep cultivation as compared with conventional plowing, allowed to significantly increase the salts washing out from the soil and to reduce the washing rate. The adopted irrigation regime ensured an optimal moistening of the soil in all variants of the experiment. However, the nonuniform soil desalinization during washing provided various conditions for the formation of a cotton crop.
The yield of raw cotton was obtained for a deep cultivation variant at a washing rate of 1.5 thousand m^3/ha and amounted to 36.0 c/ha. The yield increment in comparison with conventional plowing (1.5 thousand m^3/ha) was higher by 6.5 c/ha, respectively (Table 2).

Table 2. Yield of raw cotton, depending on the soil cultivation method and washing rate

No.	Method of soil cultivation	Washing rate, thousand m^3/ha	1-st year	2-nd year	3-rd year	average, c/ha	increase in yield, c/ha
1	Primary cultivation (to a depth of 32 cm) (control)	1.5 2.0 2.5	28.0 33.5 32.7	29.3 35.0 30.0	31.3 33.0 30.1	29.5 33.8 30.9	± 4.3 1.4
2	Deep soil cultivation to a depth of 55-60 cm	1.5 2.0 2.5	35.3 40.0 37.5	36.5 43.5 35.8	36.1 41.5 38.0	36.0 41.2 37.1	± (6.5) 5.2 (7.4) 1.1 (6.2)

Relatively higher yield of raw cotton is provided by the variant using deep cultivation at the washing rate of 2.5 thousand m^3/ha and amounted to 37.1 c/ha, with a yield increase of 6.2 c/ha as comparedwith conventional plowing.

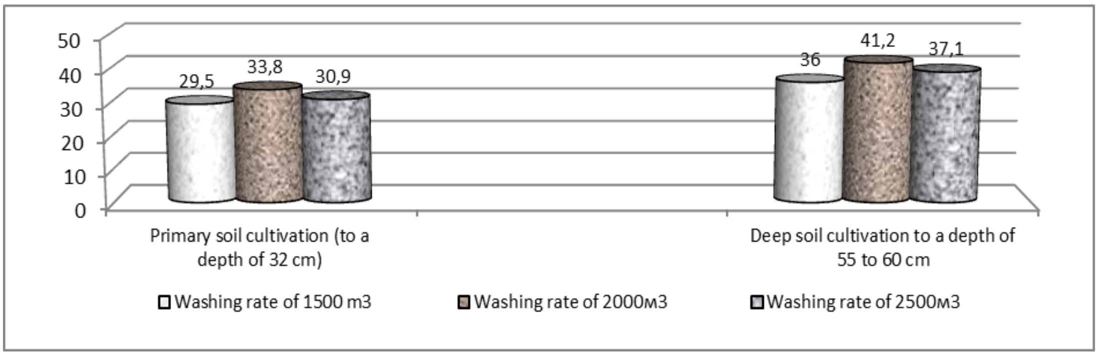

Figure 1. Comparative indicators of cotton yields, c/ha

The highest yield of raw cotton was obtained in case of deep cultivation option at a washing rate of 2,000 m^3/ha and amounted to 41.2 c/ha, with a yield increase of 7.4 c/ha (as compared to conventional plowing) .

A “plough-pan” was formed in the old irrigated zone of cotton sowing, as a result of prolonged irrigation at a depth of 32 cm, which significantly reduces the soil water permeability, desalination of the root layer and prolongs the washing time. It is necessary to cultivate the surface soils for more rational use of washing water and increasing the efficiency of washing in such conditions, which allows increasing its water permeability and creating the necessary rates of descending water movement during the washing period. Important agromeliorative methods that allow increasing the water permeability of the active layer of soil involve deep cultivation.

Consequently, washing in case of deep cultivation variant allows to reduce the volume of washing water by an average of 20% (from 2.5 to 2 thousand m^3/ha) while preserving the optimum desalination of the soil root layer. In this case, the effect of deep cultivation in improving the salt regime of soils and increasing the yield is manifested for at least 3 years.

Economic efficiency of deep soil cultivation as compared to conventional plowing is: saving fuel and lubricants - 60%; increased labor productivity by 40%; increased productivity of agricultural crops by 28 to 30%.

Deep plows destroy the soil plow pan formed as a result of annual land plowing, plow pan destruction allows for the improvement of aeration and physical properties of the soil, resulting in improved water permeability, decreased volume weight, good development of the root system of agricultural plants, increased yield, and improved products quality.

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Change of the humus state of fallow soils

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Abstract

The aim of the research was to study the humus state of the different-aged (2 years and 70-75 years) fallow soils (Luvisols) by IR spectroscopy and stepwise oxidation according to Chan. The feature of the studied different - aged fallow soils is the presence of a series of absorption bands characteristic of aliphatic esters. Probably they are the most stable and permanent structural units of soil organic matter (OM). In the fallow soil (70-75 years and 2 years) from the surface and up to a depth of 15 cm the increase in the absorption intensity in the region of about 3000 cm-1 is observed which correspond to the stretching vibrations of the CH2 and CH3 groups. The increase in their intensity with depth can be associated with the increase in the chain length of saturated hydrocarbons. In the upper 10 cm layer of fallow soils are detected absorption bands of the peroxide group which may be due to the auto-oxidation of organic and organometallic compounds with air oxygen. In the fallow soil of the age of 2 years were found series of bands of silicic oxygen stretching vibrations which is probably associated with the insignificant accumulation of secondary humus. The results of stepwise oxidation of fallow soils OM showed that in the upper layers (0-10 cm) of the old plow horizon there is the accumulation of easily-oxidized and medium-oxidized fractions of OM. In fallow soils of the age more than 70 years this process is significantly stronger. Thus, when old-arable soils are found in the fallow state for decades accumulated low-humified plant residues which will quickly mineralize when the fallow soils return to arable land.
Key words: fallow soils, soil organic matter, humus.

Introduction

At present transition in non-cultivated arable land it has become a worldwide trend especially characteristic of Russia (Kurganova et al., 2010; Lyuri et al., 2010). The formation of follow soils in the forest zone is accompanied by spontaneous successions at the beginning of the weed (the pioneering stage of overgrowth) then meadow and tree vegetation (Lyuri et al., 2010). Spontaneous restoration of the original vegetation in fallow soils is considered as a factor in the contemporary evolution of Russian soils. In the upper part of the old-arable horizon there is the formation of the secondary humus-accumulative horizon and in the lower part - the podzolic horizon (Giniyatullin et al. 2013). As a result of secondary accumulation of humus, layers with a different humic state are formed (Kvasova et al., 2007).
The aim of the research was to study the humus state of the different-aged (2 years and 70-75 years) fallow soils (Luvisols) by IR spectroscopy and stepwise oxidation according to Chan.

Materials & Methods

To study the patterns of accumulation of humus under fallow vegetation the different-aged fallow soils (2 years and 70-75 years) were selected. Vegetation of follow soils is represented by meadow vegetation, overgrown with wood cultures - birch and pine (single specimens). To measure the IR spectra samples from the old plow horizon were selected layer by layer (5 cm) to a depth of up to 20 cm. Samples after careful selection of roots were confused and passed through a sieve of 0.1 mm. To correct the absorption bands of quartz and clay minerals the mineral phase of the samples studied was used as the background which was obtained by burning 30% H_2O_2 of OM according to the procedure (ISO 11277:1998; Pansu and Gautheyrou, 2006; Valeeva et al., 2015). Stepwise oxidation of soil organic matter was carried out according to Chan (Chan et al., 2001).

Results & Discussion

The feature of the studied different - aged fallow soils is the presence of a series of absorption bands characteristic of aliphatic esters. Probably they are the most stable and permanent structural units of soil OM (fig.1).

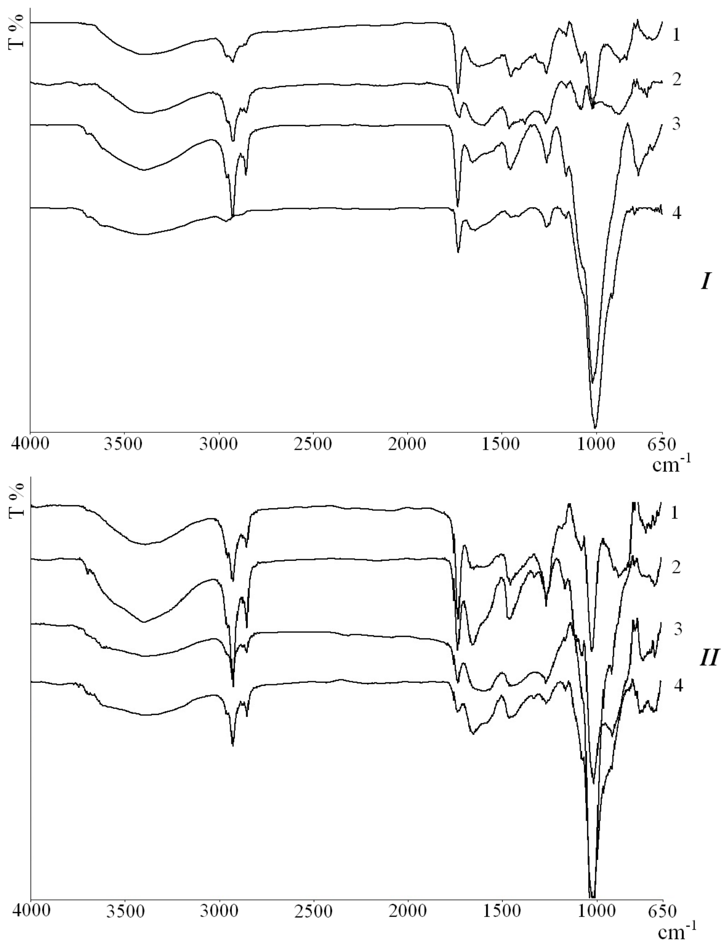

Figure 1. The IR spectra of the depths (1 – 0-5cm, 2 – 5-10 cm, 3 –10-15 cm, 4 – 15-20 cm) of follow soils (I – fallow the soil of the age of 70-75 years, II – fallow soil age 2 years)

In the fallow soil (70-75 years and 2 years) from the surface and up to a depth of 15 cm the increase in the absorption intensity in the region of about 3000 cm^{-1} is observed which correspond to the stretching vibrations of the CH_2 and CH_3 groups. The increase in their intensity with depth can be associated with the increase in the chain length of saturated hydrocarbons. In the upper 10 cm layer of fallow soils are detected absorption bands of the peroxide group which may be due to the auto-oxidation of organic and organometallic compounds with air oxygen. In the fallow soil of the age of 2 years were found series of bands of silicic oxygen stretching vibrations which is probably associated with the insignificant accumulation of secondary humus.

The results of stepwise oxidation of fallow soils OM showed that in the upper layers (0-10 cm) of the old plow horizon there is the accumulation of easily-oxidized and medium-oxidized fractions of OM (fig.2).

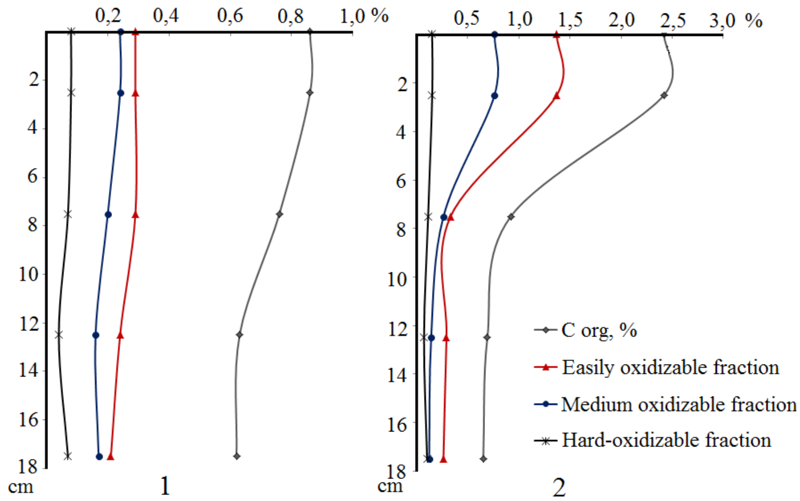

Figure 2. Profile distribution of Corg and OM fractions of fallow soils (1 – fallow soil age 2 years, 2-fallow the soil of the age of 70-75 years)

In fallow soils of the age more than 70 years this process is significantly stronger. The accumulation is also observed in the upper layer and only in the medium and easily decomposable form. Thus, when old-arable soils are found in the fallow state for decades accumulated low-humified plant residues which will quickly mineralize when the fallow soils return to arable land.

Acknowledgement

The part of this project was supported by the Russian Foundation for Basic Research (project № 17-04-00846).

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Agroecological receptions for increase productivity of grained and cereals crops in the Zhambyl region

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Abstract

The object of research is agro ecological methods for increasing the productivity of leguminous and cereal crops in the Zhambyl region.
The purpose of the study is the development and adaptation of ameliorative techniques for improving the water and physical and chemical properties of soils, increasing the yield of leguminous (soybean) and cereal (sorghum) crops and the ecological stability of agro landscapes in the Zhambyl region.
The results of investigations at the Besagash experimental production site in Zhambyl oblast are presented, and 4 variants are studied.
1. Control (conventional tillage - without meliorating and without loosening)
2. Implementation in the soil of the calculated rate of phosphor gypsum (5-7 tons / ha);
3. Loosening the soil to a depth of 40-60 cm;
4. Implementation in the soil of the estimated rate of phosphor gypsum (5-7 t / ha) and its loosening to a depth of 40-60 cm.
The results of the research showed that the growth and development rates of the studied crops - soya and sorghum - were quite high in variants with the introduction of phosphogypsum. For example, in the control variant the height of sorghum varied within the limits of 117-245 cm, and in the second variant - 156-255 cm.
The highest growth and development rates of soybean and sorghum (4th variant) ensure maximum yield and low irrigation water costs per unit of production. For example, in the control variant the yield of soybean was 23.4-24.5 centner / ha, and in the fourth variant - 33.37.7 centner / ha. Similar yield indicators were obtained for sorghum cultivation (Table 3).
Key words: Increase in productivity, agroecological methods, soybean, sorghum, deep loosening.

Introduction

In the Address of the President of the Republic of Kazakhstan Strategy of Kazakhstan 2050, the water shortage is considered as a global threat. At the same time, the Government is facing goals to ensure a stable supply of water to the population (by 2020) and agriculture (by 2040), by 2050 it is planned to solve all problems with water resources. This situation is the main prerequisite for the development of increasing the productivity of leguminous and cereal crops by developing resource-saving agro ecological methods for improving the fertility of degraded soils. In Kazakhstan soybean is grown, mainly in the south and south-east. Its area for the period from 2009 to 2012 increased from 52.4 to 84.3 thousand hectares, or 60.9%. In the Zhambyl region, the area of soybean cultivation varies within the limits of 0.1-0.7 thousand hectares, and its productivity is 6.7-8.5 centner/ha (Kovda V.A., 1984.).
Thus, high yields of leguminous and cereal crops are achieved by taking into account the emerging new agro technological policy in agro landscapes, based, among other things, on the development and development of economically effective, environmentally safe methods for regulating the water-physical and chemical properties of soils.

Materials and Methods

Two pilot sites were prepared on irrigated lands of Experience Productivity Site "Besagash" in Zhambyl region of Zhambyl region, located in the basin of the rivers Talas-Asa, in close proximity to the settlement of the same name. EPS "Besagash" is located in the zone of piedmont semi-deserts, according to its moisture content it is a dry zone, with Ku = 0.20 (Vishpol'skii F.F., Mukhamedzhanov Kh.V., 2005). The climate of the field study area is continental, with a relatively mild winter and, as a rule, wet spring, hot summer, warm and dry autumn. The average annual air temperature at the Zhambyl meteorological station is +6.9 - + 9.50C. The sum of positive temperatures with a temperature above 100C reaches 3300-34000C per year. The average annual precipitation is 250-330 mm, of which 128-172 mm fall during the warm period (IV-IX). The duration of the frost-free period reaches 150-180 days. Spring frosts on average stop in the third decade of April, autumn comes in the third decade of September or the first ten days of October. (Dospekhov B.A.). As was mentioned above, 2 experimental sites were prepared in the current year for carrying out research work. In the first section, laid down in 2015, the aftereffects of loosening of soils and the introduction of phosphogypsum into agroecological processes and their influence on the yield of sorghum and soybean were investigated. In the second phase, organized in 2016, agroecological processes were investigated, including last year's options. (Bekbayev R.K., Zhaparkulova E.D. i dr, 2007).

In studies as a legume culture, soybean variety (Swallow) was studied, and cereals variety (Kazakhstan 16) as cereal crops. The sowing of sorghum was carried out on May 15, and soya on May 22.

The irrigation of furrows of these crops in field experiments was carried out in accordance with the norms of 800 and 1000 m^3/ ha at the threshold of the presumed soil moisture of 70-75% of HB, and in lysimeters 500 and 1000 m^3/ ha.

The influence of the depth of loosening and the introduction of ameliorant (phosphor gypsum) under irrigation on the changes in agro ecological processes in the root layer of soils was investigated and established in experimental sites and in lysimeters. The area for each variant was 0.05 ha 20x25 m. The area of each of the two experimental sites was 0.40 ha for soy and sorghum.

The reliability of the results of field research was supported by experiments in lysimeters, in which soy and sorghum were also grown [4].

Results and Discussion

The results of the research showed that loosening and application of phosphogypsum in the soil improves the water-physical and chemical properties of soils. For example, loosening provides a reduction in density and an increase in the porosity of the root mass of soils (Mozheiko A.M. 1967.). (Table 1).

Table 1. Effect of loosening of soils on their density and porosity

Horizon, sm	Density			Porosity		
	before loosen-ing, t/m^3	after loosening		before loosening, t/m^3	after loosening	
		t/m^3	from soil density to loosening		%	from soil density to loosening
0-20	1,36	1,24	0,91	50,5	54,4	1,08
20-40	1,69	1,37	0,81	38,1	49,8	1,31
40-60	1,61	1,43	0,89	41,2	47,8	1,16
0-60	1,55	1,35	0,87	43,3	50,7	1,17

The decrease in soil density predetermines an increase in porosity, the parameters of which in the 0-60 cm layer vary within the limits of 47.8-54.4%, i.e. increases in 1,08-1,31 times in comparison with indicators of loosening of soils. The maximum increase in soil porosity occurs in the sub-plow (20-40 cm) layer from 38.1% to 49.8%, or 31% of the soil porosity to loosening.

Table 2. Mineralization of washed salts in watering, g/l

Variants	Anions				Cations			Sum of salts	pH
	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+		
control	track	0,259	0,207	2,119	0,124	0,294	0,548	3,551	8,2
implementation in the soil of phos-phor gypsum	0,024	0,507	0,247	2,738	0,064	0,503	0,656	4,739	8,5
loosening	0,028	0,512	0,216	2,396	0,140	0,376	0,629	4,297	8,5
loosening and im-plementation in the soil of phosphor gypsum	0,034	0,551	0,244	2,357	0,120	0,449	1,292	5,053	8,5

The pH values in the 2nd and 4th variants, where phosphor gypsum is introduced, vary within 7.6-7.85, and in the 1st and 3rd variants it is 8.5-8.75. These data indicate that the introduction of phosphor gypsum into the soil with a rate of 5 tons/ha ensured the leaching of the root mass of soils to the maximum permissible threshold. Therefore, in these variants, the growth and development indices of plants, compared with the control variant, are much higher (Magay S.D. 2014).

The results of the research showed that the growth and development rates of the studied crops - soya and sorghum - were quite high in variants with the introduction of phosphogypsum. For example, in the control variant the height of sorghum varied within the limits of 117-245 cm, and in the second variant - 156-255 cm (Vishpolski F., Qadir M., Karimov A., Mukhamedjanov H., Bekbaev U., Paroda R., Aw-Hassan A., Rarajeh F. 2008).

The highest growth and development rates of soybean and sorghum (4th variant) ensure maximum yield and low irrigation water costs per unit of production. For example, in the control variant the yield of soybean was 23.4-24.5 centner / ha, and in the fourth variant - 33.37.7 centner / ha. Similar yield indicators were obtained for sorghum cultivation (Table 3) (F. Vyshpolsky, K. Mukhamedjanov, U. Bekbayev, S. Ibatullin, T. Yuldashev, A.D. Noble, A. Mirzabaev, A. Aw-Hassan, M. Qadir., 2010).

Table 3. Yield of soybeans and sorghum in pilot plots and water costs per unit of production

Culture	Years	Variants	Irriga-tion norms, m^3/ha	Productivity, ts/ra	Water expenses on 1 ts field,	
					m^3/ts	from the control op-tion
1	2	3	4	5	6	7
Soy-bean	2015	control	4600	23,4	196,6	1,0
		implementation in the soil of phosphor gyp-sum	4600	30,5	150,8	0,77
		loosening	4600	26,8	171,6	0,87
		loosening and imple-mentation in the soil of phosphor gypsum	4600	33,1	138,9	0,71

Continuation of table 3

1	2	3	4	5	6	7
Soybean	2016	control	4600	24,5	187,8	1,0
		implementation in the soil of phosphor gypsum	4600	29,0	158,6	0,85
		loosening	4600	28,2	163,1	0,87
		loosening and implementation in the soil of phosphor gypsum	4600	33,7	136,5	0,73
Sorghum	2015	control	4600	349,0	13,20	1,0
		implementation in the soil of phosphor gypsum	4600	385,0	11,94	0,90
		loosening	4600	353,5	13,02	0,98
		loosening and implementation in the soil of phosphor gypsum	4600	472,5	9,73	0,74
	2016	control	4600	390,4	11,78	1,0
		implementation in the soil of phosphor gypsum	4600	441,5	10,42	0,88
		loosening	4600	395,0	11,64	0,99
		loosening and implementation in the soil of phosphor gypsum	4600	498,5	9,22	0,78

Conclusions

1 In conditions of degraded irrigated soils in the Zhambyl region, the main factor in reducing the yield of leguminous and cereal crops is their magnesium soling and alkalinization.

2. Affordable and most effective chemical ameliorant is phosphogypsum, the reserves of which, as waste from the chemical industry of the region, are more than 6 million tons.

3.The results of research conducted over 2 years (2015-2016) have allowed to develop methods for increasing the productivity of leguminous (soybean) and cereal (sorghum) crops.

4. The developed methods include application of phosphogypsum in soil with the norm of 5-7 t / ha and loosening of the soil to a depth of 40-60 cm. As a result of these two methods, the density and increase of soil porosity are reduced, as well as the solonetsity and alkalinity decrease, forms of phosphorus at 120-150 kg / ha.

5. The developed agroecological methods include the introduction of phosphogypsum into the soil with a rate of 5-7 t / ha and a deep (40-60 cm) loosening of the root mass.

6. The use of these two methods alone, but better together provides a reduction in density and increase in porosity of soils, as well as a decrease in the degree of alkalinity and alkalinity, an increase in the mobile forms of phosphorus by 120-150 kg / ha.

7. The joint use of phosphogypsum and deep loosening reduces water costs for the creation of 1 centner soybean grains by 27-29%, and for the creation of 1 centner sorghum mass - 22-26% relative to the control option - without any meliorative measures.

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Modelling of Soil Organic Carbon Dynamics in Kazakhstan

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Abstract

Traditional farming systems, involving intensive tillage, returning low amounts of organic matter to the field and frequently monoculture, lead to a decrease in soil organic carbon (SOC) and land degradation. In contrast, conservation agriculture (CA) has a large potential for carbon sequestration. The objective of this study is to assess the potential of CA for soil C sequestration in one Kazakhstan site, proposing a methodology that could be extended to other conditions in Kazakhstan. We performed a comparative assessment of SOC changes over 20 years under CA and conventional cropping systems in the Almaty region by using a dynamic simulation model ARMOSA. We simulated the carbon dynamics in the first metre of soil, using a set of daily data of T_{max}, T_{min} and rain from 2012 to 2017. To obtain a 20 years meteorological data series, 6-years data were extended by using the Climate weather generator. Conventional cropping system shows a constant decrease of organic carbon over time, with an annual average of 0.74% that is equivalent to a loss of about 800 kg ha^{-1} y^{-1}. The decrease stems from straw removal, which is not compensated by the carbon in the roots and from ploughing creating SOC oxidation. In contrast, conservation cropping system shows a 1.14% increase of SOC per year (equivalent to 1200 kg ha^{-1} y^{-1}). Such an increase is double than the objective of "4 per 1000" initiative aimed to halt the increase in the CO_2 concentration in the atmosphere related to human activities. Conservation agriculture has a large potential for C sequestration in Kazakhstan, particularly in irrigated areas allowing for rotation high-yielding crops together with cover crops. Future studies should be aimed to assess the performance of these cropping systems during field experiments in different climatic zones of Kazakhstan.

Key words: conservation agriculture; maize; modeling; no-till; soil organic carbon; wheat.

Introduction

Traditional farming systems, involving intensive tillage, returning low amounts of organic matter to the field and frequently monoculture, lead to a decrease in soil organic carbon (SOC) and land degradation. In contrast, conservation agriculture (CA) has a large potential for carbon sequestration. CA implies minimum soil disturbance, permanent soil cover with crop residues and crop rotation. In the Americas, CA occupies more than 50% of agricultural land.

In Kazakhstan, the areas under no-till have been increasing from virtually nothing in 2000 to 2.5 million ha in 2016 that is, however, only about 1.1% of agricultural lands. Therefore, FAO consider Kazakhstan to be "high" in terms of the potential area for the further spread of CA.

Since changes in SOC are a very slow process, long-term experiments (at least 10 years) are required to obtain reliable data and to assess the carbon sequestration of agricultural systems. There is a need to evaluate the performance of alternative cropping systems in different pedoclimatic conditions, and to assess their potential in terms of the SOC increase, yield and environmental impact. The objective of this study is to assess the potential of CA for soil C sequestration in one Kazakhstan site, proposing a methodology that could be extended to other conditions in Kazakhstan.

Materials and Methods

We performed a comparative assessment of SOC changes over 20 years under CA and traditional cropping systems in the Almaty region by using a dynamic simulation model ARMOSA that simulates the cropping systems at a daily time-step at field scale (Perego et al., 2013). The model simulates agrometeorological variables, the water balance, the carbon and nitrogen balance, and the crop development and growth. The model consists of four modules, which are:

I. micrometeorological model simulating the energy balance (latent and sensible heat) and allowing the evapotranspiration estimation;
II. crop development and growth model that uses global radiation and temperature;
III. model of soil water balance;
IV. model of soil nitrogen and carbon balance. The water dynamics can be simulated according to the physically based approach of the Richards' equation, or through the empirical cascading approach.

ARMOSA estimates the photosynthesis for five layers along the vertical profile of the canopy, selected on the basis of a Gaussian integration, to obtain an integrated value of photosynthesis of the whole canopy. The maximum potential photosynthetic rate is a function of CO_2 concentration in the atmosphere; therefore, the model was also used in studies of climate change effects (Perego et al. 2014).

Crop production was estimated under water and N limited conditions by linking growth to the soil water and N balance. The effect of water stress on plant growth is calculated as a function of soil water content by using logistic function that simplifies the original step function proposed by Sinclair et al. (1987).

Compared to a previous version (2013), the updated ARMOSA contains specific procedures to better simulate the effects of tillage and conservation agriculture:

1. Crop biomass lying on the soil surface is considered to be a specific pool with their characteristics in terms of degradation and with effects on soil water dynamic controlling the evaporation losses.
2. Bulk density and hydrological characteristics (the alpha and N of the van Genuchten retention function parameters, saturated conductivity, and water content at saturation) evolves in relation to the change in soil carbon contents and changes in relation to the different tillage operation, considering the type of tillage, its depth and the percentage of soil tilled.
3. More calibrations are available due to the use of the model in several international ring tests of the model (Pirttioja 2015; Fronzek et al. 2018).

We simulated the carbon dynamics in the first metre of soil in the Almaty region, using a set of daily data of T_{max}, T_{min} and rain from 2012 to 2017. To obtain a 20 years meteorological data series, 6-years data were extended by using the Climate weather generator. Global solar radiation was computed by using Hargeaves method (Hargeaves et al. 1985). The soil used for the simulation has characteristics reported in Table 1.

Table 1. Soil characteristics used for simulation

Soil layer (cm)	Sand (%)	Silt (%)	Clay (%)	Organic C (%)	Bulk density (t m^{-3})	Skeleton
0-20	11.5	67.9	20.7	1.41	1.25	0
20-35	8.7	71.0	20.3	1.34	1.32	0
40-80	9.9	67.5	22.6	0.70	1.30	0
80-200	7.3	70.6	22.1	0.40	1.33	5

We simulated the following cropping systems:
1) Conventional (CONV), i.e., continuous wheat cultivation, with ploughing at 0.25 m, and crop residual (straw) removed.
2) Conservation (CONS), i.e., wheat-soybean-maize rotation, with Italian ryegrass as a cover crop sowing between wheat and soybean, and soybean and maize. We have simulated a no-till system, leaving residuals on the soil surface and direct sowing. For wheat and maize, we simulated irrigation to fulfil the crop water requirement.

In the simulation, both systems were fertilized with 80 kg N ha^{-1} by using urea.

Results and Discussion

Trends in total organic carbon in CONV and CONS cropping systems appear in Figure 1. CONV shows a constant decrease of organic carbon over time, with an annual average of 0.74% that is equivalent to a loss of about 800 kg ha^{-1} y^{-1}. The decrease stems from straw removal, which is not compensated by the carbon in the roots and from ploughing creating SOC oxidation. In contrast, CONS shows a 1.14% increase of SOC per year (equivalent to 1200 kg ha^{-1} y^{-1}).

Such an increase is double than the objective of “4 per 1000” initiative aimed to halt the increase in the CO_2 concentration in the atmosphere related to human activities (Minasny et al. 2017).The mechanism underlies SOC increase is an accumulation of biomass returned to the soil through residuals and cover crops that are not subjects to oxidation due to no tillage of soil. However, it should be noticed that an increase in stable carbon is only expected after several years of CA application that is amounted to 20% of the total increase, mainly due to the presence of litter laying on the soil surface.

Moreover, even if the percolation is slightly increased (+11%) due to irrigation in CONS, nitrogen leaching shows a 56% reduction (8.9 kg ha^{-1} y^{-1} N-NO_3), compared to that in CONS (3.9 kg ha^{-1} y^{-1} N-NO_3), due to nitrogen uptake by cover vegetation continuously presented on the soil.

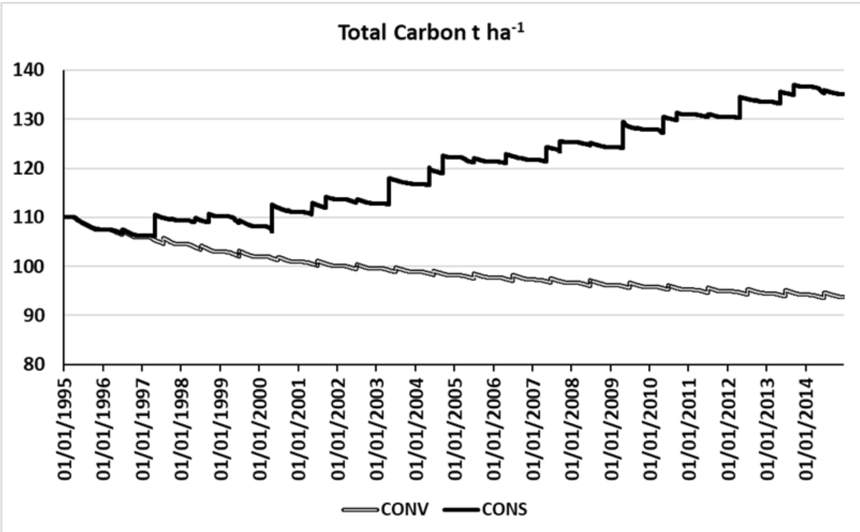

Figure 1. Simulated total organic carbon trend for conventional (CONV) and conservative (CONS) cropping systems (1995–2015)

Conclusions

Conservation agriculture has a large potential for C sequestration in Kazakhstan, particularly in irrigated areas allowing for rotation high-yielding crops together with cover crops, and also offering benefits in terms of environmental quality. Future studies should be aimed to assess the performance of these cropping systems during field experiments in different climatic zones of Kazakhstan. In particular, attention should be paid to cover crops, which seem to have significant role in C sequestration, but are not yet widely spread in practical farming in Kazakhstan.

Acknowledgements

The project "Innovative cropping systems for carbon market" was funded by Natural Resources Institute Finland (Luke).

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Visions and Innovations for Sustainable Use of Soils in Eurasia

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Key words: Land, soil, water, ecosystems, sustainability, research cooperation, monitoring, methods, soil quality, crop yield, Central Asia, Siberia.

1 Introduction

The paper aims to initiate a sustainable use of soils in Eurasia by the application and transfer of novel scientific methods. We share the visions of the originator of the modern soil science VV Dokuchaev and the great innovators of agrochemistry J v. Liebig, EA Mitscherlich, DN Pryanishnikov, UU Uspanov and others. Their visions were to eliminate hunger and poverty of the population by stable crop yields based on innovative site-adapted soil management and farming.

In the post-war period of the 20th century great progress in science and agricultural practice enabled to make these visions reality in Europe and in the whole Soviet Union. Crop yields increased and hunger was eliminated. However, some progress achieved was on costs of sustainability. Soil degradation and loss of biodiversity became significant. In the 21st century the global struggle for resources, land and water included, and men-made climate change have created new threats for soils, ecosystems and inhabitants of rural areas. Thus, food security is not stable in Eurasia whilst the status of soils and water bodies remains endangered and not adequately monitored.

Science and technology may help to find solutions for sustainable use of soils. The awareness about limited and degrading natural resources have fired the energy and creativity of responsible and innovative people to develop and install monitoring systems and countermeasures. However, the access to modern monitoring systems and agri-environmental technologies is different over regions of Eurasia. Some regions of Central Asia and Asian Russia require modern monitoring systems for their land and water resources in order to avoid their accelerating degradation and maintain their productivity function and ecosystem services for the population.

Tailored solutions have to be based on detailed analyses and data. We start with an extended analysis of water and land resources, characterising the natural conditions of North and Cen-

tral Asian landscapes, their ecosystems, crucial processes, and human impacts on soil and water quality. The status of research and monitoring is also characterised, pointing both on substantial progress achieved during the past decades, but also on gaps in our knowledge.
Following our analysis, rural landscapes in North and Central Asia have great potential for economically and ecologically viable business activities, but are currently characterized by inefficient and unsustainable land and water management practices, industrial pollution and the decay of the rural infrastructure. The land and water resources of Central Asia are in a particular critical state. Some keywords are: grassland degradation, humus loss and wind erosion on cropping land, salinisation of irrigated land, low agricultural productivity and water use efficiency, water scarcity, water pollution. Sustainable practices should be introduced soon, and this must be based on modern monitoring and management technologies.
To promote this, we offer an array of methods of measuring, assessing, forecasting, utilizing and controlling processes in agricultural landscapes. These are laboratory and field measurement methods, methods of resource evaluation, functional mapping and risk assessment, and remote sensing methods for monitoring and modelling large areas. Novel methods of data analysis and ecosystem modelling, of bioremediation of soil and water, field monitoring of soils, and methods and technologies for optimizing land use systems have been developed as well. We depict some highlights which could (a) lead to a significant knowledge shift, (b) initiate sustainable soil resource use and (c) trigger substantial improvement of the ecosystem status, provided they are introduced into landscapes of North and Central Asia or applied there very soon on a wide scale. These are (1) soil and hydrological laboratory measurement methods, (2) process-based field measurement and evaluation methods of land and water quality, (3) remote sensing and GIS technology-based landscape monitoring methods, (4) process and ecosystem modelling approaches, (5) methods of resource and process evaluation and functional soil mapping, and (6) tools for controlling agricultural land use systems such as nutrient balancing methods, conservation agriculture and their technologies. More than 15 concrete monitoring and management tools could immediately be introduced into research and practice, some of them without monetary investment.
Agri-environmental research projects should have high priority as gaps in our knowledge are particular high, and a particularly large amount of novel measurement, evaluation, modelling and management tools are available. Various tools are ready for immediate introduction into North and Central Asian landscapes in the framework of mutual pilot projects: state-of-the-science field monitoring technologies for soil and forest hydrology (EEM-HYPROP, virtual and real lysimeters) and groundwater quality (direct push sampling, multi-level wells), agro-ecological models and decision support systems (MONICA, LandCare-DSS), soil and land quality classification and evaluation tools (WRB 2014, Muencheberg Soil Quality Rating), nutrient balancing tools, irrigation control systems, grassland evaluation methods, wind erosion monitoring systems and technologies of conservation agriculture.
We conclude that strengthening international and national research cooperation in these fields will be key for making novel methods operational. The role of internationally linked monitoring capacities is particularly emphasised, with some existing stations established in the vast agri-environmental monitoring network and others to be newly built in remote regions of Asia, and supported by the latest remote sensing technologies.
More information about methodologies and innovations is given in two monographies. The books „Novel Measurement and Assessment Tools for Monitoring and Management of Land and Water Resources in Agricultural Landscapes of Central Asia“ (Новые Измерительные и Оценочные Методы для Мониторинга и Управления Земельными и Водными Ресурсами Агроландшафтов Центральной Азии) (Springer 2014), and „Novel Methods for Monitoring and Managing of Land and Water Resources in Siberia” (Новые Методы для Мониторинга и Управления Земельных и Водных Ресурсов в Сибири) (Springer 2015)

provide details. The book contributors represent an immense innovation network which should be employed to achieve both significant disciplinary and synergetic outreach effects. This should be imbedded into more sustainable strategies aiming at research cooperation between partners from EU countries, the Russian Federation and countries of Central Asia. Pilot projects, permanent think tanks, Scientific-Technical Education Centres, and Schools of Environment and Natural Resources are possible promoters who can carry novel methods into the heads and hearts of people in Eurasia. Significant progress towards food security over Eurasia and maintaining the functions of great landscapes for future human generations will be the reward of those efforts.

2 Status of agricultural land

2.2 Industrial pollution of soil

Industrial pollution of soil is a serious problem worldwide and also in Siberia. The air quality in Siberian cities and their industrial areas is very bad (Adam and Mamin 2001, Kashapov et al 2008). Urban air quality in several Siberian cities (e.g. Norilsk, Barnaul, and Novokuznetsk) is considered among the worst in Russian (Baklanov et al 2013). Siberian ecosystems have begun to show stress from the accumulation of pollution depositions that come from cities and industrial plants (Gutman et al 2013). Pollutants are being dispersed over soils of the region. Mining, transport and storage of industrial minerals or products has also led to point source pollution. Many areas around major metallurgical, chemical, and energy enterprises have been found to be polluted by toxic substances such as heavy metals, oil and oil products, sulphur oxides and chemical wastes. About 3.6 Million ha of agricultural land in Russia are contaminated with radionuclides and heavy metals (FAO 2013a). Under permafrost conditions industrial pollution is a particular threat because the damage to vegetation initiates thermokarst processes (Chuprova 2006, Baranov et al 2010).

2.3 Soil quality for agriculture

For environmental monitoring, both soil and water and quality can be measured using sets of chemical, biological and physical data. In the case of soils, there is a lack of conventions and international standards on the parameters required for this kind of monitoring. Some approaches do not meet a basic requirement of Dokuchaev (1951) that soil quality assessment on agricultural land should reflect crop yield potentials. It is useful to measure and evaluate soil quality in terms of its functions for society. For example, the specific role of soil and land in producing plant biomass for humans (productivity function, Mueller et al., 2011) remains crucial. Consequently, higher soil quality means the land has a higher crop yield potential. Land rating approaches of the former Soviet Union (Gavrilyuk 1974, Vostokova and Yakushevskaya 1979) meet these requirements in general. However, they base on yield data which are 60 and more years old and do not consider soil functional properties and climate conditions. More recent approaches (Krupkin and Toptygin 1999) based on important functional properties of soils like humus content or nutrient stocks have more regional meaning and cannot be transferred to other parts of Russia.

The overall situation of soil quality in Asian Russia and future trends in the context of the Eurasian and global situation does not seem to be clear yet but could be found out by using the Muencheberg Soil Quality Rating (M-SQR, Mueller et al., 2010) to create a strategy of assessing food security for Eurasia or the world. Work of Smolentseva et al (2014) showed that loess born soils of South Siberia have excellent basic soil properties in terms of texture, structure, rooting potential and water and nutrient storage capacity. However, climatic conditions like too late warming and drought are serious yield-declining factors. This leads to low overall rating values on a global scale (Smolentseva et al., 2014). Some examples are given in Figure 1.

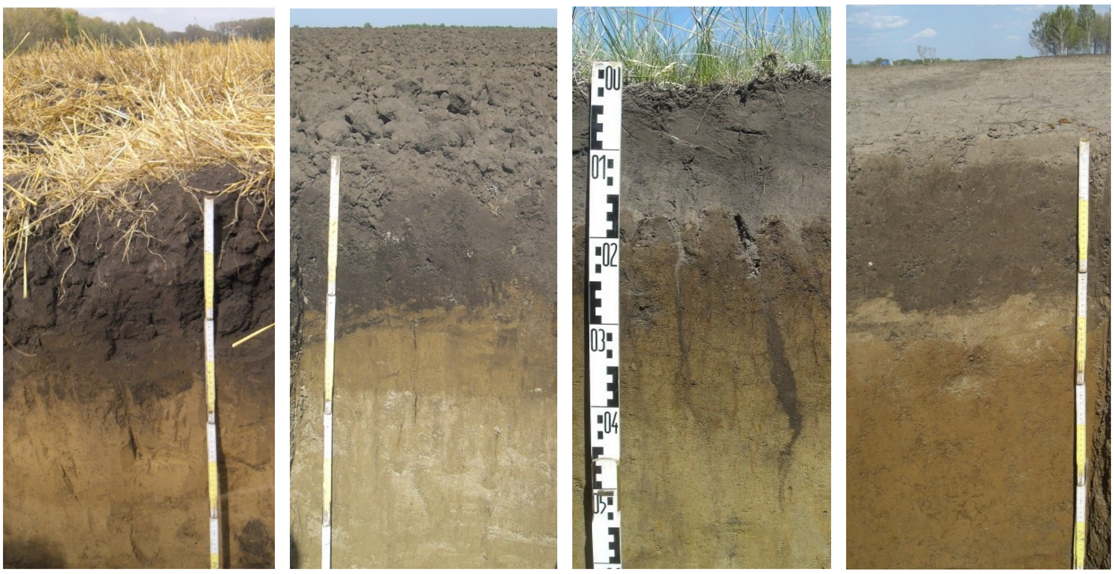

Figure 1. Examples of agricultural soils in Siberia and their quality for cereal cropping: a) Ordinary Chernozem of the research station Krasnoobsk, Forest Steppe, Rating points of M-SQR (Mueller et al 2011) 98 (Upgraded Basic Rating) /42 (Final Rating, including climate factors) b) Southern Chernozem of the Grushevka field near Bagan, Kulunda Steppe, degraded by wind erosion, Rating points 78/20, c) Solonetz near Bagan, Kulunda Steppe, Rating points 55/14, d) Luvisol of the Kochky site, Baraba Forest Steppe, Rating points 74/24. Classes of rating points are 0-20 very poor, 20-40 poor, 40-60 moderate, 60-80 good, 80-100 very good

2.4 Land degradation by agriculture

Degradation of agricultural land by wasteful and unsustainable management is one of the most important socioeconomic problems worldwide. This is also true for lands of Russia including Siberia. It poses a threat to ecological, economic and national security of the country. Data are inconsistent and differ depending on their assessment methodology but demonstrate huge dimensions of the problem.

The worst damage to Russian soils is caused by water and wind erosion (50 million ha), waterlogging (40 million ha), droughts (up to 170 million ha), land salinization and alkalinisation (40 million ha) (FAO 2014a).

Cropping agriculture if associated with soil tillage is risky for soil fertility and associated with permanent loss of soil humus and fertility. Schepaschenko et al (2012) calculated that arable land of Russia was a carbon source (carbon loss 0.8 t/ha and year), whilst pasture and hayfields were a sink of 0.29 t/ha and year. Zhulanova (2013) found negative carbon balances of the Dry Steppe (0.76 t/ha and year) and Steppe (0.19 t/ha and year), whilst carbon of the Forest Steppe was about balanced under agriculture in south Siberia. Table 1 shows the percentage of degraded agricultural land in Siberia.

Table 1. Degraded agricultural soils in Siberia (data of Gordeeva and Romanenko 2008)

	Agricultural land (Thous. ha)	Degraded land in %			
		Wetness	Water erosion	Wind erosion	Salinization and alkalinisation
West Siberia	34,434	20.3	6.6	12.9	35.1
East Siberia	23,196	7.8	9.8	14.3	3.8
Far East	7,932	36.5	7.0	0.8	4.3

Wetness of agricultural land is a permanent yield-declining issue in West Siberia and the Far East. It is often combined with salinization and wind erosion in Steppe regions. Degradation means an irreversible loss of soil productivity potential. Drought as a most severe productivity –limiting factor leading to desertification in current Dry Steppe and Steppe regions is not listed here. Also data about other soil degrading factors like permanent humus loss and soil compaction are not included in Table.

When tilled, soil loses its protective vegetation and becomes prone to wind erosion. Just in Steppe regions of Asia wind erosion may be reach global dimensions in future due to mismanagement of soils by ploughing (Suleimenov et al 2014). Halting anthropogenically induced land degradation by introducing more sustainable land management is a challenge for Asian Russia. This has also implications for the sector of agri-environmental research.

2.5 Status of grasslands

Grasslands and rangelands are an underestimated resource for biochemical cycles and for human welfare. There is a lack of reliable data on the status of pasture or rangeland degradation in Siberia. The situation is similarly unclear like in landscapes of Kazakhstan and other countries of Central Asia (Mueller et al 2014). Long- term succession studies in grasslands done by the Sochava Institute of Geography (Nechaeva et al (2010) along with chemical soil analyses are important for understanding local grassland ecosystems. However those studies lack linkages with modern diagnostic and monitoring methods. A loss of plant and wild animal diversity, an increase in unpalatable or toxic plants, a loss of soil fertility and productivity and a decline in livestock production are examples of possible indicators. Rangeland recovery may comprise palatable biomass, biodiversity and rare species.

Biodiversity of grasslands is influenced or threatened by several disturbances such as habitat loss, fragmentation of natural communities, over-exploitation such as overgrazing, penetration of non-native species, environmental pollution, climate change, and other elements. Local overgrazing or periodic ploughing of grasslands are crucially negative impact factors. Both overgrazing and underutilization decrease the natural potential of Steppe soils (Kandalova and Lysanova, 2010). Desertification tendencies of Siberian grasslands have been already detected (Meyer et al 2008).

3 Peatlands and their significance for landscape functioning

Almost 370 Million ha of peatlands are located in the Russian Federation, the majority of them in the Taiga zone of the Asian part (Table 2). They are of crucial importance for biodiversity, carbon storage, hydrology and other environmental functions (Liss et al 2001, Kremenetski et al 2003).

Table 2. Peatland areas in the Russian Federation (Climate Committee 2002)

Territory	Area Million ha
Russia as a whole	369.1
From that: In the European part	58.8
In the Asian part	310.3
In different zones;	
Tundra and Forest Tundra	106.2
Taiga and other zones	262.9
In the permafrost zone	270.6
In the West Siberian lowland	99.1

The West Siberian lowlands are the world's largest high-latitude wetland region including vast and deep peatlands. Sheng et al 2004 estimated the total area of peatlands in West Siberia at 59.2 Million ha and the total carbon pool at 70.21 Pg (Petagrams= Billion tonnes). The Vasyugan Mire is the largest of them covering an area of 5.3 Milion hectares (Inisheva et al 2011). Humid Taiga and Tundra of Siberia are regions of permanent peat accumulation and thus a permanent natural carbon sink. From recent models based on numerous measurements, sphagnum mosses grow up about by 12 mm/yr. in the northern Taiga, 16 mm/yr. in the middle Taiga and 12 mm/yr. in the southern Taiga. The annual carbon accumulation ranged from 90-160 g/m^2 (Dyukarev et al 2011). Inisheva und Berezina (2013) report on an increasing peat layer by about 0.4-0.7 mm/year and quote an enlargement of the peat area of 92 km^2/year based on data of Neistadt (1971). Also in the warmer Sub- Taiga of south Siberia, Larin and Guselnikov (2011) found an annual increase of wetland areas by 4.6 km^2 and year.

Figure 1. Peatlands in the Southern Taiga a) Natural bog with anthill of *Formica spec*. These ants are very important for biological preventing of insect calamities. b) Cultivated and abandoned peatland

Net primary production in eutrophic swamps of the Forest Steppe was about 600–700 g/m^2 and year of dry mass (Kosykh 2009). It was higher (1285 g/m^2) in peatlands of the Altai mountains where roots of wetland grasses contributed 80% of the NPP (Kosykh et al 2010). About half of the dry biomass is carbon. Inisheva et al (2011) measured NPP of peat sites 171-296 g C/m^2. Lapshina and Bleuten (2011) report on NPP of 150-500 g C/m^2 and year in peatlands of West Siberia. Carbon storage (NPP minus heterotrophic respiration) was 30-70 g C/m^2 and year, and methane emissions were about 0-5 g C/m^2 and year.

Threats to peatlands of Siberia differ from those that are known from peatland regions in Western Europe. In Western Europe, peatlands are a carbon source due to drainage and agriculture in a temperate warm and subhumid climate (Drösler et al 2008, Mueller et al 2008). Land drainage which is responsible for carbon loss of west European peatlands, had no significant influence on the carbon balance in West Siberia (Inisheva et al 2011). Loss of carbon due to heterotrophic respiration higher than NPP seems to be not a threat to Siberian peatlands. However, more reliable data are required in spite of climate change. In general, measuring NPP and respiration by different methods, which was done in most cited studies of Siberian peatlands may lead to biased results of carbon balances. Meanwhile, more sophisticated and accurate methods of measuring carbon balances in situ are available (Chojnicki et al 2010, Juszczak et al 2013).

Acknowledgements

More than 120 other scientists from more than 20 countries of the globe are part of our innovation network and have contributed to both books about the status and sustainable use of

land and water resources of Central Asia and Siberia. Their names and affiliations are listed there. They are from leading research institutes, universities, departments of agriculture, co-operative group centres, state authorities, international research and funding bodies, private companies, practical farms and others. Authors of this paper thank them for their innovative contributions.

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The effects of selenium application on germination parameters of pumpkin (*Cucurbita pepo* L.) and osmotic potential of growth media under drought conditions

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Abstract

The objective of this study was to investigate the effects of selenium application on germination parameters in pumpkin (Cucurbita pepo L.) and some soil properties of growth media under drought conditions. The study was carried out according to factorial experimental design with three replications in a chamber room under controlled conditions. The plastic pots having 2 kg soil were used as growing media with adding the basic fertilization of 250 mg kg^{-1} N, 32.75 mg kg^{-1} P and 82.65 mg kg^{-1} K into each pot. Drought conditions were created with the irrigation made in three different levels of plant available water (PAW) content at 30%, 60% and 100% rates. The four doses of selenium solutions (0 mg kg^{-1}, 1 mg Se kg^{-1}, 2 mg Se kg^{-1} and 4 mg Se kg^{-1}) as natriu m selenat (Na_2SeO_4) form were applied to the growth media when seeds were sown. The experiment was ended after seven weeks. In this study, germination rate and plant length significantly ($p<0.01$) decreased while EC and osmotic potential (OP) values significantly ($p<0.01$) increased with increasing drought levels. Germination parameters and plant length decreased significantly with increasing OP due to low soil moisture content in soil. The lowest germination rate (81.25%) and plant length (13.74 cm) were determined at 30% of PAW content. The shortest germination time 1.33 day was observed at 100% PAW content while the longest germination time 8.83 day was observed at 30% PAW content in2 mg kg^{-1} Se doses. Drought levels in soil were more effective than Se application on the germination parameters. Generally, Se application increased plant length in pumpkin under low soil moisture contents.

Key words: Drought stress, selenium, germination, osmotic potantial, salinity.

Introduction

Stress conditions cause important physiological and metabolic changes in plants, and reduce yield quantity and quality with negatively influencing plant growth. (Ashraf and Wu, 1994; Ashraf and Iram, 2005; Kutlu and Kinaci, 2010). Drought is one of the most important abiotic stress factors, and strongly influenced with global climate change recently. In the world, approximately 45% of arable fields is under drought stress and 6% of lands is face to salinity problem (Ashraf and Foolad, 2007; FAO, 2008). Plants are exposed to drought stress with increasing osmotic potential of soil moisture due to increasing salt content in soil (Levitt, 1980).

Photosynthesis rate decreases under drought conditions and shoot growth slows down. Even if there is a short period of drought condition, leaf growth in plants decreases due to loosing turgor in plant tissues and decreasing plant water potential (Borsani et al. 2003; Jones, 1986). Kuşvuran (2010), reported that melon growth restricted by drought stress and plant length was lower under water stress. Franco et al. (1993) indicated that increasing salt concentration in solution decreased water potential linearly and resulted in lower water uptake by plants. In saline conditions, high osmotic potential restricts water uptake by plants and metabolic activities related with germination are not started (Srivastava, 2002).

Selenium is an essential element and has positive effects plants with increasing antioxidative capacity of senescing plants and regulating the water status of plants exposed to drought stresses (Kuznetsov et al., 2003, Djanaguiraman et al., 2005). Recently, the protective effect of selenium on stress conditions of plants is being considered and the studies in this subject are increasing.

Pumpkin (*Cucurbita pepo* L.) is an herbaceous monoecivus, annual plant of Cucurbitaceae family (Bombardelli and Morzzoni, 1997) and can be easily grown from seed in fertile, organically rich, well-drained loam soils under full sun (Vural et al., 2000). In this study, the effects of selenium application under different water stresses levels on germination parameters in pumpkin (Cucurbita pepo L.) and some soil properties were investigated.

Materials and Methods

This study was carried out according to factorial experimental design with three replications in a chamber room of Soil Science and Plant Nutrition Departement in Agricultural Faculty of Van Yuzuncu Yil University under controlled conditions at 25±1°C. The plastic pots having 2 kg soil were used for growing media with adding the basic fertilizer of 250 mg kg^{-1} N, 32.75 mg kg^{-1} P and 82.65 mg kg^{-1} K into each pot. Pumpkin (*Cucurbita pepo* L.) was used as plant material in the study. To obtain the drought conditions in growth media, irrigation was made in three different levels of plant available water content at 30%, 60% and 100 % rates using distilled water after daily weighing the pots. The four doses of selenium solutions (0 mg Se kg^{-1}, 1 mg Se kg^{-1}, 2 mg Se kg^{-1} and 4 mg Se kg^{-1}) as natrium selenat form (Na_2SeO_4) were applied when seeds were sown. The experiment was ended after seven weeks. The following measurements; germination rate, germination time and plant length were determined during the experiment. Germination rate was calculated by percentage with counting the hypocotyl appeared on the soil surface for 10 days from the date of planting. Germination time was estimated using the following equation (Ellis and Barrett, 1994).

Moisture contents at the field capacity (FC) and the permanent wilting point (PWP) were determined equilibrating soil moisture of the saturated samples on the ceramic pressured plates at 33 kPa for 24 hours and 1500 kPa for 96 hours, respectively. Plant available water content

$$\textbf{Germination time} = \frac{\Sigma n\ (\text{germ. seed numb. at the counting day}) \times d\ (\text{counting date (day)})}{\Sigma n\ (\text{Total germinated seed number})}$$

(PAW) was estimated subtracting the PWP moisture content from FC moisture content. Osmotic potential values were calculated using EC measurements according to Bohn et al. (1985). Soil sample used in the experiment was analyzed by using standard soil analyses methods reported by Kacar (1998). The growth media used in this study had a clay loam texture, nonsaline, alkaline in pH, low in lime and organic matter contents, unsufficient in total nitrogen and available phosphorus contents and sufficient in potassium content (Table 1). Variance analyses of the experimental data were done by SPSS statistical program. Treatment means were compared with Duncan's test.

Table 1. Some properties of the growth media

Texture	pH (1:2.5)	EC (µs cm^{-1})	$CaCO_3$ (%)	Organic matter (%)	Total N (%)	Avaliable P (mg kg^{-1})	Exch. K (mg kg^{-1})
Clay loam	8.23	195.18	5.37	1.63	0.0792	7.20	290

Results and Discussion

Drought conditions caused significant effects on germination ratio, germination time and plant length at 1% level. Germination rate and plant length decreased with increasing drought levels in growth media (Table 2). While the highest germination rate (100%) and plant length (29.28 cm) were determined at 100% of PAW content, the lowest germination rate (81.25%) and plant length (13.74 cm) were determined at 30% of PAW content application. On the other hand, germination time increased 1.65 day to 6.61 day with decreasing PAW content from 100% to 30% in growth media (Table 2). Şimşek et al. (2001) reported that seeds should uptake water at least 50% of their weight to germination. Seed germination rate depends on not only absorbed water amount but also increasing level of osmotic stress (Heikal et al., 1981). Most studies indicated that drought conditions restrict seed germination and plant growth compared with unstressed conditions (Ashraf and Iram, 2005; Yin et al., 2005; Abdalla and El-Khoshiban, 2007; Kuşvuran et al., 2011).

Table 2. Germination parameters and plant length at different drought and selenium application levels

Treatments	Germination Rate (%)	Germination time (day)	Plant Length (cm)
Plant Awailable Water, %			
100	100.00 a	1.65 b	29.28 a
60	93.75 a	2.30 b	20.58 b
30	81.25 b	6.61 a	13.74 c
Significant level	0.01	0.01	0.01
Selenium Doses, mg kg^{-1}			
0	100.00 a	3.42	20.62 ab
1	88.89 ab	3.47	20.32 ab
2	91.67 ab	4.11	24.11 a
4	86.11 b	3.07	19.76 b
Significant level	0.05	ns	0.05

Increasing Se doses caused decreases in germination rate (Table 2). The highest germination rate (100%) was obtained at the control treatment while the lowest germination rate (81.25%) was at the 4 mg Se kg^{-1} application. Similar studies indicated that lower Se application doses such as; 0.1 and 0.5 mg kg^{-1} increase germination rate, but higher doses of Se decrease germination rate, germination time and plant growth (Xue et al., 2001; Han et al., 2010; Feng et al., 2013). Increasing Se doses general decreased plant length, the highest plant length was determined at 2 mg kg^{-1} of Se doses application (Table 2). Karadağ (2013) reported that plant length in poppy plant decreased with more than 2 mg kg^{-1} Se application.

Effects of interactions between drought levels and Se doses on germination parameters and plant length are given in Figure 1. Generally, germination rate and plant length decreased while germination time increased with increasing drought levels and Se doses in the growth media. While the lowest germination rate (67%) was obtained at 30% PAW and 1 mg kg^{-1} Se application doses, the highest germination rate (100%) was generally obtained at 100% PAW content in all Se doses. Similarly, the lowest plant length 12.03 cm was determined at 60% PAW and non Se application treatment. The shortest germination time 1.33 day was observed at 100% PAW and 2 mg kg^{-1} Se doses while the longest germination time 8.83 day was observed at 30% PAW and 2 mg kg^{-1} Se doses treatment. Drought levels were more effective than Se doses on the germination parameters. On the other hand, Se application, especially in high drought levels, generally increased plant length.

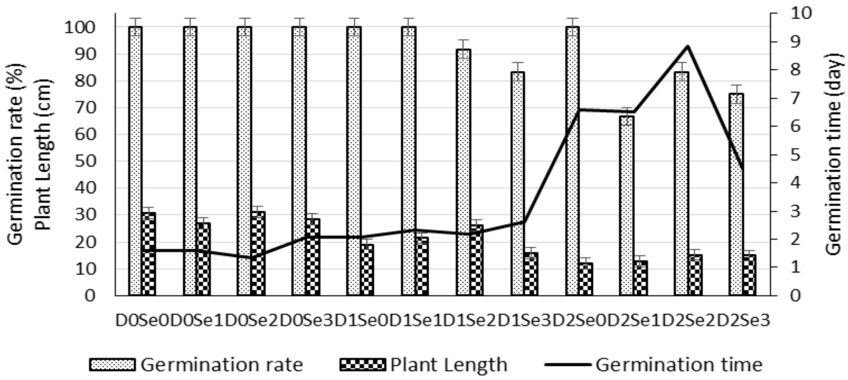

Figure 1. Effects of selenium and drought stress levels on germination parameters and plant length in pumpkin species (D0: 100% PAW, D1: 60% PAW, D2: 30% PAW; Se0:0 mg kg^{-1} Se, Se1:1 mg kg^{-1} Se, Se2:2 mg kg^{-1} Se, Se3: 4 mg kg^{-1} Se).

The effects of drought levels and Se applications on soil pH, EC, osmotic potential (OP) and salt content (Ps) in soil solution are given in Table 3. Soil pH and EC values were not influenced significantly by the drought levels. However, salt content (Ps) and OP values in soil solution significantly increased with increasing drought level or decreasing PAW content from 100% to 30%. Water content in soil was more effective on Ps and OP than Se application doses. It is known that salt content ant osmotic potential in soil increase with increasing drought level (Gosset et al. 1994). Franco et al. (1993) reported that increasing salt concentration in soil solution decrease total soil water potential and reduces water uptake by plants from soil. In saline soils, osmotic potential of soil solution is equal or higher than osmotic potential of plant roots due to dissolved salts in soil solution. Therefore, seed germination and plant growth slowdown because of less water and nutrient uptakes of plants by roots (Çırak and Esendal, 2006; Sezen, 2011).

Effects of interactions between drought levels and Se doses on EC, OP and salt content (Ps) in soil solution are given in Figure 2. Generally, OP increased with increasing Ps in soil solution due to decreasing water content in soil. The lowest Ps (0.58%) and OP (3.27 atm) were determined at 100% PAW and 2 mg kg^{-1} Se doses while the highest Ps (1.15%) and OP (6.48 atm) were determined at 30% PAW and 1 mg kg^{-1} Se doses treatment. Drought levels or soil moisture level was more effective than Se doses on the salt concentration in soil solution and pressure potential.

Table 3. Changes in some soil properties under different drought and Se application levels

Treatments	pH	EC	Ps	OP
	(1:2.5)	(dS m^{-1})	(%)	(atm)
Plant Awailable Water, %				
100	7.45	2.49	0.68 c	3.85 c
60	7.47	2.41	0.78 b	4.39 b
30	7.43	2.71	1.06 a	5.97 a
Significant level	ns	ns	0.01	0.01
Selenium Doses, mg kg^{-1}				
0	7.45	2.43 bc	0.82 ab	4.60 ab
1	7.42	2.80 a	0.93 a	5.19 a
2	7.47	2.25 c	0.75 b	4.20 b
4	7.44	2.67 ab	0.88 a	4.96 a
Significant level	ns	0.01	0.05	0.05

Ps: salt content in soil solution, OP: osmotic potential

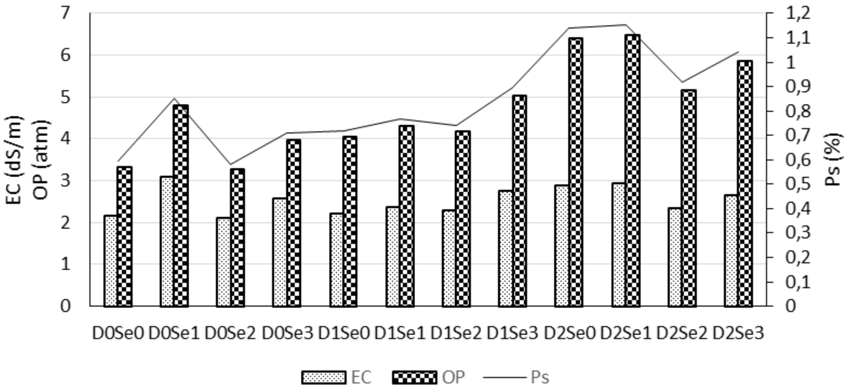

Figure 2. Effects of selenium doses and drought stress levels on EC, percent salt in soil solution (Ps) and osmotic potential (OP) (D0: 100 % PAW, D1: 60 % PAW, D2: 30 % PAW; Se0:0 mg kg^{-1} Se, Se1:1 mg kg^{-1} Se, Se2:2 mg kg^{-1} Se, Se3: 4 mg kg^{-1} Se).

The relationships among the germination parameters, plant length, OP and some soil properties are given in Table 4. While EC values of growth media had a significant positive correlation with OP (0.863**), EC values had significant negative correlations with germination time (-0.556**) and plant length (-0.713**). Similarly, OP values gave significant negative correlations with germination time (-0.373*) and plant length (-0.345*). In most studies, it was determined that high salinity level related with ion concentration in soil solution reduces plant growth and length (Houimli et al. 2008; Rui et al. 2009; Memon et al. 2010).

Table 4. The relationships between plant parameters and some soil propereties

	Germination rate	Germination time	Plant Length	pH	EC
Germination time	0.155				
Plant Length	0.69	-0.609**			
pH	-0.057	0.311*	-0.460**		
EC	0.083	-0.556**	-0.713**	-0.691**	
OP	0.017	-0.373*	-0.345*	-0.591**	0.863**

* significant at 0.05 level, ** significant at 0.01 level

Conclusions

Salt concentration in soil solution increased with decreasing soil water content. Also, osmotic potential values increased due to high salt content in soil solution. Germination rate, germination time and plant length decreased significantly with increasing drought level. High OP in soil reduced water uptake by plants from soil. High salt concentration in soil solution increased OP of soil under drought conditions. Germination time and plant length were negatively affected by increasing OP in growth media. Water content in soil was more effective than Se application on the germination parameters. Selenium application, especially in low soil moisture contents, generally increased plant length in pumpkin plant.

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The state of the degradiated pastures of Kazakhstan and the prospects of their improvement

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Abstract

In this article the materials of the state of degraded pastures of Kazakhstan and prospects of their improvement are given. Technical condition of flooding installations for the development of transhumant livestock breeding in the regions of the Republic of Kazakhstan. Recommendations are given on the use of pastures of the republic.
Key words: degradation, pasture, anthropogenic factor, forecast, fodder resource, desertification, optimal model.

Introduction

The problem of desertification (degradation) poses a serious threat to the well-being of mankind. This process has accelerated over the past decades, just at the moment when forecasts of further population growth make it necessary to sharply increase food production. It is estimated that because of desertification annually from 50 to 70 thousand km² of fertile land become unsuitable for use in the world.
Currently, out of 187 million hectares of pasture land in Kazakhstan, 14 million hectares have been completely withdrawn from circulation, and the total area of degradation has exceeded 50 million hectares. The causes of degradation are both natural and anthropogenic factors [2].
The main natural factor contributing to the development of natural pasture degradation processes in Kazakhstan is the country's inland climate, which determines the continentality and aridity of the climate, the scarcity and uneven distribution of water resources that determine the wide distribution of sandy (24.9 million hectares) and saline soils (127 million ha).
The prerequisite for desertification is also a weak formation of the soil and vegetation cover, which causes the weak stability of the natural environment to anthropogenic impacts.

Results and Discussion

In Kazakhstan there are three sources of plant feeds: arable land, hayfields, pastures. From the total amount of feed used, pasture fodder is 45-50%. Of the available 187 million hectares of pasture today is used: on agricultural land - 61 million hectares; on the lands of settlements - 20 million hectares; on the lands of the forest fund - up to 3-4 million hectares. Of the 85 million hectares of pastures used, 27.1 million hectares are in a state of failure (the last stage of degradation) and have practically lost their economic importance. According to Article 98 of the Land Code of the Republic of Kazakhstan, such (downed) pastures should be transferred to another category of land for restoration. Thus, at present about 58 million hectares of pastures are used that are capable of renewing and with their productivity of -1.6 centners per hectare of fodder units, the total feed stock is 9.3 million tons of feed units. Loss of feed from pasture malfunction - at the level of 4-5 million tons of feed units. And the reason for this is only anthropogenic factor.
The reserve of pasture forage is transhumant livestock breeding pasture (80 million hectares), the feedstock of which is 14-15 million tons of feed units.
The fodder resource of Kazakhstan pastures covers over 187 million hectares of over 300 dominant types of pastures (the map of fodder resources of Kazakh Research Institute of Ani-

mal Husbandry and Fodder Production and the Geography Institute of the Ministry of Education and Science of the Republic of Kazakhstan). Feeding stock of pastures for nutrition is equivalent to the annual collection of grain crops in the republic (20-25 million tons of feed units) [1, 3].

The cost of renewable fodder in pastures of the republic is estimated 1 billion US dollars by the World Bank more than.

The productivity of pastures is very different, depending on the plant associations and zoning that provide them, as well as the seasons of use (Tab.1).

Table 1. The areas and seasonal productivity of pastures in Kazakhstan

Region	Pasture area, thousand hectares	Productivity centner / ha, feed unit	Spring centners / ha, feed unit	Summer centners / ha, feed unit	Autumn centners / ha, feed unit
Akmola	6801,1	1,5	2,0	2,2	1,2
Aktobe	24587,2	1,4	1,6	1,8	1,0
Almaty	14724,8	2,6	3,4	4,6	1,2
Atyrau	8997,3	1,1	1,4	1,0	0,9
East Kazakhstan	19950,0	3,0	2,8	5,0	4,0
Zhambyl	8281,9	1,6	1,7	2,7	1,2
West Kazakhstan	10206,8	1,6	2,0	1,3	1,1
Karaganda	31083,7	1,5	1,6	1,5	0,7
Kyzylorda	11829,6	1,2	1,5	1,1	1,3
Kostanay	12060,9	1,4	1,3	1,3	0,6
Mangystau	12665,5	0,9	1,1	1,0	0,9
Pavlodar	1256,7	1,7	1,8	0,9	2,5
North Kazakhstan	3357,3	2,4	2,4	2,4	0,9
South Kazakhstan	9086,6	1,6	1,8	2,6	1,2

As follows from the data in the table, the maximum productivity of all types of pastures falls on the summer, increasing from the spring and decreasing towards autumn.

The vegetation of pastures in Kazakhstan can be divided into 3 types:

- ephemera and ephemeroids (marble, sedge, bluegrass bulbous, etc.) of the spring development cycle;
- cereals, legumes and herbs (brome, cocksfoot, fescue, clover, alfalfa, sedge, etc.) of the summer development cycle;
- semi-shrubs and shrubs (wormwood, ash tree, keireuk, eurotia, calligonum, saxaul, etc.) of the autumn development cycle.

The rational use of this natural production resource will be determined by the following works:

1. Identify and conduct mapping in M 1: 1500000 downed (27.2 million hectares) pastures with the provision of a temporary period for restoration. Part of these lands that cannot be restored should be determined for fundamental improvement.
2. Conduct an ecological certification of the pastures of each rural district to identify the conformity of the feedstuffs - the need for pasture feed of grazing livestock.
3. To do this, carry out land management work to streamline the land use of individuals and legal entities engaged in pasture livestock. In this case, there will be found out farms in need of pasturing.

4. Increase the areas of watered pastures and putting in order the existing water supply facilities. It is known that the efficiency of pastures depends critically on their water cut. The main sources of water supply for pasture territories are groundwater, which is taken from mine wells and wells. More than 70% of the waterworks have been destroyed almost everywhere, due to lack of proper operation, and the construction of new ones has been discontinued.
The solution to this problem is the restoration of flooding installations and water points on transhumant pastures, as well as cleaning, repair of water supply sources, restoration of their production rate, construction of new facilities. To do this, first of all, it is necessary to conduct a detailed study and research of the technical condition of the pastoral livestock watering systems, that is, the inventory (certification), which fixes the GPS coordinates of the head of the water intake structure, photographs the general view and determines the following parameters: wells), well depth, static and dynamic water level, casing string diameter, water mineralization, technical condition in watering point (pure water tank circadian regulation, watering troughs, pavings of watering fields, water lifting means). Currently groundwater is used mainly for watering pastures in the Republic of Kazakhstan.
In the country, potential sources for the development of transhumant livestock on transhumant pastures are wells and mine wells (Table 2).
An analysis of the technical condition of the flooding installations showed that out of all the 7769 water intake facilities in operation, 5,361 are in operation, that is 69%.
Of the 5,361 mine wells in operation, 3544, i.e. 68.6%, and out of 2,604 wells 69,8% 1,817 pcs, i.e. 69.8% are in working condition..
Table 2 shows the results of a survey of the technical condition of water-supply facilities of potential participants in measures for the development of transhumant livestock in the RK in the context of regions.

Table 2. Technical condition of the watering facilities of potential participants in the development of transhumant livestock in the regions of the Republic of Kazakhstan

Regions	Total	Mine wells			Wells		
		total	in working order		total	in working order	
			quantity	%		quantity	%
Akmola	3	-	-	-	3	3	100
Aktobe	535	473	446	94	62	50	81
Almaty	465	334	261	78	131	80	61
Atyrau	999	991	526	53,1	8	7	88
East Kazakhstan	676	636	306	48	40	14	35
Mangystau	1270	756	545	721	514	378	73,5
Zhambyl	230	176	162	92	54	43	80
Kyzylorda	105	82	66	80	23	13	56
South Kazakhstan	1011	834	622	75	177	153	86
Karaganda	1883	665	410	616	1217	860	70,1
Pavlodar	145	73	73	100	72	69	95,8
East Kazakhstan	345	68	51	75	277	124	45
Kostanay	72	72	72	100	100		
Kostanay	30	4	4	100	26	23	88,5
RK	7769	5165	3544	68,6	2604	1817	69,8

The largest number of working wells is in Pavlodar and Kostanay regions. In Pavlodar region, all 69 wells are available, that is 95.8%. In Kostanay oblast, all pit wells (72 pcs.) are in working condition, and there are no wells in the region. The lowest rates are less than 50% for WKO. They have out of 636 pit wells in working condition 306 (48%), and out of 40 wells only 14 work, that is 35%.
The choice of the most optimal pasture management model is one of the necessary conditions for the sustainable development of pasture livestock. From its correct choice depends the effectiveness of the use of pasture resources, investment, the orientation of scientific and technological development, personal development, the level of income and well-being of pasture users, as well as the current and future potential to meet human needs and aspirations.

Recommendations for the use of pastures:

a) Use of pastures only to increase the number of livestock:
- In this case, the livestock can grow every year, and accordingly the load on pastures increases. This situation leads to the degradation of pastures, to the destruction of pasture ecosystems, to the decline in the productivity of rangelands and farm animals, which ultimately has a negative impact on the material well-being of the rural population. This situation is already observed in places, especially around populated areas, where the load on pastures exceeds the norm by 4-5 times or more. Therefore, this contradicts the principles of sustainable management of pasture resources and can lead to irreparable disasters in the pasture economy;
b) Extensive use of pastures:
- Provides to be satisfied with what is available today, i.e. spontaneous development without strengthening the fodder base and other innovative approaches in the management of pasture resources, genetic improvement of animals. This demonstrates stability without growth. In this case, the potential of grazing resources will remain unused and lead to stagnation in the economy of the agro-industrial complex, especially in pasture cattle breeding;
c) Balanced use of pastures:
- It provides systemic application of innovative approaches in pasture management. In order to ensure sustainable development of grazing livestock, the following specific measures should be implemented:

- scientifically-based planning of pasture areas, taking into account their intended use and mode of use;
- Increasing the productivity of existing and creation of new hay-and-pasture lands by restoring degraded pasture lands on the basis of low-cost “green" technologies”;
- the maintenance on livestock of agricultural formations of a livestock according to a fodder base and forage capacity of pasture grounds, and also observance of scientifically-grounded rules and norms of grazing in pasture territories;
- strengthening of the fodder base for the winter period through the development of field fodder production and pasture infrastructure;
- decentralization of management and active involvement of local people in pasture management;
- development of alternative income-generating activities in pasture areas;
- increasing the genetic potential of animal productivity, applying effective measures to dramatically improve veterinary services and institutional strengthening of pasture management structures;
- increase the knowledge potential of pasture users in the implementation of innovative approaches;
- attraction of investments for practical implementation of principles and approaches for sustainable management of pasture resources.

Practical implementation of the above-mentioned measures requires the transition to a new model for the use of pasture resources and the creation of the necessary pasture infrastructure based on a reasonable alliance of traditional pastoral farming practices with modern achievements in science, technology.

Conclusion

According to the results of the research of Kazakhstan scientists, these principles and approaches to pasture management are especially valuable in the present period when traditional knowledge and skills transferred from generation to generation are gradually lost, and new ones are not yet created. The proposed integrated approach to pasture management fills this gap and forms the basis of the Kazakhstan model of sustainable management of pasture resources, the prospects for their improvement most fully meeting the new requirements for the development of the agricultural sector of the country's economy.

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Possibility of using land components for estimation of soil erosion (A case study of a watershed of the Second Urban Phase, Mashhad, Khorasan Province)

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Abstract

In most parts of Iran, due to population growth, deforestation, over-grazing of pastures and other factors, soil erosion is more than the world's average and increases incredibly by time. Therefore, its correct evaluation is very important. The Mashhad-Chenaran is the biggest and most important sub-basin of Khorasan, with an extension of about 223989.7 ac. Hence, it was chosen for this study in the present investigation. Two models, the MPSIAC and the Gavrilovic method (EPM), used for evaluation of sediment amounts and soil erosion stations showed 2.74 t/ha per year. However, the MPSIAC model showed 1.56 t/ha, whereas the EPM model showed larger amounts of 5.73 t/ha per year. In soil erosion studies in watersheds, researchers have often introduced hydrological units of work. In this research, factors (geological factors, soil type, vegetation, slope etc) were utilized in the erosion estimation models used in addition to the hydrological units in the land components. In view of the availability of maps of land units and their components in many regions of Iran, the present study attempted to measure the erosion and sediment in hydrological units (sub-basins) and land components. The accuracy of estimates of erosion were tested; in order to ensure that the accuracy of the results or possibly the superiority of the homogeneous units to the hydrological units is ensured, it can be used in the same areas in the future.

Key words: Gavrilovic method, homogeneous units, MPSIAC, Sediment.

Introduction

Soil is one of the most important natural resources in every country. Soil erosion is a serious issue and can be considered as a big threat for civilized mankind. Due to the lack of sufficient and reliable information, regarding the amounts and kinds of soil erosion in most watersheds in Iran and most other parts of the world, several models have been designed and accomplished to estimate soil erosion and sedimentation. However, the determination of erosion and sedimentation by using available models have some difficulties and problems due to inconsistency and inadaptability in the intended areas. (Ahmadi et al., 2011).

Materials and Method

The study area of Mashhad-Chenaran is the biggest and most important sub-basin of Kashaf Rood, extending 224009.08 acres, with geographical coordinates of 58^{0}-22' to 60^{0}-7' eastern longitude and 36 to 37^{0}-5' northern longitude. The study area of Mashhad urban phase II was divided into 4 hydrologic groups and 37 sub-basins or hydrologic units. Based on the results of resource assessment and land capability classification, it contains 7 main land types including mountains, hills, plateaus, upper terraces, piedmont plains, flood plains, gravel debris, fan -shaped alluvial gravel, and a miscellaneous type as well as composite and non-arable lands.

Results and Discussion

There is a difference between calculated sediment amount by using 2 used models in this study and reported sediment amount in sediment measurement stations (Table 1, Diagram 1).

Table 1. Erosion and sediment Rates in Mashhad urban watershed phase II by studied units dissociation

Area (ha)	Studied unit	Sediment (ton.ha^{-1} per year)			Erosion (ton.ha^{-1} per year)	
		Hydrometric stations	MPSIAC	EPM	MPSIAC	EPM
223989.7	Sub basin	2.74	1.56	5.73	3.19	9.45
	Land Component		1.50	-	3.39	9.66

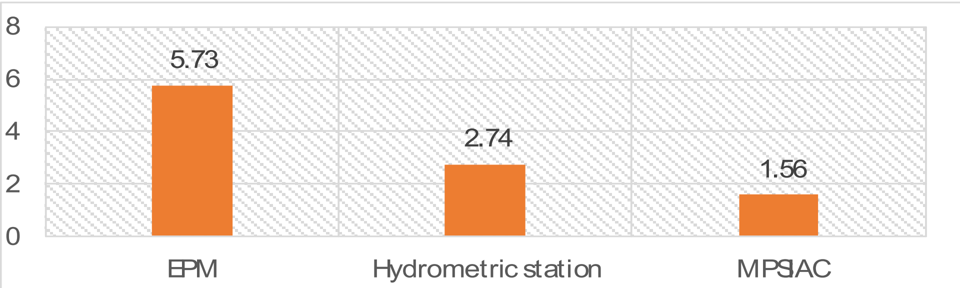

Diagram 1. Estimated sediment amount (ton.ha^{-1} per year) Comparing the results of EPM, Hydrometric stations and MPSIC

The findings in this study confirms previous studies conducted by Ahmadi et al. (2011), and Abedini et al. (2013). Based on the similarity of soil types, similar land types and being rocky, having many outcrops in these lands, high slope and low vegetation are the main factors of the high erosion rate. EPM and MPSIAC have been innovated in those countries with different climate and geology attributes. Hence, the coefficients and effective factors in erosion does not correspond to conditions in Iran completely.

The homogeneity of studied units is very important in determining the accuracy of the estimated erosion amounts in the Otan sub-basin (M_{16}), with 11333.53 hectares which contains 5.06% of the total studied area (Fig 1), has been dissociated into 10 land unit components (Table 2). Based on information in Table 4, erosion type in this hydrologic Unit (M_{16}) S_1R_1 showed low sheet and rill erosions. There are different erosion types in each land component of the Otan sub-basin (M_{16}) (Fig 1, Table 2). It is necessary to attend to erosion types numbers to reduce erosion in land usage. If our focus is on sub-basins, excess erosion in a small expanse of land will not be important.

One of the reasons for the high amount of erosion in these areas is probably the ineffectiveness and inappropriateness of the EPM and MPSIAC models for this study area. Preventing and reducing erosion in these areas is difficult but necessary.

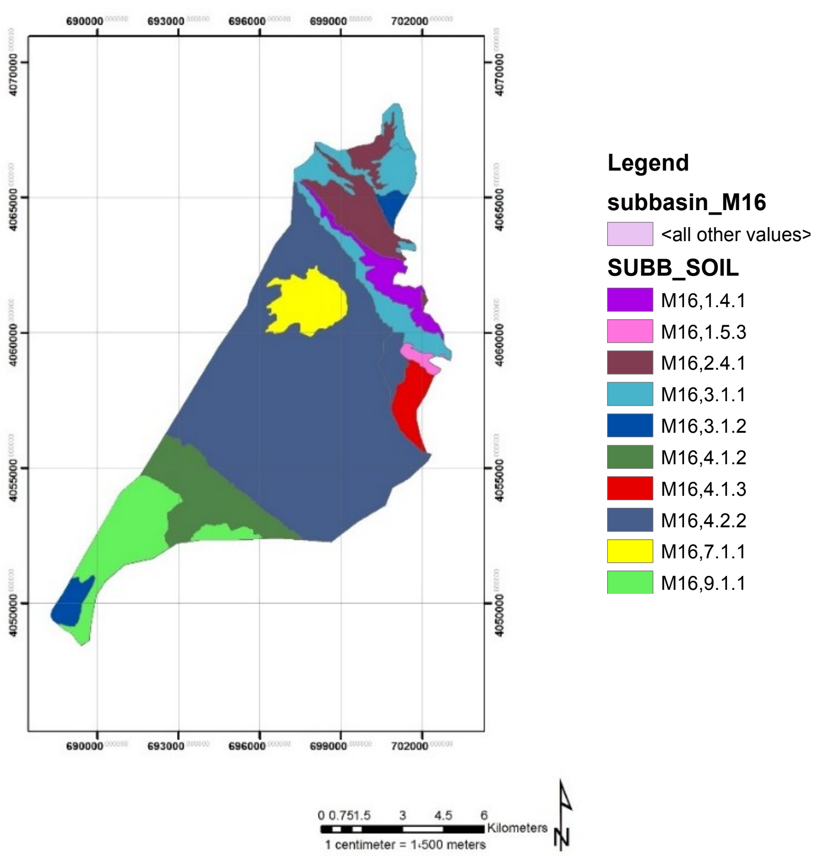

Figure 1. Map of Otan sub basin (M_{16}) (dissociation of land components)

Table 2. The amount and types of erosion in Otan sub basin (M_{16}) by dissociating the land components

Sub basin	Land compo-nents	Erosion(ton/ha.year)	Erosion type	Soil type
		MPSIAC		
Otan (M_{16})	1.4.1	1.45	$S_2R_2G_2$- $S_1R_2G_1$- S_1R_1	Lithic Xerorthents
	1.5.3	1.35	$S_1R_1G_1$- $S_1R_2G_1$- $S_2R_1G_1$- S_1R_1	Lithic Xerorthents
	2.4.1	1.44	$S_1R_2G_1$-S_1R_1-$S_1R_1G_2$- $S_1R_2G_2$- $S_2R_1G_1$- $S_2R_2G_1$	Lithic Xerorthents
	3.1.1	1.41	$S_1R_2G_1$- S_2R_2- $S_2R_2G_2$- $S_1R_2G_3$- S_1R_1	Xeric Hoplogypsids
	3.1.2	1.41	$S_1R_2G_1$- $S_2R_2G_2$- S_2R_2	Xeric Hoplogypsids
	4.1.2	1.56	S_1R_1	Xeric Hoplogypsids
	4.1.3	1.51	$S_1R_2G_1$- S_2R_2	Xeric Hoplogypsids
	4.2.2	1.39	S_1R_1	Typic Haplocambids
	7.1.1	1.62	S_1R_1	Sodic Haplocambids
	9.1.1	1.53	S_1R_1- $S_1R_1G_1$- S_1R_2	Xeric Torrifluvent

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Use of MPSIAC and EPM to estimate sediment yeild and erosion (A case study of a watershed of the Second Urban Phase, Mashhad, Khorasan Province)

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Abstract

The study area of Mashhad-Chenaran, measuring 223989.7 acres, is the largest and most important subbasin of Kashafrood. This area consists mostly of mountains and plains with variable slopes. The study area is an uneven land type and thus prone to soil erosion. Various practical methods have been developed to study soil erosion both qualitatively and quantitatively, but most of them do not accurately process information regarding soil erosion. Therefore, it is essential to confirm the credibility of these methods by investigating the results yielded by examinations compared with measured quantities taken from watersheds of Iran. The importance of the practical role of soil maps in evaluating erosion and sedimentation must also be considered. In this study, both MPSIAC and EPM were used to estimate erosion and sediment yield. Sediment measuring stations showed a rate of 2.74 t/ha per year; however, the MPSIAC model showed a rate of 1.56 t/ha per year and the EPM model showed a rate of 5.73 t/ha per year. Both the EPM and MPSIAC models were created in countries with climates and geology attributes that differ from those of Iran. Hence, the coefficients and factors affecting erosion do not correspond precisely to the conditions in Iran.
Key words: Gavrilovic method, Qualitatively, Quantitatively, watershed.

Introduction

The role of erosion and sediment yield in reducing soil fertility; soil waste; the filling of reservoirs; the obstruction of irrigation channels, streams, and rivers and the worsening of their states; and the contamination of downstream waters is undeniable. To prevent and reduce these consequences, soil, watershed, and sediment control measures are essential. Today in most developing countries, population growth, the imbalance in the ratio of livestock to pastures, overuse of pastures and forests, and the unprincipled exploitation of forests, pastures, and farms have resulted in irreparable negative environmental, economic, and social consequences. Facts and figures attest to the critical state of Iran's water for reasons mentioned above. There has been a significant increase in the quantity and severity Choosing a suitable model for determining erosion and sedimentation and calculating and drawing maps will yield important information that can be used in the management of renewable natural resources, soil conservation measures, dam designing, channel reservoirs, and land use projects. The soil erosion phenomenon is related to natural factors (morphology, soil type, climate, vegetation in the area, and human activities) (Hessel and Jetten, 2007). These factors include plowing, overgrazing, unsystematic farming, general overuse, and unprincipled management of the lands (Barovic et al., 2015).

Material and Methods

The study area (Fig. 1) of Mashhad-Chenaran is the biggest and the most important subbasin of Kashaf Rood. It extends 223989.7 acres, with geographical coordinates of 58^{0}-22' to 60^{0}-7'

eastern longitude and 36 to 37^0-5' northern longitude. Mashhad-Chenaran is a relatively steep plain located between the Hezar-Masjed and Binaloud mountains.
Identifying soil hydrologic groups helps in estimating the runoff and flooding potential in an area. The influential factors affecting influx and speed of water in the hydrologic groups were determined based on the USA's soil conservation standards and then were divided into four hydrologic units (Rafahi, 1999). The Erosion Potential Method (EPM) was presented in the former Yugoslavia to determine the percentage of soil erosion. This model was introduced in 1988 at an international conference in China. Results showed that by applying EPM, not only could erosion levels in a watershed, but also the quantity of sediment produced in the sub-basin and comparative parts of the land could be determined. (Gavrilovic, 1988).

Results and Discussion

The efficiency of the EPM and MPSIAC methods in estimating the soil erosion and sediment yield of phase two of the Mashhad urban watershed was compared. The findings presented in Tables 2 show that the sediment and erosion estimations done by both models are significantly different from the erosion reported by the hydrometric station.

Table 2. Erosion and sediment yeild of Mashhad second urban phase watershed

Area (Hectare)	Sediment (ton/ha.year)			Erosion (ton/ha.year)	
	Hydrometric station	MPSIAC	EPM	MPSIAC	EPM
223989.7	2.74	1.56	5.73	3.19	9.45

Results of the one sample test also showed that the estimations of both models have noteworthy differences with reports from the hydrometric station. By taking into consideration the incompatible statistics and database in some stations, the sediment rate estimated by the MPSIAC method was determined to be more accurate than that of EPM. The findings of the present study agree with those of studies done by Abedini et al. (2013), Ahmadi et al. (2011), Amiri (2010), and Khodabakhsh et al. (2010) in Iran. The application of GIS and RS would not only reduce the expenses and time compared to traditional methods, it would also increase accuracy in estimating erosion. Therefore, the use of up-to-date satellite images will help increase the accuracy of estimations by a great deal.
To use the EPM model under different climatic conditions, it is recommended that the model be calibrated by the climate coefficients of the climate in the study area. In addition, by changing the work-units and making them more homogenous, the results will be more accurate in studying the erosion maps in both models (EPM and MPSIAC).
While choosing a method, it is very important to place significance on its place of origin. Studies done on soil erosion and sediment yield estimation in Iran have worked particularly with the EPM model which, as mentioned before, was designed and demonstrated first in the former Yugoslavia. The former Yugoslavia has been divided into the countries of Bosnia and Herzegovina, Macedonia, Croatia, Montenegro, Serbia, and Slovenia on the west of the Balkan Peninsula, and the area has completely different climatic conditions and vegetation from the study area in the present research. Unlike the Binaloud heights, there are fewer villages in the Hezar-Masjed heights located in Mashhad Urban Watershed Phase II, and environmental degradation in this area is more significant.

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Determination of some soil properties and heavy metal contents at different soil depth of forage fields on the roadside of Van, Turkey

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Abstract

This study was carried out to determine some soil properties and heavy metal contents at the fields of alfalfa and trefoil around the main road between Van and Bitlis. Roadside was accepted as the beginning point and soil samples were taken from depth of 0-20 cm and 20-40 cm at 5 m, 25 m and 50 m away from roadside with five replications. Organic matter, lime content, pH and heavy metal contents (Fe, Cu, Zn, Mn, Ni, Cd, Cr, Pb and Hg) determined in the soil samples changed with distance from the roadside of soil sampling positions. pH levels did not significant change depend on soil sampling depth. pH levels were found range of 8.52-8.09 Whereas organic matter content decreased toward from top soil layer to sub soil layer while lime content increased depend on increasing soil depth. The highest organic matter content and lime content means were found as 2.55 % and 17.28 % respectively. The highest Fe, Cu, Zn, Mn, Ni, Cd, Cr and Pb contents for alfalfa fields were determined as 29.13 mg kg^{-1}, 3.35 mg kg^{-1}, 2.19 mg kg^{-1}, 23.64 mg kg^{-1},182.55 mg kg^{-1}, 3.67 mg kg^{-1}, 2.08 mg kg^{-1} and 49 mg kg^{-1} in the soil samples taken from depth of 0-20 cm within 5 m from the roadside in Dokuzagaç Village, respectively. Similarly, the highest Fe, Cu, Zn, Mn, Ni, Cd, Cr and Pb contents for trefoil fields were determined as 49.72 mg kg^{-1}, 2.06 mg kg^{-1}, 0.54 mg kg^{-1}, 17.74 mg kg^{-1},243.60 mg kg^{-1}, 1.79 mg kg^{-1}, 1.78 mg kg^{-1} and 16.45 mg kg^{-1} in the samples taken from depth of 0-20cm within 5 m from the roadside in Atalan Village, respectively. The heavy metal contents of the soil samples generally decreased from the sampling position of 5 m to 50 m away to roadside.

Key words: Soil properties, soil depth, heavy metal, roadside, forage fields.

Introduction

Enviromental contamination with heavy metals is a serious worldwide problem. Recently there is no way to avoid the exposure to toxic chemicals and metals in industrialized cities (Dean et al., 1972). Soil pollution caused by heavy metals such as cadmium, zinc and lead and their mobility in the environment is a danger for all living organism because of these metals enter into life cycle and a serious problem which must be solved in the future (Badora, 2002). Although heavy metals are naturally present in soils, contamination comes from mostly industry, agriculture,waste incineration, combustion of fossil fuels and road traffic (Anonymous, 1995). Automobile emissions cause remarkable metal contamination of the neighboring roadside ecosystems. Lead, cadmium, copper and zinc are associated with the mobile sources since they included in petrol, engines, tires, lubricant oils and galvanized parts of the vehicles (Falahi-Ardakani, 1984, Imperato et al., 2003, Viard et al., 2004). Risks associated with polluted soils are contamination of the food chain. Heavy metal transfer from soil to plant is dependent on many factors such as soil properties, plant species and metals bioavailability for uptake in the soil-plant system (Adriano, 1998).The main objective of this study was to determine heavy metal pollution in roadside forage fields of Van as a function of intensive motorized traffic.

Materials and Methods

This study was caried out to determine some heavy metal contents and some soil properties of alfalfa and sainfoin grown at the fields around the main road between Van and Bitlis. Soils in the research area occured on aluvial geological units belong on Entisol order. A total set of 30 soil samples (0-20 cm, 20-40 cm) were taken from two different forage fields of Van. Soil sampling areas for two different forage fields are given in Figure 1.

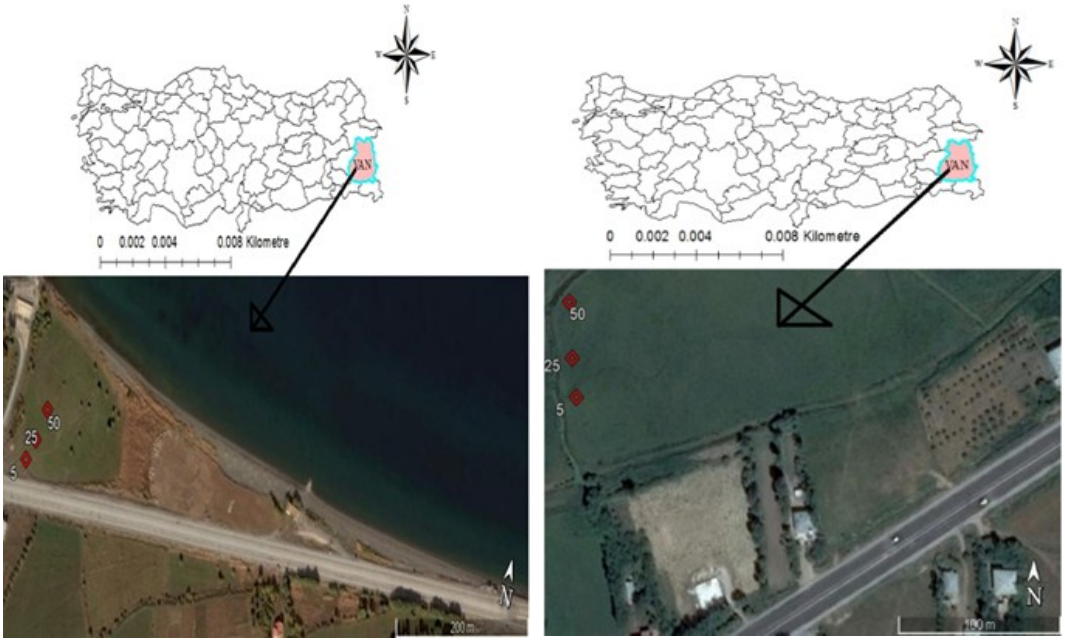


Figure 1. Soil sampling locations in Dokuzağaç and Atalan village

Roadside was accepted as the begining point and soil samples were taken from depth of 0-20 cm and 20-40 cm at 5 m, 25 m and 50 m away from roadside with five replication. Some soil properties and heavy metal contents were determined by using standart soil analyse methods reported by Kacar (2010). Variance analyses and regression analyses of the experimental data were done using the SAS package (SAS Institute, 1998).

Results

According to variance analyses results in Table 1 and Table 2, there were significant differences between sampling depth for some soil properties and heavy metal contents of soils. There were also significant differences between sampling positions for some investigated parameters.

Table 1. F values of the variance analyses for the some soil properties of forage fields soils.

Plants	Apps	df	pH	EC	Lime	OM	N	P	K	Ca	Mg
Alfalfa	Depth	1	3.43^{ns}	1.44^{ns}	2.67^{ns}	12.68**	27.07**	10.61**	1.73^{ns}	0.01^{ns}	0^{ns}
	Position	2	9.03**	1.24^{ns}	1.08^{ns}	13.05**	36.86**	3.79*	4.59*	2.16^{ns}	2.44^{ns}
Sainfoin	Depth	1	0.40^{ns}	2.05^{ns}	0.08^{ns}	8.63**	10.76**	6.92*	0.90^{ns}	0.84^{ns}	1.06^{ns}
	position	2	0.50^{ns}	21.05**	13.56**	3.63*	5.19*	5.51*	4.55*	0.46^{ns}	0.40^{ns}

Table 2. F values of the variance analyses for the heavy metal contents of forage fields soils.

Plants	Apps	df	Fe	Cu	Zn	Mn	Cd	Ni	Pb	Cr
Alfalfa	Depth	1	2.49^{ns}	10.89**	17.01**	7.43*	2.53^{ns}	9.13**	5.15*	1.18^{ns}
	Position	2	28.04**	0.60^{ns}	2.07^{ns}	15.41**	0.75^{ns}	53.42**	0.38^{ns}	0.24^{ns}
Sainfoin	Depth	1	7.22*	11.60**	5.83*	6.62*	7.91**	16.14**	9.91**	19.49**
	position	2	6.26**	5.13*	14.97**	1.32^{ns}	10.68**	11.45**	4.71*	4.69*

**: significant at 0.01 level, *: significant at 0.05 level, ns: non significant

When it was noticed that Table 1, Figure 1,2,3,4, it was shown that pH, ECC, organic matter, nitrogene and phosphorus contents of forage fields soils decreased while soil sampling depth increased. These changes were statistically significant for organic matter and nitrogene contents at 1 % level in both of plant species. The differences of phosphorus contents in alfalfa and sainfoin fields soils were determined as significant at 1 % and 5 % level respectively.

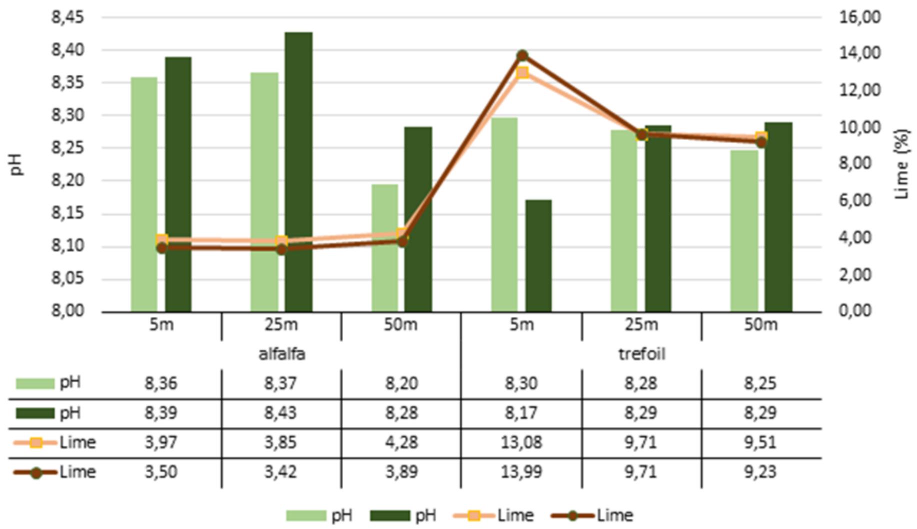


Figure 1: Effects of soil depth and sampling position on pH and lime

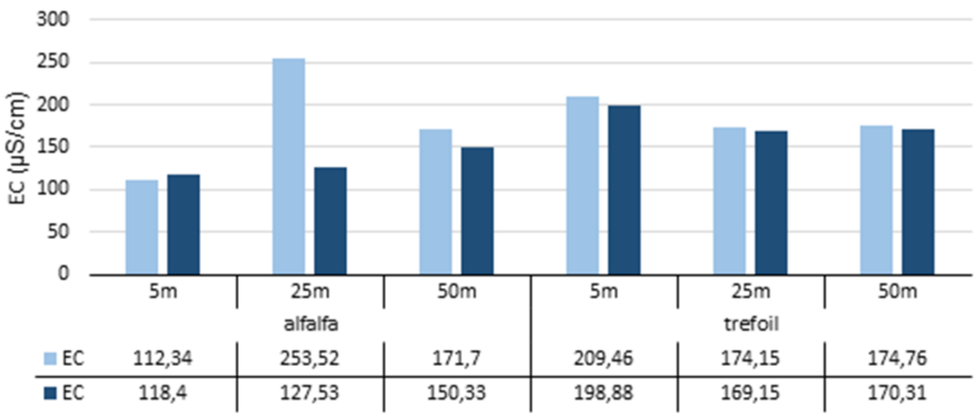


Figure 2: Effects of soil depth and sampling position on EC value

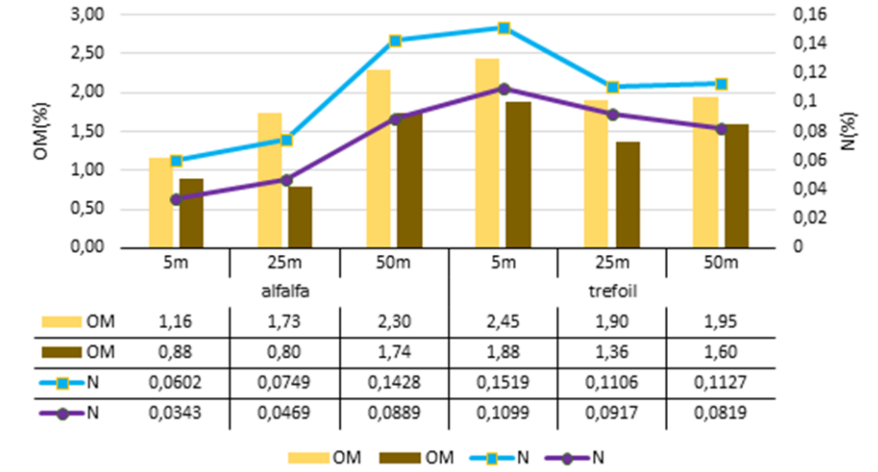


Figure 3: Effects of soil depth and sampling position on O.M and N content

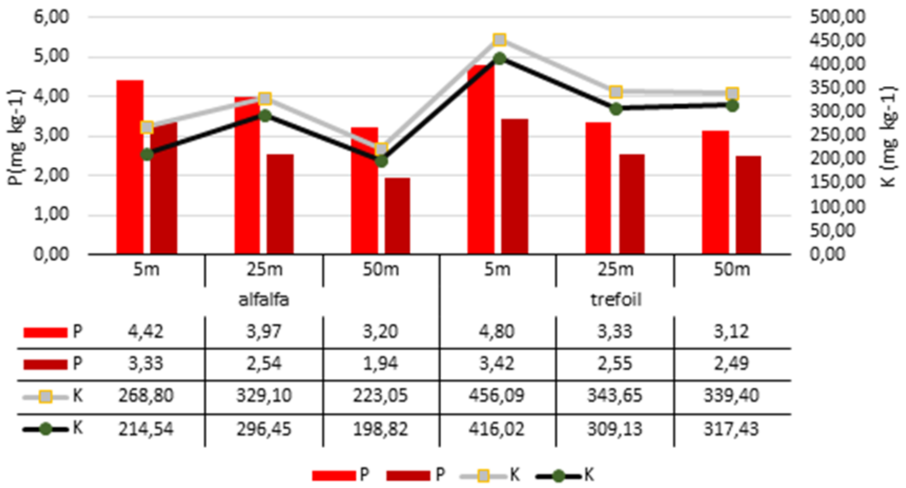


Figure 4: Effects of soil depth and sampling position on P and K content

Organic matter, nitrogene and phosphorus contents of soils taken from 0-20 cm depth and 20-40 cm depth were obtained as 1.73 %, 0.09 % and 3.90 ppm and 1.14 %, 0.06 % and 2.60 ppm respectively in alfalfa fields. In sainfoin fields, organic matter, nitrogene and phosphorus contents were found as 2.10 %, 0.13 % and 3.75 ppm for 0-20 cm soil depth and obtained as 1.61 %, 0.09 % and 2.82 ppm for 20-40 cm soil depth.

The other soil properties investigated in this study were not shown significant differences depending on soil sampling depth. Effects of soil sampling position on soil organic matter, N, P and K contents were found significant in both of forage fields statistically.

The difference among soil sampling positions were statistically significant for pH (<0.01) in alfalfa field soils, for EC (<0.01) and lime (<0.01) in sainfoin field soil. Soil EC, lime, organic matter, nitrogene, phosphorus and potassium contents were decreased while distance from away roadside increased in sainfoin field.

In alfalfa field, soil pH, phosphorus and potassium content were also decreased while distance from away roadside increased. Since soils in the research areas occured on aluvial materials the changes between in soil properties of alfalfa and sainfoin fields soils can be caused by aluvial materials showing variability.

Generally all of heavy metal contents in forage fields soils decreased depending on increasing soil sampling depth. These decreases were found statistically significant except iron, cadmium and chromium contents in alfalfa field soil (Table 2, Figure, 5,6,7,8).

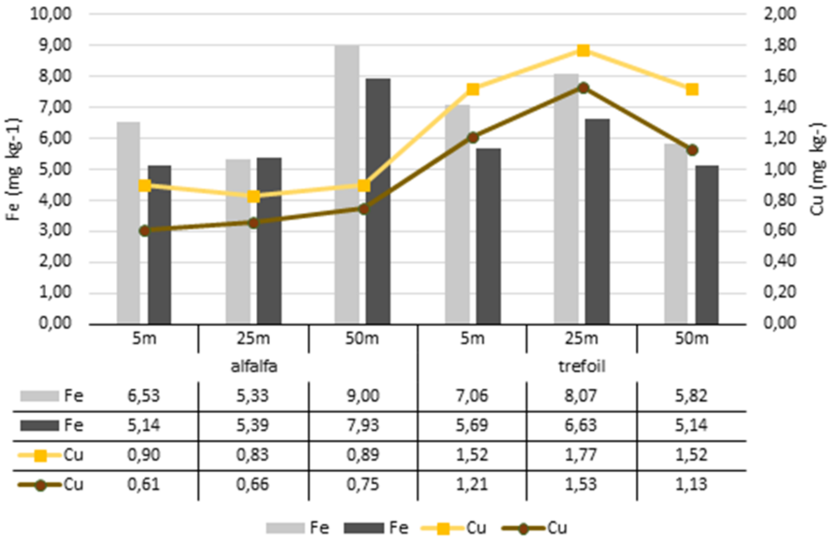


Figure 5: Effects of soil depth and sampling position on Fe and Cu content

In alfalfa field, Fe, Cu, Zn, Mn, Cd, Ni, Pb and Cr contents were determined as 6.95 mg kg^{-1}, 0.88 mg kg^{-1}, 0.52 mg kg^{-1}, 11.46 mg kg^{-1}, 1.54 mg kg^{-1}, 162.81 mg kg^{-1}, 14.11 mg kg^{-1} and 1.24 mg kg^{-1} for 0-20 cm depth and found as 6.15 mg kg^{-1}, 0.67 mg kg^{-1}, 0.37 mg kg-1, 9.47 mg kg^{-1}, 1.06 mg kg^{-1}, 134.72 mg kg-1, 10.26 mg kg^{-1} and 1.11 mg kg^{-1} for 20-40 cm depth.
In sainfoin field, Fe, Cu, Zn, Mn, Cd, Ni, Pb and Cr contents were determined 6.98 mg kg^{-1}, 1.60 mg kg^{-1}, 1.01 mg kg^{-1}, 16.20 mg kg^{-1}, 2.83 mg kg^{-1}, 142.37 mg kg^{-1}, 40.30 mg kg^{-1} and 1.53 mg kg^{-1} in soil sampled from 0-20 cm depth while these metal contents were determined as 5.82 mg kg^{-1}, 1.29 mg kg^{-1}, 0.73 mg kg^{-1}, 13.02 mg kg^{-1}, 2.40 mg kg^{-1} 115.07 mg kg^{-1}, 31.63 mg kg^{-1} and 1.116 mg kg^{-1} for 20-40 cm depth.
When it was noticed that soil sampling positions Fe, Mn and Ni contents increased depending on increasing distance from away road in alfalfa field soil. These increases were found significant at 1 % statistically.

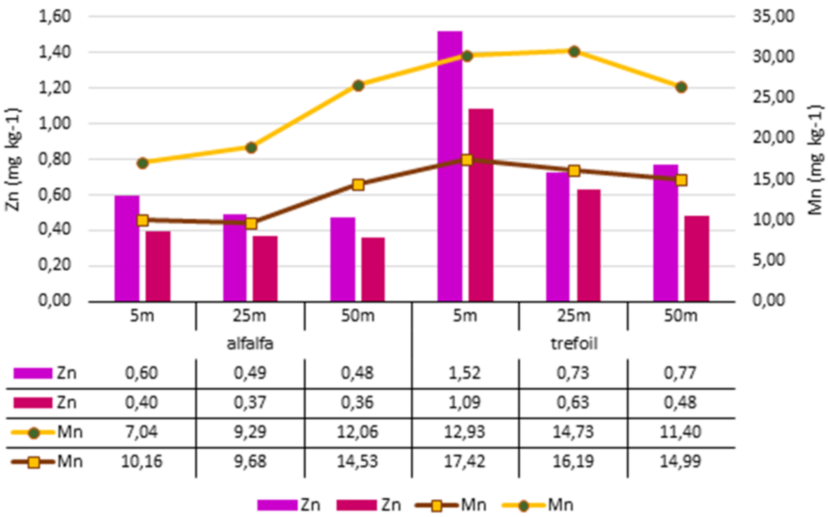
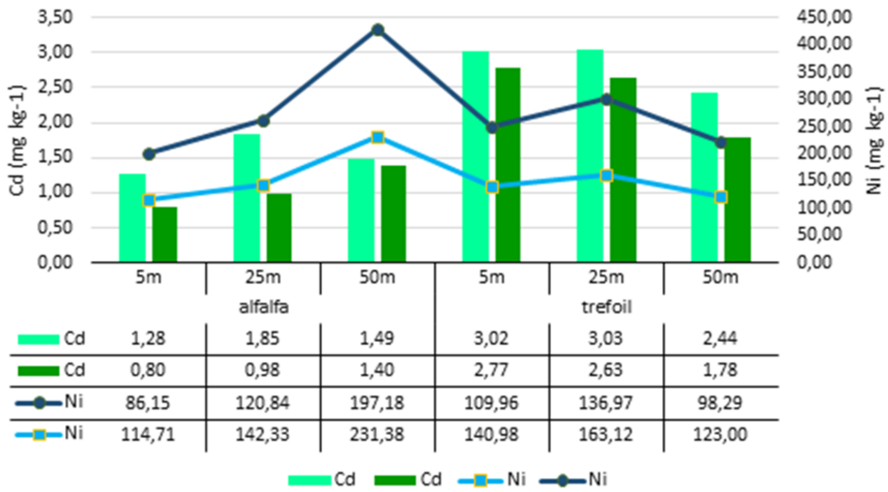


Figure 6: Effects of soil depth and sampling position on Zn and Mn content



	alfalfa 5m	alfalfa 25m	alfalfa 50m	trefoil 5m	trefoil 25m	trefoil 50m
Cd	1,28	1,85	1,49	3,02	3,03	2,44
Cd	0,80	0,98	1,40	2,77	2,63	1,78
Ni	86,15	120,84	197,18	109,96	136,97	98,29
Ni	114,71	142,33	231,38	140,98	163,12	123,00

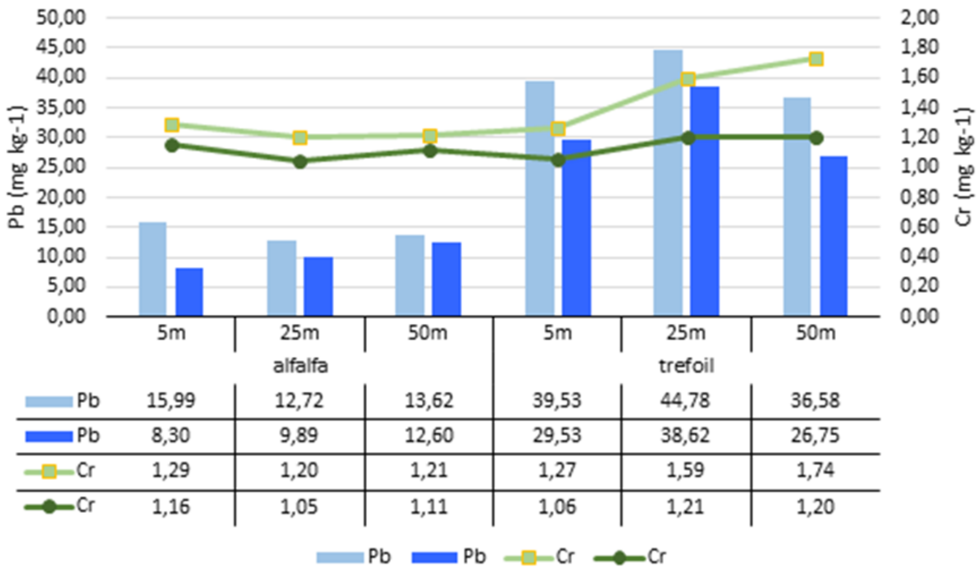
Figure 7: Effects of soil depth and sampling position on Cd and Ni content

On the contrary, heavy metal contents of sainfoin field soils decreased while the distance from away to road increased except Cr content. These decreases were found significant except Mn contents.

Rodriguez and Rodriguez (1982), Nriagu (1990), Garcia and Millan (1993), Viard et al. (2004), Nabuola et al. (2006), Gülser and Erdoğan (2008), Gülser et al. (2011), reported that there are heavy metal contaminations in road side soils caused by motorrized traffic.

Change et al. (1984), reported that more than 90 % of heavy metals were found in the surface 15 cm depth of the soil. Trace elements added through different wastes were retained in the top soil layer or moved only a few centimeters below the treated layer (Page and Chang, 1985).

Heavy metals in soils are sparingly soluble and present mostly in a sorbed state or as in soluble compounds except acidic soils. Movement of heavy metals in soils has been genarally considered minimal because of their low solubility (Dowdy and Volk 1983).



	alfalfa 5m	alfalfa 25m	alfalfa 50m	trefoil 5m	trefoil 25m	trefoil 50m
Pb	15,99	12,72	13,62	39,53	44,78	36,58
Pb	8,30	9,89	12,60	29,53	38,62	26,75
Cr	1,29	1,20	1,21	1,27	1,59	1,74
Cr	1,16	1,05	1,11	1,06	1,21	1,20

Figure 8: Effects of soil depth and sampling position on Pb and Cr content

Antoniadis et al. (2008) and Mc'Cauley et al. (2009), Bai et al. (2008), reported that organic matter is a major factor to the ability of soils for retaining heavy metals in exchangeable form. They also determined that heavy metal adsorption onto soil constituents declined while soil organic matter content decreased. Organic matter suplies organic chemicals to the soil solution. These organic chemicals can serve as chelates and increase metal availability to plants.
It was reported that soil organic material is concentrated on the upper 30 cm depth of soil. Soil organic carbon occuring by mineralization of organic material present in ratio 42 % in the 20 cm of the soil grassland relative to the layer 0-100 cm (Batjes, 1996, Jogabby and Jackson, 2000).
As a results heavy metal contents of forage fields in research area changed depend on soil sampling depth distance from away road and soil pH value and organic matter content. In alfalfa field, soil pH values decreased while distance from away road increased.
It was thought that significant increases in Fe, Mn and Ni contents belong on distance from away road caused by variabilities in pH values of alfalfa yield soils. Several researchers reported that the mobility and bioavailability of heavy metal increase with decreased soil pH (Badaway et al., 2002, Wang et al., 2006, Du Laing et al., 2007).
Organic matter content of sainfoin field soil was higher than that in alfalfa soil. On the other hand, heavy metal contents of sainfoin field soil were found higher than those in alfalfa soil. High heavy metal contents of sainfoin field soil can be influenced because of its higher level organic matter content. Apart from soil pH, organic matter content in soils is also one of the most important soil property affecting heavy metal availability (Mc Cauley et al., 2009).
Heavy metal contents of soil obtained in this study were in range of acceptable levels reported by Bergman (1993) and Özbek (1993) except nickel.
It was thought that the results obtained from this research could be an awareness in heavy metal contamination to soil having risk inclusion in the food chain.

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Chernozems of Krasnoyarsk territory: modern state and direction of evolution

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Abstract

The article reflects the genesis, properties and fertility of the chernozems in the Krasnoyarsk Territory. Modern estimates of the state of chernozems and their transformation under conditions of intensive use are given. The aim of the work is to assess the agricultural chernozems of the Krasnoyarsk Territory on the basis of soil-ecological indices (SEI). The resulting SEI, as the final value, is determined through the product of soil, climatic and agrochemical indices. Calculation of the indices is carried out using an automated electronic system (AES) developed on the basis of Microsoft Excel. The total area of chernozems in the Krasnoyarsk Territory is 4.1 million hectares, with the following dominating types: clay-illuvial chernozem (Luvic Chernozems) (60.2%) and chernozem (Chernozems) (38.0%). They do not form pronounced soil belts and are represented by different genera, species and varieties: from infertile, small, slightly humified, carbon-bearing, to highly fertile, medium-deep and deep, rich soils. These soils have good physical, water-physical, physico-chemical and agrochemical properties. A strict temperature regime determines a number of provincial features of soils: a shortened humus horizon, increased humus content, low biological activity, pockets, signs of permafrost gleying, layered texture. These soils form the basis of arable land in the region. The average weighted value of the SEI of agricultural chernozems in the region is 47.4 points. The SEI of agricultural chernozems varies from 47.7 to 30.7 points and decreases in the series: clay-illuvial agricultural chernozem - agricultural chernozem - texture-carbonate agricultural chernozem (Calcic Chernozems). The development of middle degree erosion and deflation in agricultural chernozems lowers the value of SEI, respectively, by 15 and 4-5 points. The value of the final soil-ecological index is largely determined by the values of the soil index. The importance of agrochemical and climatic indices is leveled due to the fact that the soils of the same genesis were estimated that were similar in properties and fertility features.
Key words: soil, soil properties, soil erosion, soil estimation.

Introduction

Soil and land resources are the most consumed part of the environment, the economic burden on which tends to increase permanently, and, what is especially important, land resources represent a spatial guarantee of the normal life and activities of present and future generations.

According to the Soil Map of the RSFSR with a scale of 1:2,500,000 [8], the total area of the Krasnoyarsk Territory is 233.97 million hectares, or 13.7% of the territory of the Russian Federation. The share of soil cover is 224.14 million hectares, which is 95.8% of the region's area [9]. Non-soil formations are located on 9.83 million hectares (4.2%), of which rocky placers occupy 5.85, loose rocks – 0.47, glaciers – 1.87, water – 1.64 million hectares.

The following soils prevail in the structure of the soil cover (% of the region's total area): tundra and taiga podburs – 17.2; arctic, arctotundra and their complexes – 12.8; kriozems and their combinations with kriopales, kriopeatys ahd pales – 10.0; tundra gley and their complexes – 7.7; taiga gley – 6.1; sod-podzolic and their varieties – 5,6; brownzems – 5,6; sod-calcareous and muck-calcareous – 5,0; podzols – 4,5; alluvials – 3,4; gray forest and their varieties – 3,0; peat boggy – 2,5; granuzems – 2,4; sod-brownzems – 2,3; chernozems and

meadow-chernozemics – about 2.0%. In aggregate, these soils make up more than 90.0% of the entire territory of the region and 94.2% of the soil cover. The area of the remaining soils (humus-carbonate tundra, peat-podzolic-gley, mountain primitive) varies from 1.0 to 1.6%.
In the structure of the soil cover, almost 35% are occupied by mountain soils, and the area under forest soils is 108.86 million hectares, or 48.5% of the soil cover.
The Krasnoyarsk Territory is one of the largest food producers in the east of Russia. The region ranks second in the Siberian Federal District for the production of agricultural products. The agro-industrial complex (AIC) of the region, which includes agriculture and processing sector, accounts for 8.9% of the gross regional product. Natural and climatic risks create constant threats to the stability of agricultural production and cause high producer costs. The average annual amount of precipitation in forest-steppe and steppe of the region is 200-400 mm, which is extremely insufficient to ensure high productivity of agricultural crops. Two-thirds of precipitation fall in the warm period, with a maximum in the second half of the vegetation, which creates arid conditions in early summer.
In accordance with the integral assessment of soil quality for agricultural use conducted in 2013, the Krasnoyarsk Territory is classified as one of "the most unfavorable" regions [2]. The percentage of soils unsuitable for agricultural production is 81. The area of the most fertile, and therefore most productive soils in agriculture – chernozems – in comparison with the total area, looks insignificant (only about 2%). However, these percentages correspond to approximately 4.1 million hectares – a huge area, due to which the region is one of the main producers of food and marketable grain in Siberia. The area of sod-carbonate and gray forest soils, which are also suitable for profitable agriculture, is more than four times larger. Agricultural production is carried out, first of all, on the most fertile, profitable soils, which require less processing costs, fertilizers and plant protection products.

Materials and Methods

On the basis of extensive expeditionary and analytical material, it was established that four types of chernozems are distinguished within the agricultural part of the Krasnoyarsk Territory: clay-illuvial podzolized chernozem (4.7%), clay-illuvial typical chernozem (55.5%), chernozem (38.0 %), and texture-carbonate chernozem (1.4%). They do not form pronounced soil belts and are represented by different genera, species and varieties: from infertile, small, slightly humified, carbon-bearing, to highly fertile, medium-deep and deep, rich soils. These soils are confined to six natural districts: Achinsk-Bogotol, Krasnoyarsk, Kansk, Nazarovo, Chulym-Yenisei and South-Minusinsk. The region ranks second in the Siberian Federal District for the distribution of chernozems. 50% of all Siberian chernozems are concentrated here and in the Altai Territory.
The aim of the work was to assess the agricultural chernozems of the Krasnoyarsk Territory on the basis of soil-ecological indices (SEI). SEI were calculated based on [3, 4]. The resulting SEI, as the final value, was determined through the product of soil, climatic and agrochemical indices. Calculation of the indices was carried out using an automated electronic system (AES) developed on the basis of Microsoft Excel.
The initial data for calculations were taken from the source [5]. For each of the indicators there are mathematically reliable averages and their confidence interval. Clay-illuvial podzolized agrochernozems are characterized by high content of humus (Table 1). Agrochernozem and clay-illuvial typical agrochernozem differ from it by a lower content of humus, by 2 and 1%, respectively. All soils have a neutral reaction and a very high supply of mobile phosphorus and exchange potassium.
In the work a new indicator of bioluminescence was used — the amount of residual luminescence T (%), according to which the intensity of soil contamination can be estimated: T>80%

– the sample is not contaminated; 50%<T<80% – the sample is contaminated; T<50% – the sample is heavily contaminated [1].

Results and Discussion

The chernozems of the Krasnoyarsk Territory have good physical, water-physical, physical-chemical and agrochemical properties. These are the most fertile soils of the region. The temperature regime of chernozems is defined as sharply continental and more intense, compared with the West-Siberian and especially European analogues [5]. A strict temperature regime determines a number of provincial features of Krasnoyarsk chernozems: a shortened humus horizon, increased humus content, low biological activity, pockets, signs of permafrost gleying, layered texture, increased efficiency of nitrogen fertilizers.

The value of residual luminescence increases (by 2.6–2.9 times) down the profile of the soils. Accumulation of all possible contaminants occurs most strongly in the upper part of the soil, so low values of residual luminescence were recorded in the upper (0-7, 0-10, 0-12 cm) soil layer, with the soil of the arable land being the most polluted throughout the profile. The average value of T is usually the lowest here. In the profile of chernozem in deposits and virgin lands, from a depth of 70-80 cm, pollution is not observed.

Table 1. Area and main input data for the calculation of the SEI of agrochernozems

Area, thousand hectares		Humus, %	Particle-size distribution	pH_{KCl}	Content		Amount	
total	arable land				P_2O_5	K_2O	t>10ºC	yearly precipitation, mm
Clay-illuvial podzolized agrochernozem								
191.4	176.9	9.7	heavy clay loam	6.2	very high	very high	1725	390
Clay-illuvial typical agrochernozem								
2301.1	1053.0	8.5	heavy clay loam	6.5	very high	very high	1750	360
Agrochernozem								
1563.5	722.4	7.7	heavy clay loam	7.1	very high	very high	1775	320
Texture-carbonate agrochernozem								
56.5	19.9	4.5	medium-textured loam	7.1	high	high	1825	300

In the structure of the soil cover of the plowed up massifs in the Krasnoyarsk Territory, agrochernozems occupy about 62%. The SEI of the main types of these soils is quite high, in the range of 47-48 points, and decreases in texture-carbonate agrochernozem to 31 points (Table 2). Erosion considerably, almost by 15 points, and deflation, less considerably (4-5 points), lowers their value. In general, agrochernozems of the region have high soil and agrochemical indices and the final SEI. For comparison: all soils of the Krasnodar Territory have a SEI of 100 points. According to the study, the fertility of Krasnoyarsk agrochernozems is more than 2 times lower than that of Krasnodar ones, and considering erosion and deflation - 3 times lower.

Table 2. Intermediate indices and the final SEI of agrochernozems, points

Type of soil	Index			
	soil	agro-chemical	climate	final
Clay-illuvial podzolized agrochernozem	10.08	1.23	3.85	47.7
moderately-eroded	6.96	1.23	3.85	33.0
Clay-illuvial typical agrochernozem	9.98	1.23	3.88	47.6
moderately-eroded	6.88	1.23	3.88	32.8
Agrochernozem	10.26	1.23	3.77	47.6
moderately-deflated	9.02	1.23	3.77	41.8
Texture-carbonate agrochernozem	7.22	1.10	3.87	30.7
moderately-deflated	6.37	1.10	3.87	27.1
Average for non-eroded soils	10.11	1.23	3.83	43.4
Average-weighted for non-eroded soils	-	-	-	47.4
Average for eroded and deflated soils	7.62	1.23	3.83	33.7

In the conditions of the region, a series of long-term field experiments was conducted [7] aimed at studying the effect of humus content and labile humic substances on the productivity of grain crops. Mathematical dependences were determined on the basis of which the models of grain crop yields were built and the gradations of humus content and labile humic substances in soil were developed. Dependences between the content of humus in the soil, its labile forms and the yield of grain crops are characterized as direct and medium. The connection occurs only at sufficiently low values of humus content (2.1-5.1%) and labile humic substances (90-393 mg C/100 g soil).

In clay-illuvial agrochernozems of medium-loamy and heavily-loamy granulometric composition, the following estimated gradations were proposed for use in grain crops: humus content (%)– <2.0 – very low, 2.0-3.0 – low, 3.0-4, 0 – average, 4,0-5,0 – high,> 5,0 – very high; the content of labile humic substances (mg C/100 g soil) — <100 – very low, 100-200 – low, 200-300 – medium, 300-400 – high,> 400 – very high.

On the territory of the region, water, wind and complex erosion is intensively developing. 1249.5 thousand hectares of agricultural land are subject to erosion of different types and intensity levels: deflation – 663.9 (53.1%), water erosion – 397.2 (31.8%), complex erosion – 188.4 thousand hectares (15.1%). The presence of erosion is the result of the interaction of natural factors and human economic activities, which consisted in reduction of forest areas and continuous plowing of land, without taking into account the landscape features and introduction of erosion control measures. Forest belts created in the 1960s are in an unsatisfactory condition and are not capable of protecting the soil cover from erosion.

On the basis of many years of research, it was established [6] that in the agricultural soils of the region the content of labile organic matter (LOM) varies within the limits of 0.15–1.55% of the soil mass. In comparison with soils occupied by agricultural crops, the content of LOM decreases in bare fallow soils by 30% and increases in soils of mixed-term fallows by 59%. To assess the LOM content of arable soils in the agricultural part of the region, the following gradation (%) was proposed: <0.30 – very low, 0.31-0.60 – low, 0.61-0.90 – medium, 0.91-1.20 – increased, 1.21-1.50 – high, >1.51 – very high. To estimate the degree of soil exhaustion, it was suggested to use the LOM content in the organic matter of the soil (%). With regard to arable soils of the Krasnoyarsk Territory, the following gradation (points) was proposed: <3.0 – very low, 3.1-6.0 – low, 6.1-9.0 – medium, 9.1-12.0 – strong, >12.1 – very strong.

Conclusion

The average weighted value of the SEI of agricultural chernozems in the Krasnoyarsk Territory is 47.4 points. The SEI of agricultural chernozems varies from 47.7 to 30.7 points and decreases in the series: clay-illuvial agricultural chernozem - agricultural chernozem - texture-carbonate agricultural chernozem (Calcic Chernozems). The development of middle degree erosion and deflation in agricultural chernozems lowers the value of SEI, respectively, by 15 and 4-5 points.

The study was supported by a grant from the Russian Science Foundation (project No 16-14-10115)

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Ecological assessment of influence of technogenic factors on mesofauna of soils of the Irtysh River in Pavlodar and development bioindicative and indicative indicators

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The specific properties of the soil allow considering it as a special natural-historical body, requiring a deep analyzing on presence of organisms and their influence on the environment. The contamination of the soil, it's specific and group list, number of certain representatives, character and the periods of their activity, etc. for the majority of areas has not studied yet. The reason for the relatively poor study of soil organisms lies not only in the complexity of the conditions for the existence of organisms in the soil (in a polydisperse three-phase system), but also in the difficulty of observing and studying soil animals due to the opacity and density of the habitat, and, finally, the laboriousness of even elementary work on collecting and quantitative account of soil fauna.

The research was provided in Pavlodar region, revealing that most belong to the subzone of dark chestnut soils. Dark chestnut soils of the region, in the overwhelming majority of light mechanical composition, are predominantly light loamy and sandy loamy, and in the southern region are sandy. This is a consequence of their formation on the ancient alluvial deposits of the Irtysh, which, as mentioned above, have a light mechanical composition, contain 3-4% humus in the upper horizon.

The object of the study was the mesofauna of chestnut soils of Pavlodar Priirtyshye.

During biological (mesophane) studies, comparative-geographic, comparative-analytical and experimental methods were used.

The study of soil mesofauna is important for diagnostic purposes and represents a unique opportunity to assess the evolution or degradation of soils under the influence of human economic activity.

Due to their activities, aeration of the soil is improved, its moisture permeability is increased, and other important processesmfor soil formation are stimulated. Especially mesofauna on virgin lands are important that are not cultivated by human, and the maintenance of their fertility is carried out at the expense of the vital activity of all the constituent parts of this biocenosis and, to a large extent, at the expense of the mesofauna. This fact was decisive in the choice of the object of research.

The selection of soil samples for the determination of physicochemical, physical properties and biological studies was carried out by layer-by-layer method of a continuous column of 10 cm to a depth of 40 cm. Below 40 cm, there is no soil-invertebrate infertility, which determined this lower limit for sampling.

Under the conditions of the experiments, soil samples are selected layer by layer in depths of 0-10; 10-20; 20-30; 30-40 cm in three terms (spring-May, summer-July, autumn-September).

In soil samples, the definition by conventional methods - moisture - by weight method, general humus - according to I.V. Turin; Specific gravity - pycnometric method; bulk weight using Kachinsky borer; general porosity - the calculation method, for determining biological indicators: mesofauna of soils - a method of manual disassembly according to Gilyarov were used. Ther was provided the research on the accumulation and migration of pollutants in the body of representatives of the mesofauna of the soils of Irtysh.

The main source of environmental threats (OC) is thermal power plants. In the process of industrial production, old technologies and standards, poor-quality raw materials and fuel are used.

The main polluters of the air basin of the Pavlodar region are the following enterprises: JSC Pavlodarenergo (CTE-2,3), Aluminum of Kazakhstan JSC, Pavlodar Petrochemical Plant CJSC, AES Ekibastuz LLP, Ekibastuz GRES-2 Station OJSC, Aksu Station Ferroalloy Plant, Eurasian Corporation JSC, Severny, Vostochny and Bogatyr sections.
Antropogenic complex factors that affect the condition of ecosystems, are quite diverse - it's pollution emissions of industrial production, transport, excretion of waste of natural resources of fertile land the mining industry and many others. Anthropogenic stressors arise at such a rate that biological systems do not have time to adapt to them [1], at the same time their biological characteristics change under the influence of all factors [2, 3]. To one of the most toxic substances that fall into the biosphere in the results of human production can be attributed to heavy metals. In small amounts, they are found in every organism, but a significant increase in their concentration can lead to the death of animals.
Heavy metals, accumulating in the soil and litter, plants and animals, fall into the human body, causing poisoning and disease [8]. The role of animals in biogenic migration of substances in terrestrial ecosystems has not been adequately studied. The activity of animals in biogeocenoses can be regarded as a factor regulating this nutrient cycle [4].
The block of soil-litter invertebrates is characterized by an early reaction to the contamination of their habitats with heavy metals. It is known that the representatives of the mesofauna act as active storage rings [5]. Migration of microelements along the trophic chains of these animals and other consumers arouse interest to determine their resistance to toxicants, and to identify loads on the ecosystem as a whole [6]. Thus, insects - representatives of mesofauna, the concentration of heavy metals in food is one of the main factors that determines their content in the animal's body. The absorption of toxic trace elements in them in most cases occurs through the intestine. Subsequently, their redistribution across all parts of the body is observed. Studies on the accumulation of heavy metals by soil-littered vertebrates were carried out near the above pollutants.
The quantity of heavy metals in invertebrate animals was carried out using the method of atomic absorption spectrophotometry on an AAS-30 spectrophotometer according to the standard procedure [7]. The results of the analyzes were calculated using the formula: $C = CoV / P$, where Co is the quantity of the element in the test solution; V is the volume of the solution, ml; P - weight of the sample, g.
More than 40 samples were prepared for the atomic absorption analysis. The samples analyzed the presence of such elements as Cu, Pb, Cd, Zn, which are priority pollutants for the study region.
In addition, the presene of heavy metals in the upper soil horizon, litter, was investigated.
It is known that macro- and microelements occur in the body of animals and bioaccumulate in them in the process of feeding. Therefore, the specific features of the accumulation of heavy metals in invertebrates, not only on the taxonomic level, but also on the trophic level, are of undoubted interest.
The structural and functional composition of the representatives of the soil mesofauna is diverse and includes representatives of zoophages, phytophages and saprophagous. Representatives of each trophic group have a specific way of feeding.
Invertebrates living in the upper soil horizon - litter, are closely connected on the one hand with plants, which, like animals, accumulate heavy metals and are the object of food for the representatives of phytophages. On the other hand, they are associated with a litter that performs barrier functions on the way of toxicants entering the soil, being not only the habitat of the animal group under study, but also an object of destructive influence of representatives of saprophagous. During the study, representatives of Carabidae, Scarabaeidae, Elateridae, Formicidae were determined.

Representatives of each functional group accumulate heavy metals in various quantities. Naturally, the highest quantity of microelements of biogenic origin in representatives of all functional groups, such as Cu, Zn, Pb, Cd. It has been revealed that such highly toxic elements as Cd, Pb accumulate in invertebrate animals in a much smaller quantity.
Copper. Significant differences in the accumulation of copper by representatives of all trophic groups are not recorded. Each of the three trophic groups of soil invertebrates accounts for 32.9-36.1% of this element from its content in the studied groups of soil invertebrates.
Zinc. If the share in the accumulation of zinc in representatives of zoophages and saprophagous is 34.4-35.1%, then phytophages in comparison with them accumulate it in 1,14-1,16 times less.
One of the toxic elements, which has the most negative impact on the life of the representatives of the mesofauna, is lead. This element in the largest number is accumulated by representatives of zoophages - 1.14 times more compared to phytophages and, in turn, 1.19 times more than in saprophages.
Cadmium is accumulated in the greatest quantity by representatives of saprophagous - 54.5% of the total quantity in the mesofauna of the soil, and in the smallest - of zoophages, 6.9%. Comparative analysis of heavy metals in representatives of different functional groups of invertebrates shows that cadmium, in comparison with all microelements, is accumulated by animals in the smallest quantity (1.1-9.1 mg / kg dry weight) (Table 1).

Table 1. Accumulation of heavy metals by representatives of soil invertebrates of various functional groups on the highway (mg / kg dry weight)

Functional groups	Cu	Zn	Pb	Cd
Phytophagous	492,3	1816,6	147,3	6,5
Zoophages	523,6	2058	165,8	1,7
Saprophages	571,9	2104,1	89,5	9,1

As a result, the importance of these groups of invertebrates in the migration of heavy metals through food chains, including vertebrates, can not be overestimated. In the future, it is necessary to continue monitoring studies of the migration of heavy metals in biogeocenoses, including trophic networks.
The obtained data can be used for bioindication and monitoring studies of environmental pollution.Thus, it was revealed that the accumulation of heavy metals by representatives of various trophic groups of soil invertebrates is not unambiguous. In conditions of technogenic pollution of cadmium, representatives of the soil mesofauna accumulate in the smallest amounts under these conditions.

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Processes of transformation of the soil cover of the Northern Aral Sea area under anthropogenic impact

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Key words: soil, pastures, fallow land, pasture digression, degradation.

Introduction

General development provisions of disturbed soils are based on the study of various forms of manifestation of anthropogenesis and determination of the direction of transformation. The basis is the identification of specific processes and the associated with states that arise under the pressure. An important task of studying the transformed territories is to analyze the changes in the structure of the soil cover and the properties of disturbed soils. The result of the research is the identification of regularities in the development of transformed soils during time under various types and degrees of disturbance, the possibility of natural restoration. Degree and nature of anthropogenically caused disturbances in soils is determined by the complex of morphogenetic features and properties of soils, as well as by the processes taking place in them.

Arid regions with growing signs of degradation of pastures tend to decrease their productivity. The main factor in the degradation of the lands on the Northern Aral Sea region is pasture digression, accompanied by a degradation of ecosystems under overgrazing pressure. Pasture digression is an aggressive factor, accompanied by a change in the composition of the vegetation or its destruction, which entails intensive wind and after-rain erosion and soil degradation with a change in their agrophysical and agrochemical properties. Usage in the system of protection and improvement of desert pastures of the basic methods: for semi-root and superficial improvement of desert pastures with the alternation of the natural vegetation strips and the coulisse of forage grasses, shrubs and half-shrubs along plowing, prevents development of erosion processes and contributes to the restoration of soil fertility. The prospectivity of this approach for the northern deserts was demonstrated by a series of experiments [1, 4]. In unfavorable bioclimatic conditions, the application of the root method of improving pastures by continuous plowing does not show efficient results, as a result of this approach disturbed lands become a fallow lands with negative characteristics and a long process of restoration.

Materials and Methods

The object of research was the desert soils of the region of Northern Aral Sea, with signs of anthropogenic disturbance caused by changes in the morphological structure of the soil profile and individual genetic horizons, physical and chemical properties, depending on the forms of manifestation, the degree of transformation, and the characteristics of natural restoration. Soils are distinguished by a small thickness of the humus horizon, a low content of humus in it, and a low absorption capacity. Field surveys included a conjugated analysis of the morphological features of disturbed soils and their background analogs with using conventional methods [5]. The main physicochemical properties of soils were determined by the following parameters: granulometric composition, humus content, total nitrogen, CO_2 carbonates, exchange cations, water-soluble salts, and reaction of soil solution.

A comparative analysis of spatial and temporal changes in soil characteristics and properties makes it possible to determine the patterns of changes in the morphological structure of the soil profile and in different genetic horizons, assess the stability of the original soils, and the possibility of their restoration under the condition that the pressure ceases.

Results and Discussion

The region of Northern Aral Sea refers to the desert zone, the subzone of the northern desert with the development of a subtype of brown desert soils [3]. The features of soil formation are caused by bioclimatic conditions determined by small amount of precipitation, high temperatures in summer and low in winter, in vegetation cover predominant xerophytic half-shrubs and saltworts with little participation of grasses and herbs. Researching of the soil cover showed its heterogeneity and complicated structure, caused by various conditions of soil formation and factors of anthropogenic impact. Brown desert soils create the main background of the soil cover, occupy elevated positions in a slightly-wavy plain, plateau tops and eroded slopes of the remains, form complexes with solonetses, or combine with meadow-brown soils, solonchaks, takyrs and sands. Analysis of the morphogenetic properties of the studied soils revealed differences between the humus horizons of natural and disturbed soils. The changes are determined by the thickness of the humus horizon, its structure and composition, the contents of the basic chemical indices typical for the zonal and intrazonal types of soils.

Soils of the survey area are used as pasture land. Disturbances of the soil cover associated with grazing are related to a strong degree of anthropogenic disturbance. This process determined by compacting of soil during trampling, destruction of the integrity of the surface horizons and their composition, removing of fine-grained material of soils and a decreasing humus content caused by the destruction of vegetation, occurrence of erosion processes.

A comparative analysis of morphogenetic features and properties of soils with signs of pasture digression revealed the following changes with respect to undisturbed analogs. The destroyed humus horizon is characterized by the absence of a superficial crust, has a loose build composition without signs of layering, a dusty structure in opposite to the powdery or fragile lumpy structure of the background soil horizons. Compacting of the surface during trampling is accompanied by deformation of the horizons and boundaries between them, clarification of color and absence of a pronounced structure. The illuvial horizon retains the characteristics of soils of natural analogs, but differs by the presence of vertical cracks due to the processes of desiccation. In the disturbed soil horizons, the content of humus is reduced in 2 times; the absorptivity is reduced in 2–2.5 mg-equivalents due to reducing the content of absorbed cations (Ca and Mg) to 20 and 10%, respectively. The changes correlate with the data of the granulometric composition, which showing the depletion of the horizon with dusty-silty particles to 12–15%. Restoration of disturbed soil-vegetation cover in conditions of unregulated grazing has not been identified, some formation of weedy or ephemeral vegetation groups is noted along the channels of temporary watercourses.

In the system of protection and improvement of pastures, the main methods include: root, semi-root and superficial improvement, the creation of pasture protective belt and forest-pasture plantations. The use of continuous plowing as a root method for improving desert pastures led to the transformation of soils, associated with mechanical disturbance of the surface horizons, loss of their structure and composition. Sowing grass species returned no results, experimental plot area was left as a fallow land, and the restoration process took several stages of forming vegetation. During the period of research, the late succession stage was identified with the development of the spatial and sinusoidal structure of zonal wormwood (*Artemisia terrae-albae*) communities [2].

The soils of the fallow lands are characterized by the restoration of differentiation by the horizons of the disturbed part of the morphological profile according to the desert type of soil formation with the formation of the humus-eluvial and humus-illuvial horizon. The underlying illuvial carbonate horizon, combined with an solonetsous horizon without signs of transformation. A comparative analysis showed that the surface horizon has a less dense composition than the background soil horizon. In the humus-eluvial horizon there is no layering, as it is inherent in natural analogs. The structure of the humus-illuvial horizon is not formed; it is dusty, unlike the lumpy structure of the horizon of undisturbed soils. Illuvial-carbonate horizon of disturbed soils retains the morphological features of the original soils in color, composition and structure. The data of the analytical study showed that in the upper crust horizon of brown soils on a long-term fallow lands, the amount of humus and total nitrogen is almost half time lower than in the background content. In both cases, the upper part of the soil profile is leached from carbonates, the maximum of which is observed in the carbonate horizon. The horizons retain a slightly alkaline reaction and increasing alkalinity with depth. The amount of exchangeable bases is reduced to 2–4 mg-equip compared with undisturbed analogues, but a gradual increase in the values with depth is maintained. Half-meter layer of soils in both variants is not saline, the amount of water-soluble salts increases till 0.5% in deeper horizons. In the soils on fallow lands, a depletion of the silt fraction of the upper horizons is expressed, which arose due to mechanical disturbance and deflation processes with the removal of fine-earth material.

The plowing of lands refers to a strong degree of anthropogenic disturbance, because it is the destruction of the integrity of structures and composition of the upper part of the humus horizon, mixing of horizons, a decrease in the supply of organic matter after destruction of vegetation and a decrease in the content of humus and nutrients.

According to the results of the research, it can be concluded that, after plowing (more than 30 years), brown desert soils partially restored the differentiation to genetic horizons, which are distinguished by a less dense composition and less formed structure in comparison with undisturbed soils. The chemical composition is characterized by a lower content of humus and total nitrogen. The exchange capacity (by the sum of the absorbed bases) in the upper part of the profile is lowered relative to the background soils, which correlates with a change in the granulometric composition in connection with the sanding of the disturbed horizons.

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The influence of heavy metals in soils on early stages of seedlings development

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Abstract

Plant–soil interactions play a fundamental role in many important processes including climate change, human health and food production. Plant growth and development largely depend not only on the availability of mineral nutrients, but also on soil contamination with different pollutants. Heavy metals are amongst the most frequently found and intensively studied inorganic chemical substances that contaminate the environment. This is due to their negative effects to the environment and human health. If heavy metal concentration is significant, it will become toxic for most plants. Metal toxicity is important for scientists from both theoretical and practical point of view, because it affects crop yields, soil biomass and fertility. Plants growing on soils contaminated with heavy metals show a reduction in growth, performance, and yield, what is especially important when plants have an economical value, i.e. they are crop plants, including cereal plants. The objective of the present study is to examine the toxic effect of selected heavy metals (Pb, Zn, Ni, Cd and Cu) on the cereal plants, i.e. on most important cultivable grains – wheat, rye, oat, barley, and maize. Seeds were placed in soil with increasing concentration of investigated heavy metal ions. The incubation temperature was set at 23℃ with a 12-hr photo period under 1000 lx. Plants were harvested after 14 days. After seedlings collection seed germination rates were calculated. Biometric parameters of underground and aerial organs were measured. The concentration of chlorophyll *a* and *b* were determined using DMSO extraction and spectrometry. Generally, all examined heavy metals had detrimental effect on germination and seedlings growth at early stages of development, although in different rates. This was proved by decreasing of length and mass of all organs as well as by chlorophyll content. Total chlorophyll (both investigated types of this photosynthetic pigment) content declined progressively with increasing concentrations of heavy metals. The obtained results showed that different species of investigated cereal plants exhibited diversified sensitivity for increasing concentration of heavy metal in soil.
Key words: heavy metals, cereal plants, soil, contamination.

Introduction

Heavy metals are amongst the most frequently found and intensively studied inorganic chemical substances that contaminate the environment. Soils may become contaminated by the accumulation of heavy metals through various types of emission mostly from the significantly expanding industrial and urban areas, transportation, land application of fertilizers and pesticides, and fossil fuels combustion residues (Wuana, Okieimen, 2011). Heavy metal contamination of soil is the source of serious environmental pollution and may influence to humans and the ecosystems on different levels; direct ingestion or contact with contaminated soil, the trophic relationships, drinking of contaminated ground water, as well as reduction in food quality via phytotoxicity and reduction in land usability for agricultural production (McLaughlin et al., 2000). Plants are the first stage of a metal's pathway from the soil to heterotrophic organisms such as animals and humans, hence the concentration of metallic trace elements in edible parts of a plant represent available load of these metals that may enter the trophic chain through plants. Although some heavy metals are essential elements for plant growth and metabolism, anthropogenic activities increase the concentration of these elements to amounts that are harmful to both plants and animals. Growth reduction of plants as a result of changes in physiological and biochemical processes in cells and tissues growing on heavy metal polluted soils has been recorded (Öncel, 2000; Chibuike, Obiora, 2014). The aim of the present study was to investigate the influence of selected heavy metals (Pb, Zn, Ni, Cd and Cu) on seed germination, biometric parameters and chlorophyll content of cereal plants seedlings.

Materials and Methods

Seeds of five species were used for experiments of the present study: wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), rye (*Secale cereale*), oat (*Avena sativa*), maize (*Zea mays*). Seeds were obtained from Seed Centre in Kielce. Seeds were placed into plastic flowerpots filled with 200 g of soil (universal gardening substrate). Into all flowerpots (except control samples) increasing volume of 1 M heavy metal salts solutions were added. All samples were left in lumistate (23°C; 12-hr photo- period under 1000 lx) for 14 days and were watered every day. After two-week period seedling were removed from the soil and subjected to biometric measurements and chlorophyll determination. Doses of heavy metals added into soil in subsequent experiments were shown in Table 1.

Table 1. Doses of heavy metals added into soil in subsequent experiments (millimoles of heavy metal $\cdot$ g^{-1} of soil)

Sample	control	1	2	3	4	5
Heavy metal concentration	0.00	0.02	0.04	0.08	0,16	0,32

The following biometric parameters were determined: percentage of germination, length of the root system, length of the shoots. Chlorophyll *a* and chlorophyll *b* contents were measured using modified methods described by Hiscox and Israelstam (1979) and Richardson et al. (2002). 200 mg of plant organs were placed in screw-cap tubes. 7 cm^3 of DMSO were added into each samples and closed test-tubes were placed in an oven at a temperature of 65°C for 90 minutes. After incubation the tubes were cooled. The extract was decanted into a conical flask. 3,5 cm^3 of DMSO were added into a tube and after washing the plant material, this part of the solvent was combined with the main extract.
The absorbance measurement was performed using a LANGE DR 28000 spectrophotometer for 665 nm and 649 nm wavelengths. The chlorophyll content was calculated from the formulas:

$$a = (12{,}9 \cdot A_{665} - 3{,}45 \cdot A_{649}) \cdot 10 \cdot 5 \text{ (µ g/g of fresh weight)} \quad (1)$$
$$b = (21{,}99 \cdot A_{649} - 5{,}32 \cdot A_{665}) \cdot 10 \cdot 5 \text{ (µ g/g of fresh weight} \quad (2)$$

where:
A_{665} – the absorbance value at wavelength λ = 665 nm

Results and Discussion

The experiments consisted of sowing the seeds of basic cereal species to a substrate with increasing content of heavy metals (Pb, Zn, Ni, Cd and Cu) and observing the germination process and early stages of seedling growth. After 14 days, the seedlings were isolated from the soil and biometric measurements were made and the level of chlorophyll *a* and *b* was determined. The decrease in germination percentage of seeds along with the increase of heavy metals in soil is presented in Table 2.

Table 2. Percentage of seed germination

spiecies	control	sample 1	sample 2	sample 2	sample 4	sample 5
Lead (Pb)						
wheat	100	70	60	20	0	0
barley	100	50	20	10	0	0
rye	100	70	60	10	0	0
oat	100	80	70	60	10	0
maize	100	100	90	60	30	0
Zinc (Zn)						
wheat	100	90	80	70	70	0
barley	100	100	100	90	90	20
rye	100	70	50	50	50	10
oat	100	90	90	90	70	0
maize	100	90	30	20	10	0
Nickel (Ni)						
wheat	100	90	70	40	20	0
barley	100	80	70	30	10	0
rye	100	90	60	40	10	0
oat	100	90	80	50	20	0
maize	100	60	50	50	10	0
Cadmium (Cd)						
wheat	100	100	80	30	10	0
barley	100	90	80	50	20	0
rye	100	90	70	40	10	0
oat	100	80	80	50	20	10
maize	100	70	60	30	0	0
Copper (Cu)						
wheat	100	90	60	20	10	0
barley	100	80	70	40	20	0
rye	100	80	60	30	10	0
oat	100	100	80	60	30	0
maize	100	90	60	50	20	0

In almost all tests with metal concentration of 0.32 mmol per 1 g of soil no seed germination was observed, except barley and rye with zinc and oat with cadmium. Also in some tests with lead and cadmium with concentration of 0.16 mmol no seed germination was observed. Smaller doses of tested metals inhibited germination of seeds to a different degree, but they did not completely eliminate it. Although many reports exist over toxic effect of the heavy metals, relatively small number of publications exist on how heavy metals affect seed physiology. Sethy and Ghosh (2013) summarized the effects of heavy metals (Ni, Pb, Cu, Cd) on seeds of different plants affecting the germination process.

The excess of heavy metals affects not only germination of seeds, but also the early stages of seedlings development. The quality of seedling development can be assessed using biometric measurements. In the present work, many measurements of morphological features have been made. Among them the root length and height of seedlings were considered the most interesting. Root system is the first organ in contact with the different components of the soil. Heavy metals present in the soil inhibit root growth, but to a different extent due to the mechanism of action. The negative effect of heavy metals was observed not only on seed germination and root elongation but also on shoot growth. The latter effect was observed by many authors (Peralta et al., 2001; Moosavi et al., 2012; El Rasafi et al., 2016). Reducing of shoot length was observed also in the present study Shoot length of investigated species decreased with increasing the concentrations of all the heavy metals tested. However, the influence of individual metals varied. Generally, the largest reduction in length even at low doses was observed under the influence of lead. Nickel and copper had the least impact on reducing the length of the shoots. The reaction of individual cereal species under the influence of a given metal was not very different.

The content of chlorophyll is more comparable feature between species than size of seedlings. However, in our studies we found relatively large interspecies discrepancies. For example, the chlorophyll content in the control was the smallest in the barley leaves (815 $\mu g \cdot g^{-1}$ fresh weight), the highest in the leaves of maize (1163 $\mu g \cdot g^{-1}$ fresh weight). Generally, the decline in chlorophyll content in the plants exposed to heavy metals stress is believed to be probably due to: (a) inhibition of important enzymes, such as 6-aminolevulinic acid dehydratase (ALA -dehydratase) (Padmaja et al., 1990) and protochlorophyllide reductase (Van Assche and Clijsters, 1990) associated with chlorophyll biosynthesis; and/or (b) impairment of the supply of Mg^{2+} and Fe^{2+} (Kupper et al., 1996). The decrease in the content of chlorophyll in the leaves of the seedlings of the studied cereal species was most influenced by lead. Nickel and cadmium had a weaker effect although the toxic effects of these metals in plants are mainly revealed by the inhibition of enzymes involved in chlorophyll biosynthesis, which in turn leads to a reduction in the content of photosynthetic dyes in plant cells and limitation of photosynthesis processes. Copper and zinc in the case of the smallest doses used even had a slight stimulating effect. This is in line with the observations of some authors (Kalaikandhan et al., 2014; Samreen et al., 2017). The content of chlorophyll *b* was lower than the level of chlorophyll *a*, what is typical for higher plants. A downward trend in chlorophyll *b* content was similar to that observed for chlorophyll *a*, with the difference that no stimulating effect of small doses of zinc and copper was observed.

Conclusions

The progressing anthropopressure (industry, transport and chemization of agriculture) contribute to the increasing pollution of the natural environment with heavy metals. Mobility and availability of heavy metals in the soil depend on many factors. Excessive accumulation of heavy metals in the soil increases their penetration into plant tissues. This has a negative effect on germination processes, root growth, development of above-ground organs as well as photosynthesis through disturbances in chlorophyll biosynthesis. All of the mentioned phenomena were observed in the presented research. Analysis of data on germination of cereal seeds, development of seedlings and chlorophyll level in leaves leads to the following conclusions:

- increasing level of all metals tested (Pb, Zn, Ni, Cd and Cu) in soil caused unfavorable consequences in seed germination and in seedlings increase at an early stage of development,

- the dose (0.32 mmol of heavy metal · g^{-1} of soil) completely inhibited germination of the seeds of the examined cereal species, except barley and rye with zinc and oat with cadmium. However, in these samples the development of seedlings was too weak to make biometric measurements and chlorophyll analysis,
- among the examined metals, lead had the most negative effect on morphological characteristics,
- all examined metals caused a decrease in the level of chlorophyll. However, the lowest applied doses of zinc and copper caused a slight stimulation of chlorophyll *a* biosynthesis.

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Sustainable production of cellulase by soil bacterium *Sinorhizobium meliloti* using commercial and agroindustrial waste substrates

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Abstract

Cellulases are industrially important enzymes which can convert the most abundant natural polysaccharide - cellulose into glucose, making it as a renewable resource of carbohydrate for the obtaining of bio -based products and bioenergy. The latest trends in microbial cellulase production include the use of various waste products for the microorganism's growth, especially of agroindustrial origin, within the solid-state fermentation (SSF), as a promising technology that can potentially reduce the overall costs. Among soil bacteria, rhizobia are rarely investigated as a cellulase producer. The rhizobial soil bacterium Sinorhizobium meliloti strain 224 was able to grow and express the metabolic activity on the commercial substrate carboxymethyl cellulose (CMC), but also cellulose based waste materials, such as soybean stems and oat dust. The cellulase produced in a liquid medium with commercial substrates, containing 0.1% (w/v) of CMC in yeast mannitol broth and 10% of the inoculum, after 48 h of incubation, at 28 °C, expressed maximum Avicelase activity of 0.077 U/mL. On the other side, the cellulase produced in a medium with waste substrates, containing 1 g of soybean waste with 10% of the inoculum, after 48 h of incubation, at 28 °C, expressed maximum Avicelase activity of 1.295 U/g. The hydrolysis of Avicel indicate a pre-dominant activity of exoglucanases, those produce the glucose, with traces of other soluble sugars, showing that the crude enzyme, produced on waste material using the soil bacteria S. meliloti 224, could be used in eco-friendly processes of cellulose bioconversion and reduction of biological waste.
Key words: cellulase production; waste material utilization; Avicelase activity; rhizobium.

Introduction

The use of plant growth-promoting rhizobacteria (PGPR) in agriculture contribute the development of the plant, by several direct mechanisms, such as nitrogen fixation, or indirectly, by decreasing the potential harmful effects of pathogens, as well as by producing some lytic enzymes, like chitinases, proteases and cellulases. Moreover, cellulases produced by rhizobia species might help in rhizospheric soil decomposition, increasing the availability of nutrient for the plant (Menendez et al., 2015).

Cellulase is a complex of three enzymes: endo-1,4-β-D-glucanase (endoglucanase), exo-1,4-β-D-glucanase (exoglucanase) and β-glucosidase, that hydrolyzes cellulose by its synergistic action on the substrate. Bacterial cellulases are inducible enzymes and they are produced in the presence of cellulosic substrates (pure commercial substrates or residual substrates, such as agroindustrial waste) (Attri and Garg, 2014). Endoglucanases (CMCase) are typically produced by cellulolytic bacteria, while exoglucanases (Avicelase) are essential components of fungal cellulase systems, and limited information on Avicelase from bacterial sources is available (Bronnenmeier, 1991). The most common cellulolytic bacteria belong to the following genera: *Paenibacillus*, *Bacillus*, *Streptomyces, Clostridium Geobacillus* and *Brevibacillus* (Menendez et al., 2015). However, there is an increasing interest in the search for new cellulolytic bacterial strains today. Rhizobia are rarely investigated as a cellulase producer. There are only a few reports about the production of cellusase, specifically CMCase, from the

Rhizobium leguminosarum bv. trifolii, *Sinorhizobium fredii* CCRC 15769 and *Sinorhizobium meliloti* M5N1CS (Michaud, 2002; Chen et al., 2004).

Solid-state fermentation (SSF), instead of liquid fermentation, has become a potential technology for the production of the microbial enzymes and its application offered several advantages, such as simplicity, lower production costs, high enzyme yields and low wastewater output (Sandhya, 2005). Utilization of agroindustrial residues as substrates in SSF processes provides an alternative in the production of enzymes, and also gives value-addition to these otherwise non-utilized residues (Pandey, 2003).

Materials and Methods

Microorganism and inoculum preparation

Working culture of the microorganism was prepared by using of *Sinorhizobium meliloti* strain 224 from the Collection of the Institute of Soil Science (ISS WDCM375-Collection of Bacteria, Institute of Soil Science, Department of Microbiology). The rhizobium was grown in Erlenmeyer flasks containing yeast mannitol broth (YMB) in a rotary shaker (125 rpm), at 28 ° C, for 2 days (Vincen, 1970). This strain was selected according to qualitative test of the growing of bacterial strain on CMC agar plates (per liter: CMC 1 g, yeast extract 3 g, K_2HPO_4 3 g, KH_2PO_4 1 g, $MgSO_4$ 0.5 g and agar 6 g) (Mihajlovski et al., 2016).

Liquid fermentation

Batch experiments were carried out in 100 mL Erlenmeyer flasks which were placed in a translatory shaker at 28 °C. Cellulases were produced by growing of 10% inoculum of the *S. meliloti* 224 in media containing commercial substrat carboxymethyl cellulose (CMC). The experimental parameters those were investigated are as following: the CMC concentration (0.05, 0.1 and 0.2%) and the incubation time (24, 48 and 72 hours). Each batch experiment was done in triplicate and performed under the conditions where one parameter changed while the other parameters were held constant. After predetermined time of incubation, the culture medium was subsequently centrifuged (6000 × g, 15 min) and the cell-free supernatant (enzyme sample) was tested for Avicelase activity.

Solid-state fermentation

All experiments related to the production of the cellulase during the SSF were performed in 100 mL Erlenmeyer flasks with 1 g of substrate. Two types of plant waste materials (soybean stems and oat dust) were used as a substrate for SSF and enzyme production. Before substrate sterilization at 121 °C for 20 min, distillated water was added in ratio 1:4 (w:v). Overnight bacterial culture in a concentration of 10%, which grew in YMB and in a medium with presence of 0.1% of CMC, was inoculated into sterile solid mediums in the thermostat at 28 °C. After 2 days of incubation, 10 mL of 0.1 M tri-sodium citrate buffer (pH 4.8) was added for enzyme extraction. All the samples were filtrated and the liquid aliquot was centrifuged and analyzed as enzyme sample as explained below.

Enzyme assay for cellulase

Cellulase activity was measured according to the method of Miller (1959). Avicelase activity was determined using the following procedure: 500 μL of enzyme solution and 500 μL of 1% (w/v) Avicel solution in 0.1 M tri-sodium citrate buffer (pH 4.80) was mixed and incubated in a rotary shaker at 125 rpm, at 50 °C. After 30 min of incubation 1 mL of DNS reagent was added and the reaction mixture boiled for 5 min, cooled and diluted by adding 5 mL of distilled water. The absorbance was read on the UV/visible spectrophotometer (UV-160A, Shimadzu Corporation, Japan) at 540 nm against a blank (non incubated enzyme). One unit of Avicelase activity was defined as the amount of enzyme that released 1 μmol of glucose equivalents per minute.

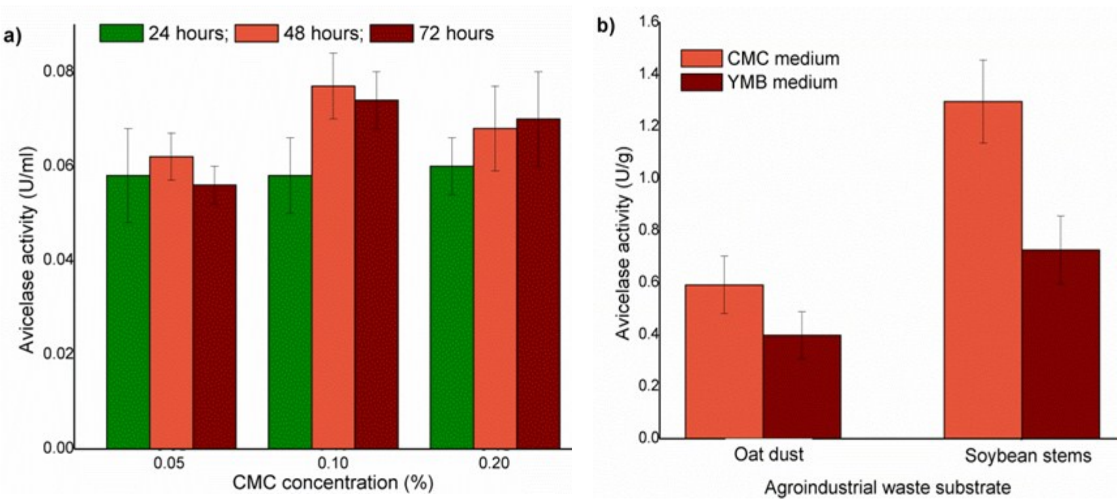
Results and Discussion

Production of cellulase during the liquid fermentation

The effects of the concentration of CMC in liquid growing medium and the time of incubation on cellulase production by rhizobium *S. meliloti* 224 were examined, and the results of obtained Avicelase activities were presented in Fig. 1(a). With the increasing of the time of incubation from 24 to 48 hours, Avicelase activity was increasing as well. That increasing did not appear linear, because after 72 hours of the incubation, the enzyme activity slightly decreased. Similar observations have been noted when it comes to the influence of the CMC concentration on the Avicelase activity. Maximum Avicelase activity of 0.077 U/mL was obtained in a liquid medium containing 0.1% (w/v) of CMC in yeast mannitol broth and 10% of the inoculum, after 48 h of incubation, at 28 °C. Therefore, strain 224 is the first *Sinorhizobium* sp. reported to Avicelase producer and Avicelase activity found in this study cannot be compared to any other *Sinorhizobium* sp. According to the results of other cellulolytic bacteria from soil, Avicelase activity obtained in this study was higher than Avicelase activity produced by *Geobacillus stearothermophilus* and *Bacillus cereus* (Aunsaart, 2015). On the other hand, Avicelase activity of crude enzyme produced by strain 224 was slightly lower than Avicelase activity produced by *Paenibacillus chitinolyticus* CKS1 (Mihajlovski, 2015).

Production of cellulase during the solid-state fermentation

The use of cellulose waste as a substrate, rather than commercial pure cellulose, is a better economically sustainable enzyme production strategy. The results of solid-state fermentation by using of soybean stems and oat dust as cost-effective substrate for cellulase production are presented in **Fig. 1(b)**. The maximum Avicelase activity of 1.295 U/g was obtained with utilization of soybean waste by *S. meliloti* 224 which previously growth in medium with 0.1 % of CMC substrate. This CMC concentration was selected according to the highest obtained Avicelase activity in one factorial experiment previously realized. The success of cellulase production was two times lower when the oat waste was used as an alternative enzyme substrate (0.590 U/g). In addition, a higher Avicelase activity was achieved when the microorganism was previously grown in the CMC medium, than when the rhizobium was grown in the YMB medium. This can be explained by the effect of the bacterial passaging on Avicelase production, where microorganism is forced to use cellulosic material as a source of carbon (Mihajlovski et al., 2016).



Fifure 1. a) Effect of CMC concentration and incubation time on Avicelase activity of crude enzyme of *S.meliloti* 224; b) SSF of two agroindustrial waste by *S.meliloti* 224, which previously grew in the CMC and IMB medium

The hydrolysis of Avicel indicates a pre-dominant activity of exoglucanases. The crude enzyme, produced on soybean waste material using the soil bacterium *S. meliloti* 224, could be used in eco-friendly processes of cellulose bioconversion of agricultural waste materials to useful products, reducing the amount of this waste at the same time.

Acknowledgements

The financial support for this investigation given by the Ministry of Education, Science and Technological Development of the Republic of Serbia under the project TR 31035 and TR 37006 is gratefully acknowledged.

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Evaluation of soil stress related with erosion

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Abstract

Evaluation of soil stress is one of the important parameters of soil management and conservation practices. The objective of this study was to determine stress and deformation in solid media theoretically with the functional relation between stress and strain. For this aim, an analytical expression was determined using time independent equations between stress and deformation to evaluate soil stress after erosion. Soil stress values were calculated for different soil depths using soil particle density values in this expression after erosion process. After erosion process, the vertical surface stress was directly proportional with particle density and soil depth. It was found that change in soil depth was more effective on soil stress than change in particle density. When soil particle density ranged from 2.50 to 2.80 g/cm3, stress in sandy soil with an average Poisson number 0.25 varied from 0.0327 to 0.0366 kPa in 0.20 cm depth, and from 0.8175 to 0.9156 kPa in 0.50 cm depth.

Key words: Soil stress, erosion, rheology, Poisson number.

Introduction

Rheology is a specific discipline which examines the attitudes of objects such as; stress, deformation, elasticity, general flow under load, formation, and time factors. Therefore, some disciplines like hydrodynamic, hydraulic, elasticity, the theory of plasticity and uninterrupted environmental mechanic also depends on the theory of rheology (Burov and Cloetingh, 1997; Qi and Hou, 2006; Burov, 2011; Hart et.al., 2011). The all massive rock shaped crystalline objects in nature transform to soil as a result of external forces. Thus, basic rheology laws can be applied to soil (Vyalov, 1986; Or and Ghezehei, 2002; Markgraf et. al., 2006). In soil rheology, some processes such as; shear, compaction, and deformation are related with irreversible deformation and develop by time.

As a result of external loads on a partially saturated soil component, the liquid between two soil particles relocates, and the contact surface area between the soil particles increases. Increasing contact surface area depends on the deformation of soil components. The determined stress-strain relationship for metal materials cannot define the deformation of the soil components. Stress-strain relationships which are improved for other materials, except metals, can be applied to soil (Prevost and Höeg, 1975; Terzaghi et al., 1996, Richards, 2000). Changes in rheological properties influence on soil physical properties which have a significant importance on soil tillage and development of plant-root system. Optimum soil tillage can be maintained when the less deformation occurred by stress.

While soil depth decreases, rheological properties such as; stress and deformation are changed by the erosion processes. Stress occurred as a result of erosion has a negative effects on optimum level of soil physical properties. Stress formation in soils varies due to potential energies of factors influencing erosion. Soil stress has a great impact on transportation of nutrients, chemicals, water and salts in soils.

In ground mechanic, there are two kinds of equations defining rheological properties especially in soil. While one of these equations expressing stress and deformation is time dependent, the other one is time-independent. Therefore, force variation, which affects on surface of media and depending on time, is not used in the first kind of equation (Koltunov et. al., 1983).The objective of this study is to examine the time independent stress-deformation equation, and to assess the soil stress after erosion theoretically.

Materials and Methods

Quantitative assessment of soil stress process is related with time-independent stress-deformation equation. In the equation, isotropic stress condition, three basic stresses ($\sigma_1, \sigma_2, \sigma_3$) and deformations ($\varepsilon_1, \varepsilon_2, \varepsilon_3$) are considered. To express of soil stress after erosion, stress-deformation equations and soil data, used in evaluation (depth, specific gravity), are the materials of derived analytical expression in this study. Mathematical approximation method is used to derive this expression.
Deformation and stress condition of media (soil) are the factors affecting erosion process significantly. The force acting on unit area and spreading as a result of mutual impact among particles (atoms) express the stress of media. While the perpendicular stress acting on media surface is defined as normal stress, the parallel stress spreading on media surface is defined as shear stress. Mean of normal stress values acting on layers indicates the pressure. Stress occurring in elastic solid media causes deformation. The ratio of change of the initial length of solid media to the initial length defines the normal deformation. Internal friction angle is the measure of the shear strength of soils due to friction. A half of the decrement in the right angle due to deformation defines the shear stress.

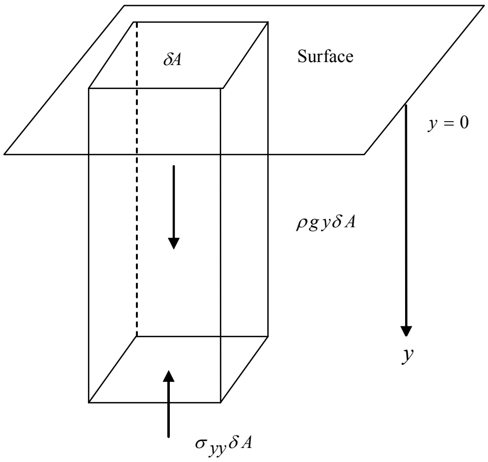

Figure 1. Surface forces and weight influencing vertical column shaped media.

Multiplying gravity force in unit volume (ρg) by cross sectional area (δA) and length (y) of media is equal to the total gravity force ($\rho g y \delta A$) (Figure 1). The force balancing the total gravity force in opposite direction is $\sigma_{yy}\delta A$. In this case, it is assumed that there are not perpendicular forces from horizontal sides, and ρ is a constant. Therefore, $\sigma_{yy} = \rho g y$ which is perpendicular force acting on unit area, expresses normal stress or pressure. This force increases through the depth linearly. Stress and Deformation status in solid media are evaluated according to basic stress ($\sigma_1, \sigma_2, \sigma_3$) and deformation ($\varepsilon_1, \varepsilon_2, \varepsilon_3$) values (Turcotte and Schubert, 1985).

Results and Discussion

Functional Relationship Between Stress and Deformation in Solid Media

If stress and deformation of solid media are linearly depended and mechanical properties are independent from direction, it becomes an elastic solid media which is linear and isotropic. In this media, basic axes of stress and deformation are the same. Time independent expression between stress and deformation related with basic axes in coordinate system is given as below (Turcotte and Schubert, 1985):

$$\sigma_1 = (\lambda + 2G)\varepsilon_1 + \lambda\varepsilon_2 + \lambda\varepsilon_3 \tag{1}$$

$$\sigma_2 = \lambda\varepsilon_1 + (\lambda + 2G)\varepsilon_2 + \lambda\varepsilon_3 \tag{2}$$

$$\sigma_3 = \lambda\varepsilon_1 + \lambda\varepsilon_2 + (\lambda + 2G)\varepsilon_3 \tag{3}$$

where, λ and G elasticity modules of he media or Lame parameters (G is also called as shear parameter). According to linear and isotropic properties of the media, $(\lambda + 2G)\varepsilon$ stress occurs with the effect of ε deformation in the same direction. The other two $\lambda\varepsilon$ stresses occur in the opposite parallel directions.
The deformation elements are obtained from (1)-(3) equations as given below:

$$\varepsilon_1 = \frac{1}{\frac{G(2G+3\lambda)}{G+\lambda}}\sigma_1 - \frac{\frac{\lambda}{2(G+\lambda)}}{\frac{G(2G+3\lambda)}{G+\lambda}}\sigma_2 - \frac{\frac{\lambda}{2(G+\lambda)}}{\frac{G(2G+3\lambda)}{G+\lambda}}\sigma_3 \tag{4}$$

$$\varepsilon_2 = -\frac{\frac{\lambda}{2(G+\lambda)}}{\frac{G(2G+3\lambda)}{G+\lambda}}\sigma_1 + \frac{1}{\frac{G(2G+3\lambda)}{G+\lambda}}\sigma_2 - \frac{\frac{\lambda}{2(G+\lambda)}}{\frac{G(2G+3\lambda)}{G+\lambda}}\sigma_3 \tag{5}$$

$$\varepsilon_3 = -\frac{\frac{\lambda}{2(G+\lambda)}}{\frac{G(2G+3\lambda)}{G+\lambda}}\sigma_1 - \frac{\frac{\lambda}{2(G+\lambda)}}{\frac{G(2G+3\lambda)}{G+\lambda}}\sigma_2 + \frac{1}{\frac{G(2G+3\lambda)}{G+\lambda}}\sigma_3 \tag{6}$$

If it is assumed that $E = \frac{G(2G+3\lambda)}{G+\lambda}$ and $\nu = \frac{\lambda}{2(G+\lambda)}$, equations (4) to (6) can be stated as:

$$\varepsilon_1 = \frac{1}{E}\sigma_1 - \frac{\nu}{E}\sigma_2 - \frac{\nu}{E}\sigma_3 \tag{7}$$

$$\varepsilon_2 = -\frac{\nu}{E}\sigma_1 + \frac{1}{E}\sigma_2 - \frac{\nu}{E}\sigma_3 \tag{8}$$

$$\varepsilon_3 = -\frac{\nu}{E}\sigma_1 - \frac{\nu}{E}\sigma_2 + \frac{1}{E}\sigma_3 \tag{9}$$

where, E and ν are Yung module and Puasson coefficient, respectively and define elastic property of media. E , G and ν values for some materials are given in Table 1.

Table 1. Elasticity values of some materials

Material	ρ, gr/cm^3	E, 10^{11} Pa	G, 10^{11} Pa	ν
Clay	2.1-2.7	0.1-0.3	0.14	
Sand	2.2-2.7	0.1-0.6	0.04-0.3	0.2-0.3
Lime	2.2-2.8	0.6-0.8	0.2-0.3	0.25-0.3
Dolomite	2.2-2.8	0.5-0.9	0.3-0.5	
Marble	2.2-2.8	0.3-0.9	0.2-0.35	0.1-0.4
Basalt	2.95	0.6-08	0.3	0.25
Granite	2.65	0.4-0.7	0.2-0.3	0.1-0.25

If deformation occurs in one direction, one of the deformation elements is different from zero. In this case, $\varepsilon_1 \neq 0$ ($\varepsilon_2 = 0$ ve $\varepsilon_3 = 0$), from the equations (1) to (3), defining the relationship between stress and deformation, the following equations;

$$\sigma_1 = (\lambda + 2G)\varepsilon_1 \tag{10}$$

$$\sigma_2 = \sigma_3 = \lambda\varepsilon_1 = \frac{\lambda}{\lambda + 2G}\sigma_1 \tag{11}$$

from the equations (7) to (9), the following statements;

$$\sigma_2 = \sigma_3 = \frac{\nu}{1-\nu}\sigma_1 \tag{12}$$

$$\sigma_1 = \frac{(1-\nu)E\varepsilon_1}{(1+\nu)(1-2\nu)} \tag{13}$$

are obtained. The relationships between λ, G and ν, E, defining the elastic property of the media (soil) and assessing the changes of soil mechanical properties, are obtained using the statements from (10) to (13) as follows;

$$\lambda = \frac{E\nu}{(1+\nu)(1-2\nu)}; \qquad G = \frac{E}{2(1+\nu)}.$$

Determining Soil Stress in Erosion Process

The deformation equation in one direction can be used in consolidation and erosion which are opposite processes (Jaeger and Gook, 1976; Turcotte and Schubert, 1985). Generally, initial stress condition of soil surface is normal before erosion. Therefore, basic stresses in h depth of soil are stated as $\sigma_1 = \sigma_2 = \sigma_3 = \rho g h$. As a result of erosion, after soil removed from the h soil layer, upward stress becomes $\bar{\sigma}_1 = 0$. In this case, change in upward stress is obtained as $\Delta\sigma_1 = \bar{\sigma}_1 - \sigma_1 = -\upsilon g h$. When $\varepsilon_2 = 0$ and $\varepsilon_3 = 0$, the statement in (12) becomes as follow:

$$\Delta\sigma_2 = \Delta\sigma_3 = \frac{\nu}{1-\nu}\Delta\sigma_1 = -\frac{\nu}{1-\nu}\rho g h.$$

In this case, vertical surface stress after erosion is stated as below:

$$\overline{\sigma}_2 = \overline{\sigma}_3 = \sigma_2 + \Delta\sigma_2 = \rho g h - \frac{\nu}{1-\nu}\rho g h = \left(1 - \frac{\nu}{1-\nu}\right)\rho g h = \frac{1-2\nu}{1-\nu}\rho g h \quad (14)$$

If $\nu = 0.25$ (Table 1), vertical stress values of soil after erosion are calculated for the different values of ρ and h using the statement of (14) and given in Table 2.

As shown in Figure 2, vertical surface stress of soil after erosion is linear with particle density and soil depth. Increment in particle density has a lower effect on stress than increment in soil depth. The stress occurred after erosion causes elasticity in soil and acts negatively soil structural-mechanical properties. Also, the length between connected particles changes due to stress and deformation occurs.

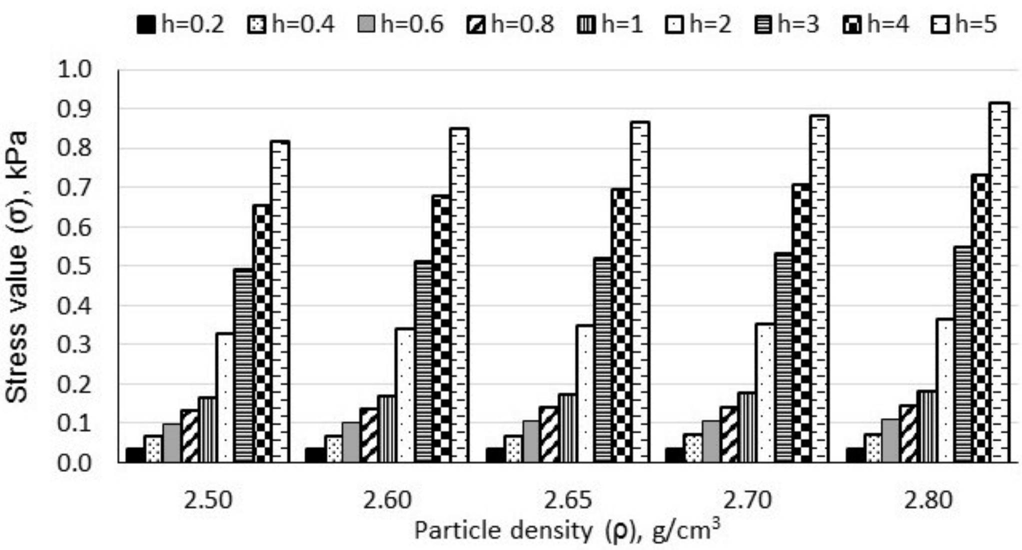

Figure 2. Changes in vertical stress values at different soil depths (h, cm) after erosion (kPa)

Conclusion

Soil temperature and moisture significantly influence on stress-deformation level. Volume deformation in soil may be especially dangerous when the soil is saturated with water due to increasing pore water pressure in a reduced volume size. There is no danger of erosion of the soil particles if the upward force acting on particles is smaller than the downward force by the gravity (Verruijt, 2011). Therefore, if the shear stress in soil surface is greater than the gravity force acting on the soil particles, erosion can occur especially in saturated conditions. To improve the results of this study, other factors acting on stress processes of soil should be considered. Therefore, coming different research disciplines together is important to make many studies in this subject under different soil conditions including cultivation, moisture level, temperature, and other soil properties.

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Microbiological properties in a soil with addition of Philoscia muscorum and wheat straw

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Abstract

Organic matter decomposition is one of the main processes in material cycling and energy transformation in terrestrial ecosystems. Decomposition of organic waste can be substantially affected by the interactions of soil microflora and fauna. Whereas the soil microflora play a primary role in the chemical transformation and mineralization of soil organic matter, soil fauna contribute to litter decomposition by digesting substrates, increasing substrate surface area through fragmentation, and enhancing microbial activity. The effects of earthworms on the distribution of organic matter in the soil profile and on decomposition and carbon sequestration have been well studied, but less is known about effects of other macrofauna including terrestrial isopods. Isopods mainly inhabit the litter layer; by fragmenting leaf litter, they facilitate litter decomposition and nutrient cycling. As a consequence, terrestrial isopods indirectly affect the activity and community composition of the soil microflora. The isopod Philoscia muscorum is a common and abundant member of the saprophagous soil macrofauna in Turkey. The objective of this study was to determine effect of Philoscia muscorum (Isopoda; Philosciidae) on microbial biomass in wheat straw added clay loam soil. The microbial biomasss due to addition of increasing number of Philoscia muscorum into the soil was measured over a short term (four-week) period under laboratory conditions. Incubated microcosms under standard conditions were inoculated with a natural assemblage of Philosciidae species. At the end of the experiment, the soil with a high number of Philoscia muscorum content showed higher microbial biomass than the soil with a low number of Philoscia muscorum content. Philoscia muscorum stimulated soil microbial biomass and altered the response of this biomass with addition of wheat straw into the soil microcosms.
Key words : Soil, isopod, microbial biomass

Introduction

Soil organisms are an integral part of ecological environment and contribute greatly to the disintegration of the plant and animal based wastes, especially in agricultural areas. Morover, they have importants effects on plant nutrition and soil fertility because they are actively involved in the biological processes and sometimes they direct these processes (Bardgett, 2005). The effects of earthworms on the distribution of organic matter in the soil profile and on decomposition and carbon sequestration have been well studied, but less is known about effects of other macrofauna including terrestrial isopods (Lavelle and Spain, 2003; Coleman et al., 2004; Bardgett, 2005). Isopods mainly inhabit the litter layer; by fragmenting leaf litter, they facilitate litter decomposition and nutrient cycling. As a consequence, terrestrial isopods indirectly affect the activity and community composition of the soil microflora. The isopod *Philoscia muscorum* is a common and abundant member of the saprophagous soil macrofauna in Turkey. The objective of this study was to determine effect of *Philoscia muscorum* (Isopoda; Philosciidae) on microbiological properties in wheat straw added clay loam soil.

Materials and Methods

In the experiment the soil (14.45% clay, 42,65% silt, 42,9% sand) which was used as material, has no salt (Electrical conductivity 0.11 dSm^{-1}) little calcareous (5.76 %) and mild acid reaction (pH 6.86).In the experiment wheat straw (Organic material %91.16, N %0.42, P_2O_5 %0.25, K_2O %4.77, C/N 170.05) has been used, and after being dried and groundedit was mixed with the soil (<0,5 mm). Also*Philoscia muscorum* (Isopod; Philosciidae) which was used in the experiment, has been collected from the field of Ondokuz Mayıs University Campus.

Experiment pattern:

On top of 50 gr air-dried soil which was contained within 150 ml glass containers, 10% (5 g) wheat straw has been added. Afterwards, the moisture content of the soil has been moistened with distilled water enough to be at field capacity level. Subsequently, on top of the soils *Philoscia muscorum* has been added in increasing numbers (0, 5, 10, 15 and 20 piece/50gr). The glass containers containing the soil, organic material and *Philoscia muscorum* has been left to incubation (25±2^{o}C) in the laboratory.The experiment established as 3 replications, and formed with 60 glass containers. During incubation, by weighing every day, the diminished water from the soil re-added to the medium, and microbial biomass C content of the soil samples which were taken in 7th, 14th, 21st and 28th days of the incubation has been determined in 3 parrallels as the way reported by Anderson and Domsch (1978). In order to perform the ANOVA test for the results obtained from the experiments and to demonstrate the statistical differences, the LSD test has been performed with SPSS 11.0 statistical software package.

Results and Discussion

The most important function of the soil microflora is to decompose the organic materials.Since this phenomenon is a property of all heterotrophic microorganisms in the soil, it is evaluated as an indicator of microbial activity as well, and accordingly microbial biomass C forms an important parameter used for this purpose. In the experiment, the changes within the microbial biomass C content of the soil which were caused by isopod *Philoscia muscorum* added in increasing numbers to the soil mixed with 10% wheat straw, and their statistical evaluations are given in figure 1.
As it can be seen from Figure 1, it is determined that the isopod *Philoscia muscorum* added in increasing numbers to the soil significantly increases ($P < 0.01$) the microbial biomass C content of the soil, and the said increase prominently emerges as the incubation period increases. Without doubt, this condition shows that the microorganism activity which is primarily responsible from the decomposition and degradation of organic materials in agricultural soil, is not only affected by the soil characteristics, addition of organic materials to the soil and environmental conditions, but also from the macro fauna activity in the soil. Especially, in the event of agricultural pest control influences the macro fauna other than the targeted organism, it is obvious that, this condition not only will disrupt the ecological balance but also will cause to a reduction of microbial activity which is responsible for the decomposition of organic materials in soil. It is particularly determined by the studies conducted that the synthetic pesticides have negative impacts on the population of many organisms other than targetted organisms (Eijsackers, 1981;Akça et al.,2009; Paoletti and Hassall, 1999; Al-Zaidi et al.,2011). However, in recent years, in the fight against the pests which are negatively impacting the yield efficiency and quality in crop production, Azadirachtin like organic pesticides of plant origin are also being used. It is determined that their usage in agriculture, both has a positive impact on the biological properties of the soil and does not adversly affect the activity of isopod Philoscia muscorum (Akça et al., 2006; 2015; Kızılkaya et al. 2012a,b). Similarly, it is thought that promotion of the activity of macro fauna which doesnt has any potential damage on crop production is both provides the increase of soil microorganism activity and also will be crucial in the waste management applied to the soil by promotion of the mechanical decomposition of organic materials by these organisms in the soil.

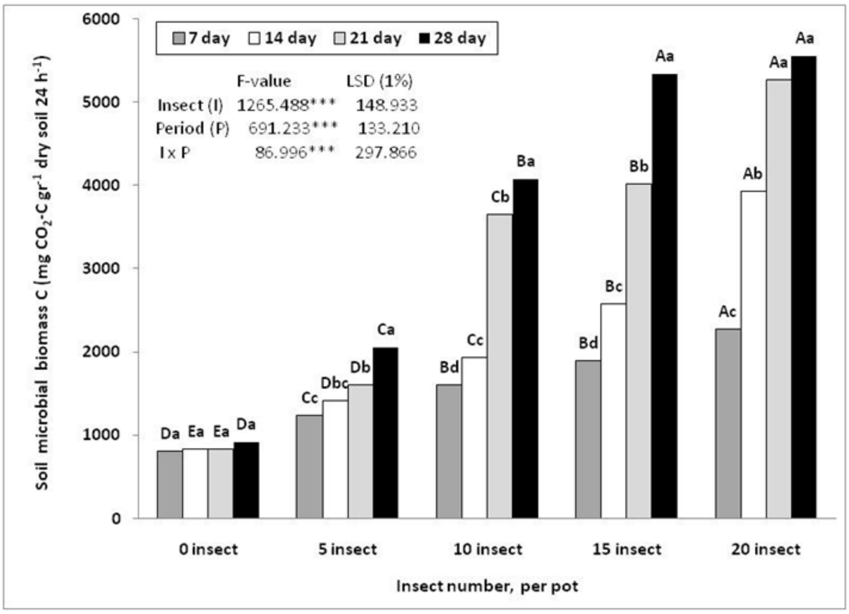

Figure 1. The impact of isopod Philoscia muscorum added in increasing numbers to the soil mixed with 10 % wheat straw, on the microbial biomass C content of the soil

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Adaptation FAO approach and tools on scaling out of SLM to enhance improvement of soil fertility and agricultural productivity of the salt affected landscapes: learning from Decision-Support GEF/FAO SLM project in Uzbekistan

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Abstract

The article shows the results of activities towards mainstreaming and scaling out of best agricultural practices that contribute to conservation and improvement of soil fertility and increase of productivity of irrigated and rain-fed croplands, demonstrated in the framework of global GEF/FAO project "Decision Support for Mainstreaming and Scaling up of Sustainable Land Management" (DS-SLM). The overall goal of the project - to assist the Government in increasing the agricultural productivity of salt affected and drought-prone croplands through promoting SLM best practices based on the FAO LADA, WOCAT technologies and tools. Project team has performed joint efforts to adapt and demonstrate the most acceptable SLM best practices, enhance building capacity of target groups and identify the needs in SLM measures to sustain the productive capacity of fertility declined and salt-affected soils. Knowledge has been obtained through spatial and temporal assessment of DLDD and selection of reliable SLM options that combine the best practices, soil conservation, restoration/reclamation measures and other activities in support of planning and decision-making to ensure resilience against land degradation, soil loss, and climate challenges. The environmental benefits of project demonstrations during 2016-2018 is an follows: (i) increase of vegetative cover by 10-20% through the introduction of secondary and green manure crops and reduction of secondary salinization in the root zone of saline soils; (ii) preventing erosion and sequestration of 4.5 t/ha of carbon in wood based biomass and soil (equivalent to 16.5 tons of CO_2) by planting perennial desert forage plants and creating an almond plantation. As a result of general and expert evaluations, 11 most appropriate SLM technologies were selected and documented for wider scaling out and has been integrated into the WOCAT global knowledge base.
Key words: land degradation, soil health, best practices, technologies and approaches, SLM capacity.

Introduction

The Global Project "Decision Support for Mainstreaming and Scaling up of Sustainable Land Management" was initiated by the FAO with the financial support of the Global Environment Facility to promote resilience against desertification, land degradation and droughts (DLDD) in 15 countries, including the Republic of Uzbekistan. The national project component fully complies with the key strategic directions identified in the recently adopted government decisions and strategic documents [1, 2,4].

The overall goal of the national component of GEF/FAO DS-SLM project is to assist the Government in increasing the agricultural productivity of salt affected and drought-prone croplands through mainstreaming and scaling out of SLM technologies in accordance with the national priorities for enhancing of food security and wellbeing of population. The specific goal of the project is to raising awareness, knowledge, skills and experience of land users, and building capacity to mainstream and scaling up of SLM practices and tools in the project area.

The UZGIP Institute under the coordination of the Ministry of Agriculture and Water Resources in cooperation with the Center for Hydrometeorological Service under the Ministry of Emergency Situations, responsible for coordinating the CACILM program, and the UNCCD National Coordinator is implementing the project. The National Coordination Council of the

CACILM program oversees the implementation of project activities, with the participation of the key ministries, departments, academic institutions, NGO and the local communities.

Materials and Methods

The methodological basis for mainstreaming and scaling out of SLM, developed by the global project team for all country-partners of the FAO DS-SLM project, shown in Figure 1.

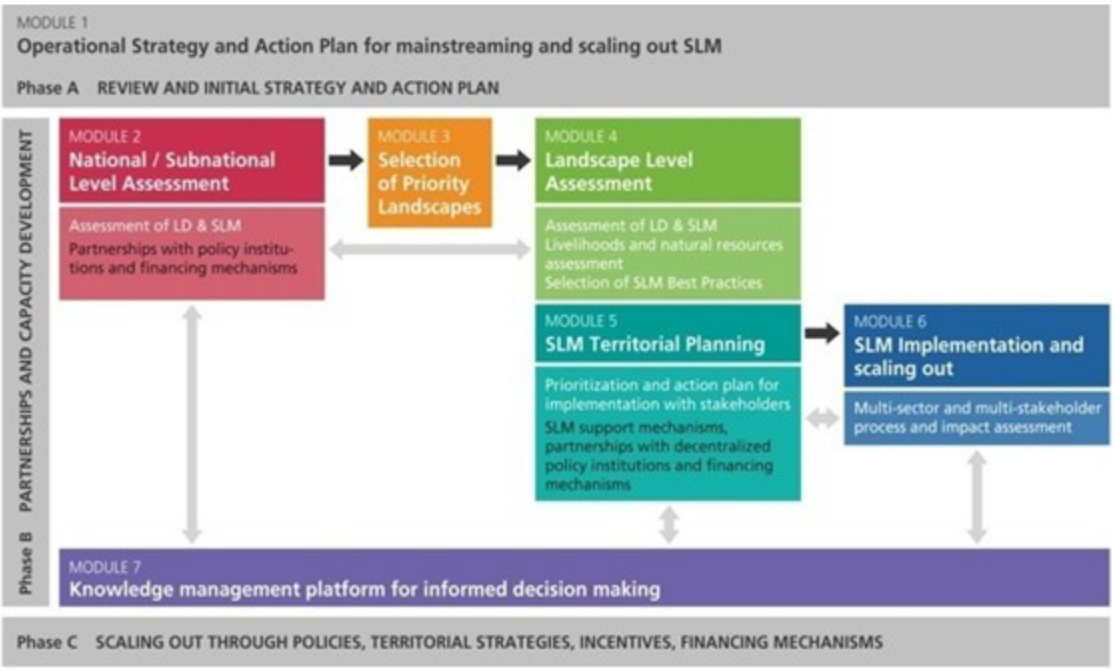

Figure 1. The logical structure of the DS-SLM project [3]

FAO LADA, DPSIR and FAO Farmer Field Schools (FFS) approaches and tools, Participatory Land Use Development (PLUD) and other international guidelines were used to assess the current status of land degradation, impacts, problem analysis and needs for SLM adoption [3,4].

Results and Discussions

Implementation of the DS-SLM project activities in Uzbekistan was started in the 2015-2016 as a development of baseline information on land degradation and SLM activities at local and sub-national level. Selected project area is located in the foothill zone of the semi-desert province and covers: (i) saline irrigated lands in Zarbdar district of the Djizzak province; and (ii) drought-prone eroded rainfed croplands in Kamashi district of the Kashkadarya province. The results of the field survey in project area showed that about 80% of irrigated soils in Zarbdar district suffer from secondary salinization and loss of soil humus, over 45% of the rainfed croplands of Kamashi district is the fertility-decline eroded soils, 38.7% out of which is heavily eroded.

Demonstration of SLM Technologies. Within selected project area in Zarbdar and Kamashi districts identified two project demonstration sites (DS) based on the FAO and CACILM criteria. The following four SLM technologies were demonstrated in the DSs:

Irrigated DS:	2016			2017		2018
1. Crops diversification with introduction of legumes and green manures on salt affected soils	winter wheat	mung beans	Green manure crops (winter rye)	cotton	winter wheat	mung beans
2. Introduction of new drought and salt tolerant «Gulistan» cotton variety	«Gulistan» cotton variety					
Rainfed DS:						
3. Planting of almonds on small terraces to increase productivity of eroded soils in rainfed landscapes	Almonds on small terraces					
4. Cultivation of desert drought-resistant crops on rainfed lands for reduces of soil erosion and provision of fodder production growth	Crops: *Kochia prostrata, Ceratoides ewersmanniana, Halothamus subaphylla, Onobrychis horossanica*					

The results of demonstrations during 2016-2018 showed a positive effect on the soil health and productivity of agricultural croplands. The yield of the new salt-tolerant variety of cotton "Gulistan" was 3.2 t/ha, almost 2 times higher than the yield on the farm field (1.8 t/ha). Diversification of crops with introduction of secondary crops (legume, winter rye) contributed to improve soil properties and additional harvest mung beans in the amount of the 0.7 t/ha that increasing of farmer income by 4 million UZS per hectare. The total area under the green hail in 2017 was 2,400 hectares, the next 2019 is planned to increase the area under the beans to 10,000 hectares.

Evaluation, documentation and mapping of SLM options. Based on available national and international sources, a general list of best practices was compiled and database of 60 SLM technologies was formed, of which 29 were selected for detailed economic evaluation. Consultations and expert meetings were initiated to select the most suitable technologies, and the National SLM Delivery Capacity Building Workshop was conducted, involving the key scientific and project institutions, NGOs, projects and international organizations. As a result of general and group discussions, 11 most appropriate technologies were selected for scaling out and integration into the WOCAT global knowledge base [4].

Based on biophysical and ecological-economic indicators and assessment of the soil conditions, a zoning of the project area in Djizzak and Kashkadarya provinces has been carried out in relation to the needs in SLM technologies. GIS mapping of SLM options for each soil polygon, including a combination of technologies and soil conservation, restoration/reclamation activities, their costs and investment needs, has been done to assist in planning and decision-making at local and sub-national level. Scheme of SLM options development is given in Figure 2.

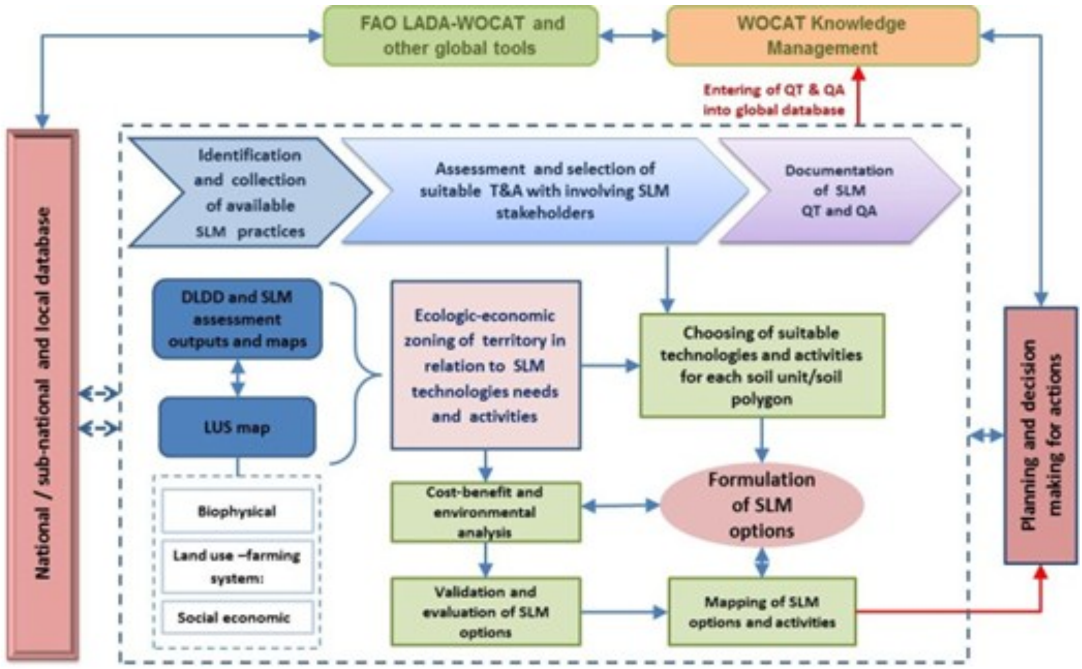

Figure 2. Scheme of SLM Options Development

Capacity building for SLM scaling out. The capacity-building program for scaling out of SLM technologies on a wider landscape, was carried out based on FAO LADA approaches and tools (FFS, PLUD) for main target groups at all levels. 740 people, including 200 women have been involved to the SLM scaling out activities: 216 stakeholder groups participated in the FFS, over 384 people, including WCA members and 4 rural communities, took part in workshops and trainings on PLUD (Participatory Land Use Development), etc. [4]. Local communities discussed and proposed best practices and technologies, including traditional methods for rainwater harvesting, formulated local strategies to prevent land degradation and implement SLM in land-use planning at the local level.

The overall environmental benefits of project demonstrations include: (i) increase of vegetative cover by 10-20% through the introduction of secondary and green manure crops and reduction of secondary salinization in the root zone of saline soils; (ii) preventing erosion and sequestration of 4.5 t/ha of carbon in wood based biomass and soil (equivalent to 16.5 tons of CO_2) by planting perennial desert forage plants and creating an almond plantation on small rain-fed terraces.

The results and experience gained from the SLM scaling out project, clearly demonstrated the high efficiency and significance: iii) the expansion of investments and SLM policies to improve soil fertility and health, (ii) capacity building for planning and decision-making on SLM at all levels.

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Existing condition of the soil resources in the Republic of Khakasia

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Key words: Climate, soil, fertility, agricultural land, productivity, degradation.

Introduction

The problem of the rational usage of soil resources in the Republic of Khakasia is very actual due to increasing agricultural significance and following from it goals to improve soil fertility and its conservation. Modern condition of soil resources was considerably reversed due to soil degradation both in the period of mass reclamation of virgin and fallow soils (1955-1965) and during the intensive development of agriculture (1970-1985). All that led to widespread soil drifting, erosion, salinization. That decreased the productivity of agricultural land and caused its withdrawal from circulation, had a negative effect on the social and economic living conditions of the population of the region. The area of agricultural land was reduced as a result of flooding it by the reservoir of the Krasnoyarsk Hydroelectric power Station as well as the result of turning it into coal mining industries, industrial objects and house building.

Materials and Methods

The Republic of Khakasia located on the south of the Central Siberia on the left bank of upstream and downstream of the Yenisei is a part of the Altay and Sayans mountainous region and it occupies a large part of the Minusinsk Hollow. Its area forms 61,6 thousand km^2 (0,4% of the territory of the Russian Federation) and stretches in the meridian direction between 51^{o}20' N and 55^{o}27' N latitude. Natural-historical conditions of Khakasia (geologic and geomorphologic structure, climate, vegetation, soils) are so peculiar that this small area is considered to be an original and quite separate object of research. Climate is characterized by strongly pronounced continentality, cold long-lasting dry winter (5 months), short hot summer, dry windy spring and wide temperature and rainfall changes. The perspective of using soil resources is in some degree associated with the tendency of global warming. In the territory of the Republic in the period from 1941 to 2000 there was increase of annual air temperature by 0,02^{o}C in the woodlands and by 0,04 ^{o}C in the steppe [3]. On the whole climate has grown warm by 1,2^o C during 60 years. On the one hand, it is a rather positive factor of increase of regional bioclimatic capacity, on the other hand, these changes are followed by the growing risk of some negative features (aestival droughts, extreme temperature changes, frequent winter thaws). Soil droughts are the most dangerous for growing crops, during the last ten years (2002-2012) their frequency was increased in the dry steppe zone in comparison with the period of 1993-2001: in May by 54,5%, in June by 45,4%, in July by 27,3% [8], it limits there the possibility to lead effective bogharic agriculture, the aims of managing the productivity of agrocenosis and the soil fertility are becoming essentially more complicated.
The comparative analysis of soil conditions is based on the materials the Station of Agrochemical Service «Khakasskaya» concerning the soil survey of agricultural lands, the Khakas Republic National Environmental report, the results of multi-year research (2001-2016) of the Research Institute of Agricultural problems of Khakasia on the productivity changes of fallow lands and and long-used in the arable land.

Results and Discussion

According to the data of the State statistical reporting, soil resources of Khakasia form 6156,9 thousand ha, 1883,6 thousand ha of which are agricultural lands. Most part of the territory is occupied with the land of the forest resources (59,4 %) and 10 % are all the rest lands (residential area – 1,1; industry, transport – 0,8; water resources – 1,0; nature conservation area – 4,1; land reserve – 3,0 %) [2].

Mountain landscapes with close bedding and dense rock exposure dominate in Khakasia, there are more mountain tundra gleysolic soils, mountain taiga soddy podzolic and brown forest soils. Much less area is occupied with more favorable soils of steppe and forest-steppe cultivated land. Black soils, chestnut soils and immature soils prevail in the structure of soil cover of the agricultural land while in arable land black soils (79,6%) and chestnut soils (13,6%) also prevail, while other soil types occupy only 6,8 % (Table 1).

Table 1. Structure of soil cover of the agricultural land in Khakasia [10]

Types of soils	Proportion of total area, %	
	Agricultural land	Arable land
Grey forest	3,9	0,8
Humus-carbonate	1,1	0,8
Black soils	59,1	79,6
including: podzolized	0,5	0,2
degraded	6,0	7,0
plain	36,2	51,8
southern	16,4	20,6
Chestnut	12,1	13,6
Meadow black soil	2,5	1,4
Meadow chestnut	0,7	0,6
Meadow	1,1	0,5
Marshy	1,3	-
Saline	1,0	0,1
Solonetzic	1,7	0,5
Alluvion	4,5	1,9
Immature	10,6	-
Other types	0,4	0,2
Total	100	100

The area of agricultural land has decreased by 0,9 thousand ha when comparing it only with the data of 2015 because of using the land for natural resources development. Currently there are 115 mining enterprises, intensive coalfield development by surface mining operations is observed in the central and southern parts of Khakasia. The area of disturbed agricultural land as a result of coal mining is still small, however, under these conditions the soils are completely destroyed and it is impossible to restore them even with the help of the intensive recultivation. Neighboring rangelands are polluted and the quality of soil cover is decreased.

The total area of arable land as for 01.01.2017 forms 650,6 thousand ha [2], while the cultivated area of agricultural crops is by 2.3 times less (268 thousand ha). Under conditions of the country's economic downturn (1990-2002) not only degraded but also a few fertile lands were withdrawn from the rotation, a particular harm was done to previously reclaimed land. 50 thousand ha were irrigated in the past, currently 3 thousand ha of which are used as private housing constructions and only small area is irrigated (5 thousand ha). One of the most successful way of agricultural production development in Khakasia and receiving necessary agricultural products, from a historical perspective, was irrigation, when soil and thermal resources of steppe were optimally used allowing to increase the productivity of irrigated crops more than by 2-4 times [5]. Reducing arable lands has its own positive and negative consequences. Filling up with natural vegetation from ecological point of view is a positive effect leading to restoring of soil productivity while in the land legislation it is definitely considered as improper use or even as waste. The study of uneven-aged fallow lands shows an ecologically and economically positive role of fallow lands, in particular, in restoring the productivity and storing organic carbon [6]. Vegetation cover can turn into virgin land on average for 25-30 years, and restoring the productivity takes considerably longer periods and depends on the soil degradation factor [4; 7]. The value of soil resources decreased significantly as a consequence of blowing and water erosion. Erosion processes are tragically caused by heavy rain or prolonged rainfall of rare frequency

On the steppe slopes the erosion range changes from 0,07 to 0,48 mm a year or 0,7-4,8 tons per ha under conditions of low erosion-resisting potential of soil and thinned grass stand and depending on the slope characteristics. Truncation is not always compensated by the soil formation. 34% of agricultural lands, 5,6 % of arable lands suffer to different extents from blowing erosion. Stony agricultural lands occupy most part (22%) and 16 % are arable lands. Combined revealing of blowing and water erosion on the arable land is 20%, salinization – 10%. According to the data of the Station of Agrochemical Service «Khakasskaya» for the period from 1970 to 2009 in the dynamics of organic matter the area with low humus supply has increased. Annual loss of humus supply on the arable lands, for the Republic as a whole, forms 1,1 tons per ha, since 2005-2016 humus content has become stable at 4,6-4,7%. It is necessary to mark that the balance of nutritional elements stays in a long-lasting negative condition [2].

Appearance of zonal soils on the arable lands has obviously changed, the area of secondary carbonated black soils and chestnut soils has increased. Eroded soils are abundant, some part of arable lands is on the shallow stony soils. Currently, widespread soil drifting is almost stopped after excluding arable lands, which were spontaneously preserved, from rotation by the beginning of XX century. The pervasive reduction of sheep population (5-6 times) and also some part of cattle and horses contributed to the full stop of erosion processes. Current state of steppe pasture and stocks of fodder in the natural ecosystem proves that the increasing of sheep population in Khakasia is again reasonable.

Only rare local cases of erosion process are observed on the used arable land in case land owners violate the techniques of soil conservation and cropping. In spite of the reduction of the anthropogenous causes of revealing soil erosions, edaphoclimatic factors have left and can bring new soil drifting and erosion in case of irrational land usage [9].

So the variety of natural conditions in the Republic with relatively small area for agricultural purposes requires differential, thoughtful and caring usage of soil resources, paying constant attention to such issues as soil conservation and increasing of soil fertility. To support economical stability in the Republic under conditions of climate change it is necessary to restore irrigation farming and develop bogharic agriculture – in the favorable climate conditions of forest steppe and piedmount of steppe, with high and medium potential of black soils fertility.

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Impact of biochar application on soil microbiological attributes under corn plant culture subjected to water deficit stress

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Abstract

Biochar as a stable carbon source can affect soil properties including microbiological attributes. The effects of biochar may also be influenced by plant growth and water deficit stress. In a greenhouse study, the biochar at three levels of 0, 1 and 2% w/w was thoroughly mixed with soil. Half of pots were planted with corn seeds (*Zea mays* L. Single Cross 704) and the rest were left un-cultured. Soil moisture levels of 80-90% FC (S0), 60-70% FC (S1) and 40-50% Fc (S2) were applied to the pots by daily weighing and watering. After two months, the soil basal and substrate induced respirations (BS and SIR), microbial biomass carbon, nitrogen and phosphorus (MBC, MBN and MBP) were determined. Metabolic and microbial quotients (q_{CO2} and q_{mic}) were also calculated as microbial eco-physiologic indices. The BS in un-cultured pots was markedly enhanced by increasing biochar level but there was no alteration in cultured pots with increasing biochar level, although the BS was higher in cultured than un-cultured pot at comparable biochar levels. SIR was adversely affected by increasing water deficit stress in un-cultured pots, but it was not affected in cultured pots. At soil moisture levels of S0 and S1 the addition of biochar caused an increase in MBC. Biochar levels had no significant effects on MBN at S0 and S1 but a marked increase in MBN was recorded at S2 with 2% biochar amendment. MBP was not affected by water deficit stress or biochar addition. q_{CO2} tended to increase by increasing water deficit stress but biochar at 1% level alleviated this index at all moisture levels. Both biochar levels of 1 and 2% exhibited positive effects on q_{mic} at S0 and S1, but biochar levels had no pronounced impact on q_{mic} at S2.

Key words: Biochar, Metabolic quotient, Microbial biomass carbon, Soil respiration.

Introduction

Biochar as an organic amendment improves soil fertility by its high surface area which acts as of source of nutrients (Ogawa et al. 2006). Sohi et al. (2010) reported that biochar application in Brazilian soils led to increase in soil organic matter and nutrients (P, N, K and Ca) availability and a marked increase in crop yield. The higher porosity of biochar enhances its water holding capacity and could help plants under water deficit stress (Xu et al. 2012).

Besides influencing carbon sequestration, biochar through its high surface area and porosity can support microbial establishment. Type of raw materials and the temperature of pyrolysis can affect chemical properties of biochar surface (Ahmad et al. 2014). Therefore, depending on biochar production process, it may exerts positive, negative or neutral effects on microbial establishment. Biochar with free phenolic compounds is not suitable for microbial activity. Particle size and the ratio of macro to micro-porosity of biochar are important parameters affecting microbial establishment (Jaafar et al. 2015b). Freshly prepared biochar usually increases soil microbial biomass due to its labile carbon. Ahmad et al. (2016b) pointed out that biochar prepared at 300 °C had pronounced effects on soil microbial biomass (SMB) but the biochar produced with same raw materials at 700 °C showed no significant effect on SMB. Soil microbial respiration might be enhanced by addition of biochar due to increasing readily available carbon and/or improvement of soil aeration, although there are evidences indicating that biochar has no significant effect on soil respiration (Lu et al. 2014; Liu et al. 2016b).

Soil water holding capacity may also be influenced by biochar addition. Liu et al. (2016a) reported that biochar amendment could improve water holding capacity in soils with lower organic carbon. Thus, the positive effect of biochar on WHC is much obvious in sandy than clayey soils (Mulcahy et al. 2013; Dugan et al. 2010). Although, Wang et al. (2014) stated out that the impact of biochar on soil WHC, mainly depends on soil particle size distribution and characteristics of biochar surfaces.

This study was aimed to assess the effects of biochar amendment on soil microbial properties under water deficit conditions in the presence or absence of corn plant growth.

Materials and Methods

Biochar production and analysis

Pruned materials of poplar tree were oven dried at 105 °C for 24 h and heated at 400 °C for 70 min under very low oxygen conditions. They then soaked in distilled water for 24 h at room temperature to remove soluble salts. Biochar particles were oven dried at 50 °C for five days, then grounded and passed through 1mm sieve. Ash percent, water holding capacity (WHC), pH and EC were determined as per described by Song and Guo (2012). The frequency of functional groups using FTIR (Fourier transform infrared spectroscopy) method (He et al. 2014) and elemental analysis using CHN analyzer (Melo et al. 2013) were measured (Table 1).

Soil preparation

A loamy sand soil was air dried and passed through 4.7 mm sieve for pot culture experiment. A subsample of soil was sieved (<2mm) and analyzed for some physical and chemical properties as per standard methods (Table 2).

Pot culture experiment

All pots filled with 4 kg soil and and biochar was added at rates of 0, 1 and 2% w/w (B0, B1 and B2, respectively). Soil moisture levels of 80-90, 60-70 and 40-50% FC (S0, S1 and S2, respectively) were applied to the pots by daily weighing and watering. Half of pots were planted with corn (*Zea mays* L. cv. Single Cross 704) at 4 seeds per pot and the rest were left un-planted. Pots were kept under greenhouse conditions for two months. At the end of experiment, soil basal and substrate induced respirations (BR and SIR), microbial biomass carbon, nitrogen and phosphorus (MBC, MBN and MBP, respectively) were measured as biological attributes. Metabolic and microbial quotients (q_{CO2}, q_{mic}) were calculated as microbial ecophysiologic indices (Schinner et al. 1996). The experiment was carried out as a factorial completely randomized design with three replications.

Results and Discussion

Chemical and physical characteristics of soil, biochar and raw materials are shown in Tables 1&2. The biochar has high WHC and C/N and is relatively alkaline. The lower H/C (0.03) is indicating its higher aromaticity and relatively higher stability.

Table 1. Some chemical and physical properties of soil used in this study

Chemical properties		Physical properties	
pH	7.64	Clay (%)	7.31
EC (dS/m)	1.8	Sand (%)	86.60
Total N (%)	0.02	Silt (%)	6.09
OC (%)	0.2	Soil texture	Loamy sand
K (mg/kg)	198	FC (%, w/w)	20
P(mg/kg)	7.4		
Fe (mg/kg)	0.75		
Zn (mg/kg)	0.58		
Cu (mg/kg)	0.09		
Mn (mg/kg)	2.43		

K, by ammonium acetate (1N, pH7); P, by sodium bicarbonate (0.5M, pH 8.5); Fe, Zn, Cu and Mn (DTPA extractable).

Table 2. Characteristics of biochar and raw material used in this study

	Biochar	Raw material		Biochar	Raw material
pH (1:5)	8.90	-	H (%)	1.92	7.01
EC (1:5, dS/m)	1.10	-	O (%)	5.15	47.09
WHC* (%, w/w)	125.68	-	C/N	82.77	65.33
Ash (%)	26.16	-	O/C	0.08	1.04
Yield (%)	30.60	-	H/C	0.03	0.15
C (%)	65.97	45.21	*C_b/C_f	1.46	-
N (%)	0.797	0.692			

*WHC, water holding capacity; $C_{b,}$ carbon of biochar; $C_{f,}$ carbon of raw material.

The FTIR analysis of biochar produced in this study indicated that it has many functional groups including aromatic, aliphatic, carbonyl, carboxyl, hydroxyl, ketone, ester and anhydrides (Figure 1).

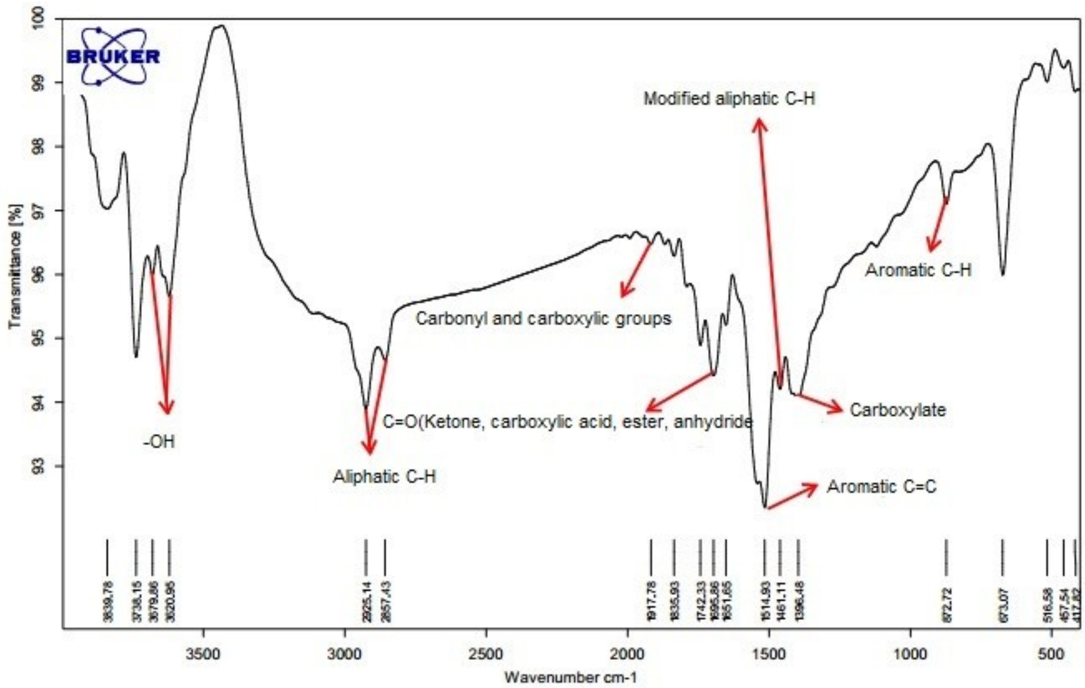

Figure 1. FTIR spectrum of biochar produced in this study

The basal respiration in un-cultured soil tends to increase by increasing biochar level while in cultured pots, a slightly decrease in BR is seen by increasing biochar level. However, the BR is higher in cultured than un-cultured pots at all biochar levels (Figure 2). In the presence of alive roots, the labile carbon is more than un-cultured conditions which led to higher microbial respiration. The increment of soil respiration by increasing biochar level under unculture conditions may be due to presence of phenolic compounds in biochar which promote respiration in microbes. Microbial cells usually consume more carbon to their maintenance when they subjected to the toxic compounds (Liu et al. 2016b).

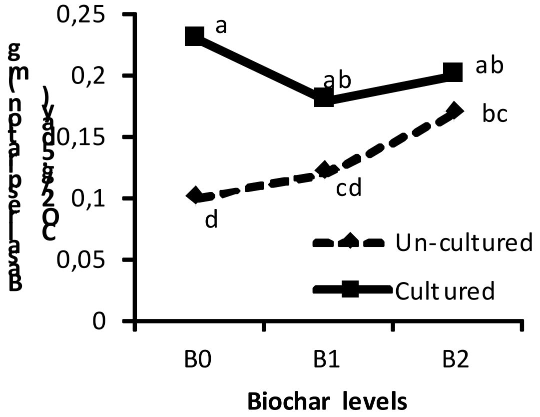

Figure 2. Effects of biochar levels and plant culture on soil basal respiration

Substrate induced respiration was enhanced by increasing biochar levels, although the highest SIR was achieved at B1 level (Figure 3).

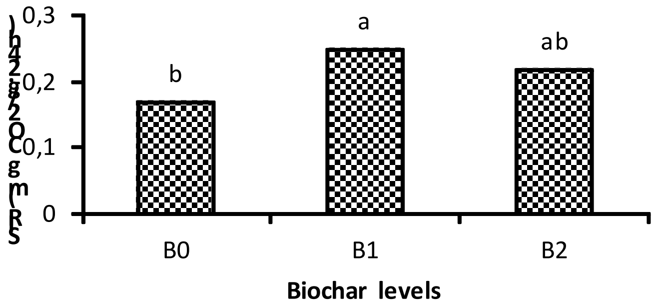

Figure 3. Effects of biochar levels on substrate induced respiration (SIR)

Soil water deficit stress caused a marked decline in SIR under un-cultured conditions, but there was no significant reduction in SIR by increasing water deficit stress under cultured conditions. At soil moisture level of S0 there was no difference in SIR between cultured and un-cultured treatments (Figure 4). SIR as an index of soil active microbial community, decreases by increasing water deficit stress. It seems that lower water content in soil inhibits microbial activity, especially under un-cultured conditions, however the presence of alive roots and their metabolites could support microbial activity even in water stress conditions.

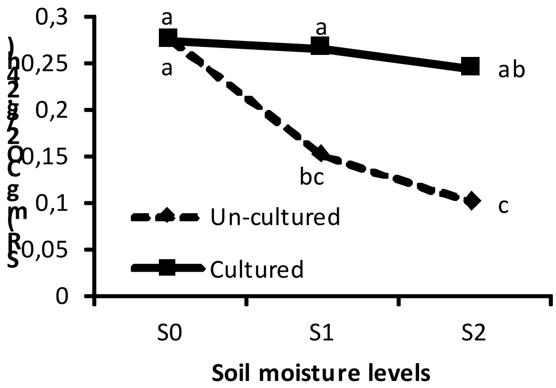

Figure 4. Effects of soil moisture levels and plant culture on substrate induced respiration

Microbial biomass carbon was slightly increased by increment of biochar level in cultured pots, although it was not statistically significant. Under un-cultured conditions, MBC showed an increase from B0 to B1, while a decline was seen from B1 to B2. At biochar level of B2, the MBC was significantly higher in cultured than un-cultured pots (Figure 5). Although MBC was not significantly changed by increasing biochar level but the statistically difference between cultured and un-cultured treatments at B2 level could be explained by toxic effects of phenolic compounds in biochar. The lower H/C (0.03) in biochar produced in this study (Table 2) can explain the higher aromaticity of this biochar (Sohi et al. 2010). However, this adverse effect of biochar on MBC has been alleviated by plant culture (Figure 5).

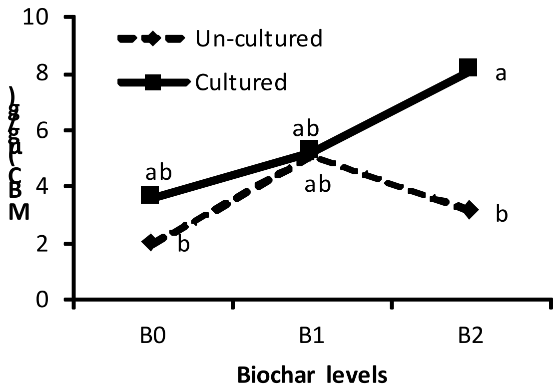

Figure 5. Effects of biochar levels and plant culture on microbial biomass carbon (MBC)

At biochar level of B0, water deficit stress caused a slightly increase in MBC, while at B1 level, the MBC decreased by declining soil water, although it was not statistically significant. A different bihavior was seen at B2 level for MBC and it reached the highest value at soil moisture level of S1 and then significantly decreased by increasing water deficit stress to S2 (Figure 6). The relatively higher MBC in S0B1 and S1B2 treatments can be contributed to the presence of labile carbon in biochar, but the sever water deficit stress at S2 level inhibits microbial growth at all levels of biochar.

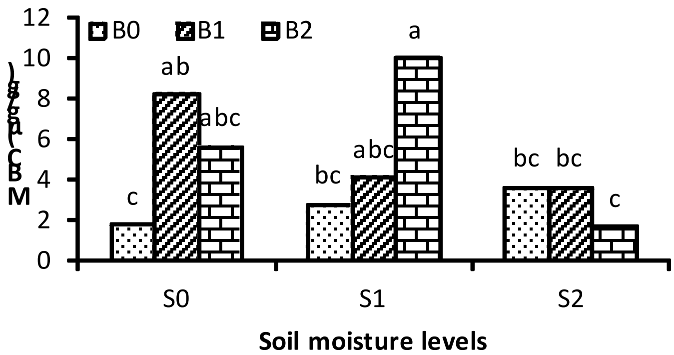

Figure 6. Effects of biochar and soil moisture levels on microbial biomass carbon (MBC)

Microbial biomass nitrogen (MBN) was not affected by biochar levels under soil water conditions of S0 and S1 but it was significantly declined at S2 in both B0 and B1 levels. However, the biochar level of B2 caused a marked increase of MBN under sever water deficit (S2) conditions (Figure 7). It seems that the higher microbial respiration in S2B2 treatment (using maintenance carbon) led to declining of C/N ratio which in turn causes an increase in MBN.

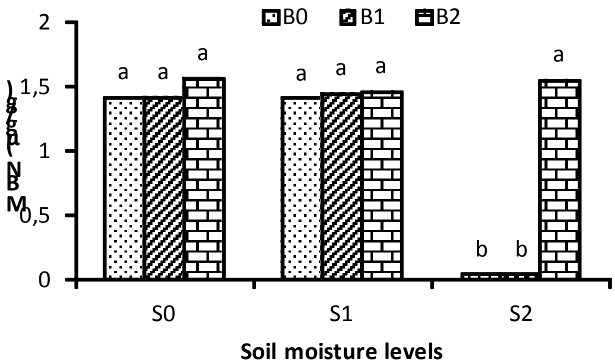

Figure 7. Effects of biochar and soil moisture levels on microbial biomass nitrogen (MBN)

The interaction effects of plant culture with biochar or soil moisture levels were not significant on MBN and MBP. However, both MBN and MBP were significantly higher in cultured than un-cultured treatments (Figure 8). It is obvious that root exudates and depositions can support microbial growth, hence a significant increase of MBN and MBP is seen in cultured compared to the un-cultured conditions.

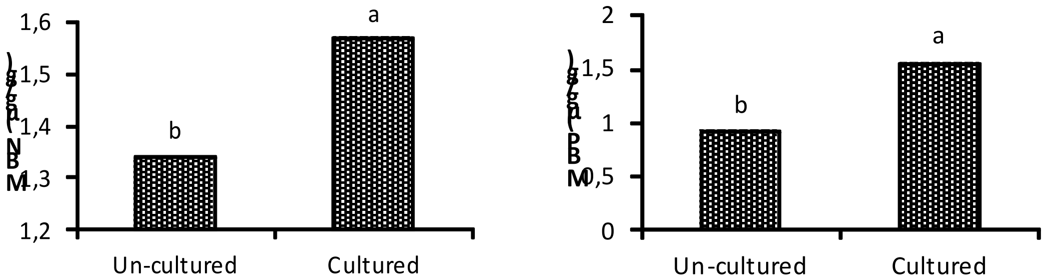

Figure 8. Effects of plant culture on microbial biomass nitrogen (MBN) and phosphorus (MBP)

Microbial quotient (q_{mic}) in cultured pots was more than un-cultured ones at all biochar levels. A marked decrease in q_{mic} was seen with increasing biochar level from B1 to B2, although it was increased at B1 compared to B0 (Figure 9). As discussed above, the non-significant reduction in q_{mic} at B2 level can be explained by inhibitory effects of toxic compounds which clearly appears at high levels of biochar.

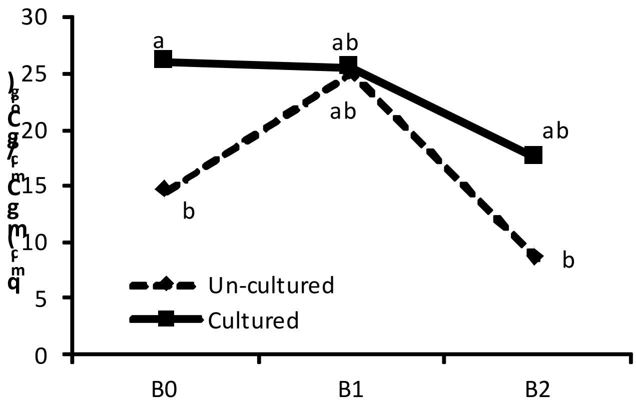

Figure 9. Effects of biochar levels and plant culture on microbial quotient (q_{mic})

There was no significant change in q_{mic} by increasing water deficit stress at B0 and B1 levels, although a slightly decrease was recorded by declining soil moisture content at B1. The trend in B2 level was different and the highest q_{mic} was recorded at soil moisture level of S1, thereafter a significant decrease in q_{mic} was occurred by increasing water deficit stress to S2 (Figure 10). q_{mic} is directly estimated from MBC, therefore the alteration pattern of q_{mic} as a result of biochar application and soil moisture levels is same as MBC which addressed above.

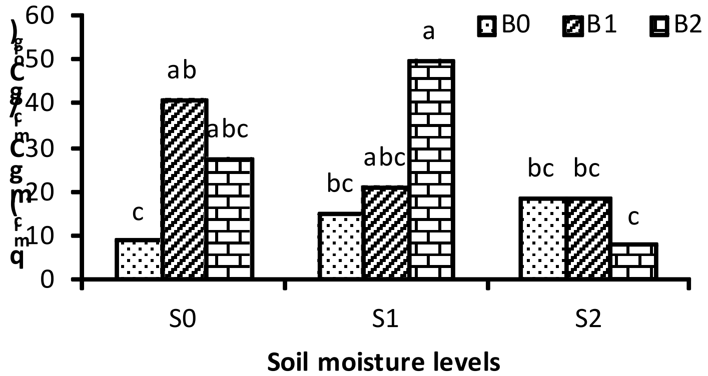

Figure 10. Effects of biochar and soil moisture levels on microbial quotient (q_{mic})

Metabolic quotient (q_{CO2}) was not changed from B0 to B1 in both cultured and un-cultured treatments, but it markedly enhanced by increasing biochar level from B1 to B2 and the increase was statistically significant under un-cultured conditions. However, the q_{CO2} was lower in cultured than un-cultured pots at B2 level (Figure 11).

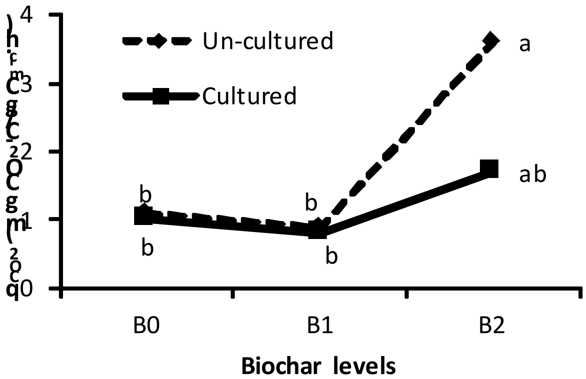

Figure 11. Effects of biochar and plant culture on metabolic quotient (q_{CO2}).

Increasing of soil water deficit stress caused an enhancement of q_{CO2} at all biochar levels, although the increase was significant in B2 by increasing water stress from S1 to S2 (Figure 12). q_{CO2} as a microbial eco-physiologic index is usually used for illustration of stress condition in microbial communities (Schinner et al. 1996). Both increasing of phenolic compounds with increasing biochar levels and reduction of soil moisture level, accelerate stress conditions for soil microbial community which in turn cause higher respiration as discussed above for basal respiration, hence a marked increase is seen at higher levels of biochar and water deficit stress conditions.

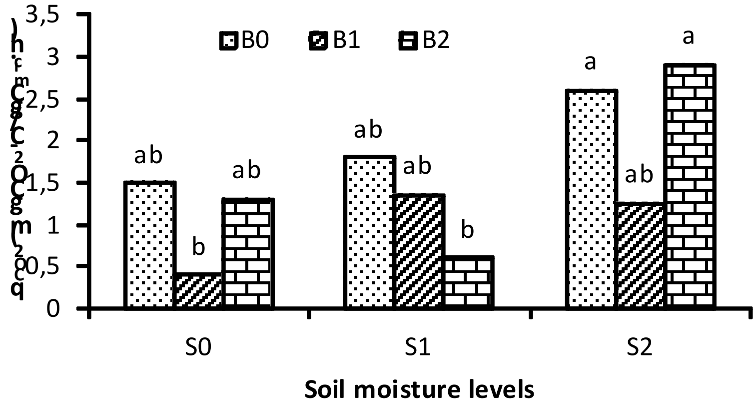

Figure 12. Effects of biochar and soil moisture levels on metabolic quotient (q_{CO2})

Acknowledgements

Financial support by the Research Affairs of the University of Tabriz is gratefully acknowledged.

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Assessment of soil quality index for rice cultivated soils based on standard scoring functions and weight assignment approach

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Abstract

Rice is an important food crop across the world. However, rice ecosystems are currently faced with numerous issues, such as unsuitable soil and land conditions, water scarcity, biotic and environmental stresses, and inefficient agronomical practices, which result in low returns from rice production. In order to increase rice production by developing sustainable management practices, it is quite important to try understanding of soil quality for rice cultivation. The aim of this study was to determine soil quality by using Integrated Soil Quality Index (SQIw) model based on standard scoring functions and weight assignment approach in agricultural lands used for rice cultivation in Çarşamba Deltaic Plain located on central Black Sea Region of Turkey. A total of fourteen soil quality parameters based on the key predictor variables that determine rice yield mentioned in relevant literatures were included in SQIw model by grouping in three classes which are; i-physical indicators (hydraulic conductivity, bulk density, available eater capacity and percentage of sand, silty and clay), ii-chemical indicators (soil reaction, electrical conductivity and lime content), iii- nutrient elements (nitrogen, phosphors, potassium, and zinc). Soil samples were collected from the study area divided into 600 × 600 m grid squares and a total of 159 grid points were obtained. According to obtained results, 36.1% of soils were classified as high quality level whereas, %23.2 of the total soils has low and very low soil quality property in terms of rice requirement soil quality in the study area. It was also not detected very high soil quality. In addition, it was determined that mostly low and very low quality soils were located on Typic Ustipsmment soils whereas, high quality soils were found on Typic Haplusert and Typic Calciustert.
Key words: Soil quality index, analytical hierarchy process, standard scoring functions rice.

Introduction

Rice is an important food crop across the world and is a staple food for more than half of the world's population a staple food for more than half of the world's. Gençtan (2009) reported that rice is grown on 156 × 106 ha and the production is 660 × 106 ton on the worldwide. If the worldwide population growth rate continues at this rate, by 2030 rice production will have to be increased by 50% to meet both international and domestic demands (Sezer and Dengiz, 2014). In most of the Asian countries rice ranks second in agricultural production. It is also an important cereal crop in Turkey, where it is grown in every region; however, the Marmara region, especially the European section (Thrace), and the Black Sea region are the main rice cultivation areas. Turkey has approximately 27.5 × 106 ha of total arable area (Dengiz, 2013). However, rice ecosystems are currently faced with numerous issues, such as unsuitable soil and land conditions, water scarcity, biotic and environmental stresses, and inefficient agronomical practices, which result in low returns from rice production. In order to increase rice production by developing sustainable management practices, it is quite important to try understanding of soil quality for rice cultivation.

Soil quality was originally defined as the capacity of soil to function within ecosystem and is a tool in order to sustain productivity, maintain environmental quality, and promote plant growth (Doran and Parkin, 1994; Karlen et al., 2001). A large number of different physical, chemical and biological properties of soil, known as soil quality parameters, are used to soil quality assessment. These properties, that are sensitive to stress or disturbance, are synthesized using numerical quality indices obtained by several different types of methods.

Many different approaches such as comparative assessment, dynamic assessment, and soil quality index (SQI) assessment can be used for soil quality assessment (Doran and Jones

1996; Larson and Pierce 1994). Of these methods, SQI assessment is probably the most preferred method by researchers because, it is easy to use and has measurement flexibility (Qi et al. 2009; Marzaioli et al. 2010; Fernandes et al. 2011; Lima et al. 2013; Liu et al. 2013; Li et al. 2013). The SQI assessment, which generally starts by gathering a data set, defines different indicators with different numerical scales, and scoring functions are used to normalize the data. Non-dimensional indicators, which are obtained through the normalization of quality parameters, can be associated with many different ways that are based on addition, multiplication, or weighted-average methods (Andrews et al., 2002).
The insufficient information regarding the best combination of factors suitable for rice cultivation contributes to low rice production (Dengiz et al., 2013). Therefore, the aim of the current study was to determine soil quality by using Integrated Soil Quality Index model based on standard scoring functions and weight assignment approach in agricultural lands used for rice cultivation in Çarşamba Deltaic Plain located on central Black Sea Region of Turkey. In addition, it can be contribute the sustainability and reliability of land and soil resources by taking into consideration of management plans for rice cultivated soils leading to important economical potential for the area.

Materials and Methods

Field description

The study was carried out in the Çarşamba Deltatic Plain formed by the Yeşilırmak River and located in the central Black Sea Region of Turkey (Figure 1).
The study area is about 30 km far from the east border of the Samsun province and coordinated 45669281 - 4582885 N - S and 291727 -302306 E-W (37 Zone, UTM m). The study area covers about 6080 ha and it lies at an elevation from sea level of 1-2 m. According to long term meteorological data (1960 – 2017, DMI, 2017) of the Çarşamba district, the current climate in the region is semi-humid. The summers are warmer than winters (the average temperature in July is 23.5 and in January is 6.2°C). The mean annual temperature, rainfall and evaporation are 14.3ºC, 1045.2 and 739.1 mm, respectively. According to soil climate regime of Newhall simulation model (Van Wambeke et al, 2000), it was determined that the study site has mesic soil temperature regime and udic (dry tempudic in subgroup) moisture regime. These areas are commonly flat and slightly sloped (0.0-1.0%).

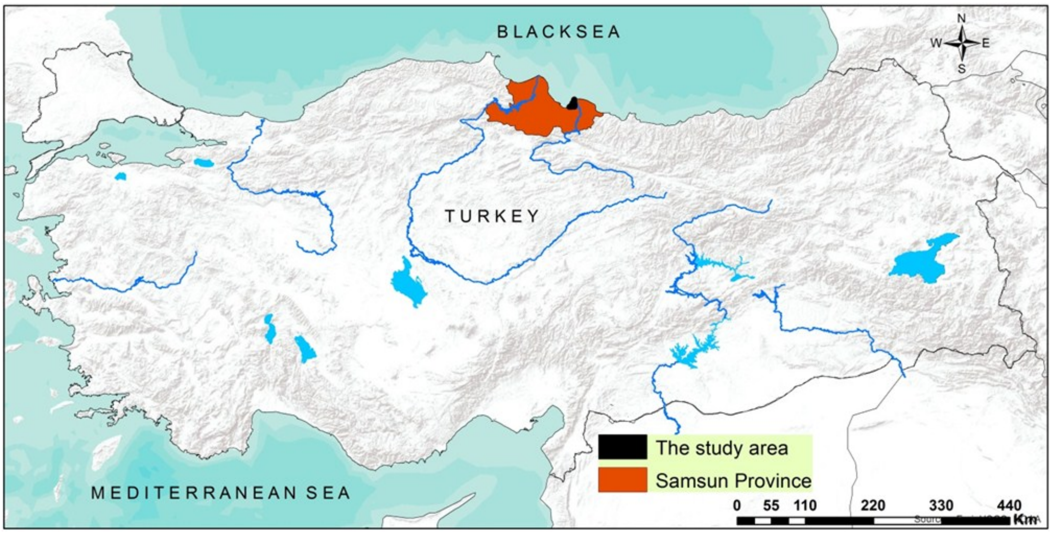

Figure 1. Location of the study area

Total eight soil series were described in the study area. The majority of soils were classified as Typic Haplustert, Fluventic Haplustept, Typic Ustipsamment, Typic Ustifluvent, Vertic Hapustalf, Typic Calciustept and Typic Calciustert in Soil Taxonomy (1999) and presented in Figure 2.

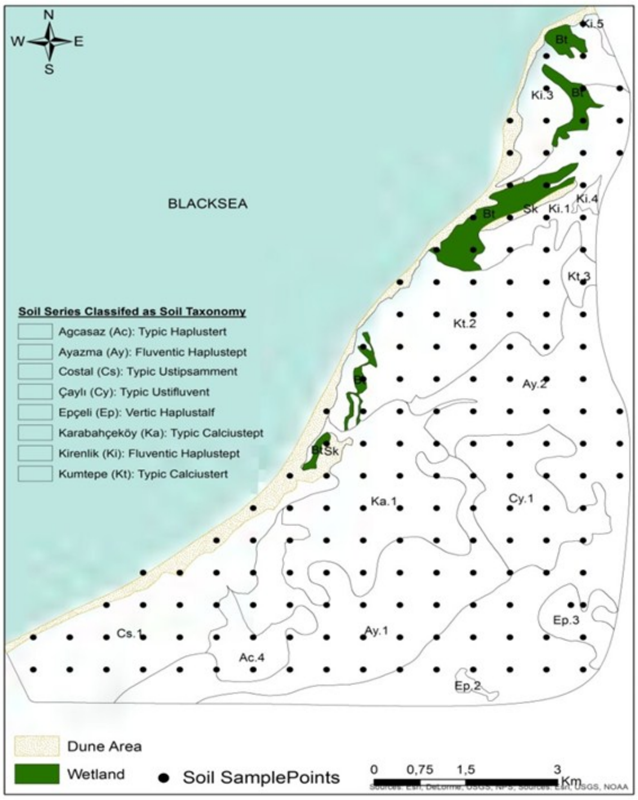

Figure 2. Soil sample patern and soil map of the study area

Agricultural activities have been intensively conducted in the study area. Mainly, rice, maize, pepper, watermelon, cucumber and tomato with sprinkler and furrow irrigations have been produced in the summer, and cabbage and leek in winter. In addition, small some part of the study area is covered with forest, pasture-meadow, marsh and dune areas.

Method

Sampling and indicator scoring

Filed study was conducted in 2017 and a total of 160 soil samples from Vertisol, Entisol, Inceptisol and Alfisol soils order were collected from the site divided into 600 × 600 m grid squares and a total of 160 grid points were obtained (Figure 2). The samples were taken in the fall after harvest and before the next cropping season in order to avoid the effect of direct fertilization during the crop growing season. Each soil sample was a composite of sub-samples and on a soil surface disturbed by tillage (0–30 cm). Coordinate of each soil sample point was recorded using a handheld GPS (global positioning system) tool. Samples were air-dried and passed through a 2 mm sieve. A total of fourteen soil quality parameters were included in SQI model by grouping in three classes which are; i-physical indicators (bulk density (BD), hydraulic conductivity (HC), available water capacity (AWC), percentage of sand, silty and clay), ii-chemical indicators (soil reaction, electrical conductivity, organic matter and Ca2CO3 content), iii- Nutrient elements (nitrogen, phosphors, potassium and zinc content). Table 1 indicates the analytical protocols selected.

Table 1. Protocol measurements for parameters selected in the study

Parameters	Unit	Protocol	Reference
BD	gr cm^{-3}	Undisturbed condition	Blacke and Hartge, 1986
HC	cm h^{-1}	Undisturbed and saturated condition	Oosterbaan (1994)
AWC	%	Calculated from taking difference between FC and PWP	Klute (1986)
OM	%	wet oxidation method (Walkley-Black) with potassium dichromate ($K_2Cr_2O_7$)	Nelson and Sommers 1982
Texture (Clay, Silty and Sand)	%	hydrometer method	Bouyoucos (1951)
pH	1:2.5	(w:v) soil-water suspension	Soil Survey Laboratory (1992)
EC	dS m^{-1}	(w:v) soil-water suspension	Soil Survey Laboratory (1992)
Ca_2CO_3	%	Scheibler calsimeter	Soil Survey Staff (1993)
$NaHCO_3$–P	mg kg^{-1}	the molybdophosphoricblue method	Olsen et al. 1954
Total N	%	Kjeldahl	Bremner and Mulvaney (1982)
NH4OAc–K,	mg kg^{-1}	Ammonium acetate extraction, flame spectrometry detection	Soil Survey Laboratory 1992
DTPA–Zn	mg kg^{-1}	DTPA extraction, AAS detection	Lindsay and Norvell (1978)

In this study, due to variation of parameters units, a standard scoring function (SSF) was used by taking into consideration of Andrews et al. (2002) in order to score soil parameters to use with each indicator method and scores ranging between 0 and 1 were assigned. Three types of indicators were separated according to their functional effect on soil quality, where the best soil functionality was joined with high, low or intermediate values (Liebig et al., 2001): (1) “More is better” function was applied to clay content, AWC, OM and nutrient elements for their roles in soil fertility because their high concentration was considered constructive for a good soil functionality of rice cultivation. (2) “Less is better” function was applied to EC, silt content, CaCO3, BD, HC, sand and silty content for water holding capacity and degradation of soils. (3) “Optimal range” function was applied to pH and scores were assigned using the more is better or the less is better function depending on whether the indicator value was below or above the optimal range. The SSF equations for the parameters are listed in Table 2.

Table 2. Standard scoring functions and parameters for quantitative soil parameters

Parameters	FT*	L	U	SSF Equation**
Sand	LB	6.5	76.2	$f(x) = \begin{cases} 0.1 & x \leq L \\ 1 - 0.9 \times \frac{x-L}{U-L} + 0.1 & L \leq x \leq U \\ 1 & x \geq U \end{cases}$
Sity	LB	11.1	38.5	
EC	LB	0.09	0.76	
$CaCO_3$	LB	1.82	15.47	
BD	LB	1.23	1.56	
HC	LB	0.61	17.17	
Clay	MB	12.8	64.9	$f(x) = \begin{cases} 0.1 & x \leq L \\ 0.9 \times \frac{x-L}{U-L} + 0.1 & L \leq x \leq U \\ 1 & x \geq U \end{cases}$
AWC	MB	8.29	19.28	
OM	MB	0.9	4.12	
TN	MB	0.007	0.578	
AvP	MB	1.0	72.1	
AvK	MB	2.0	147.95	
AvZn	MB	0.08	6.743	

Continuation of table 2

pH	OR	L1	U1	$f\ (x) = \begin{cases} 0.1 & x \leq L\ or x \geq U \\ 0.9 \times \frac{x - L1}{L2 - L1} + 0.1 & L \leq x \leq L2 \\ 1 & \end{cases}$
		7.80	8.08	
		L2	U2	
		8.08	8.22	$f\ (x) = \begin{cases} 0.1 & \\ 0.9 \times \frac{x - U1}{U2 - U1} + 0.1 & L2 \leq x \leq U1 \\ 1 & U1 \leq x \leq U2 \end{cases}$

*FT means function type; MB means more is better; LB means low is better; OR means optimal range.
**SSF means standard scoring function; in these three equations, x is the monitoring value of the indicator, f(x) is the score of indicators ranged between 0.1 and 1, and L and U are the lower and the upper threshold value, respectively.

Soil quality index and weight assignment

The land utilization type in this study is rice plant. In order to determine the soil requirements for rice cultivation taking into consideration of soil physico-chemical properties, some literatures were reviewed including those of the FAO (1983, 1985), Sys et al. (1993), Mongkolsawat et al. (2002), Bunting (1981), Özcan (2004), Dengiz (2013) Dengiz et al (2015), Nath et al. (2016), Horuz and Dengiz (2018). Particularly, the clay content of soil has vital role for rice cultivation areas and the soils with a high clay content get the greatest score values in terms of rice cultivation appropriateness (Dengiz, 2013). In addition, many researchers (De Datta, 1981; Landon, 1991; Razavipour and Farrokh, 2014) also indicated that soils with high clay content are more suitable for rice production due to their high capacity to retain plant nutrients and water, further restricting the percolation of water through the soil and encouraging bunding of the ponded fields.

Soil characteristics criteria that are bulk density, hydraulic conductivity, available water capacity, percentage of sand, silty clay, soil reaction, electrical conductivity, organic matter, $CaCO_3$ content, total nitrogen, available phosphors, available potassium and available zinc content and weighting rates normally employed in rice growing soil quality evaluation were used to compile information on the study area. After indicators were scored and weighted, soil quality indices were calculated using the Soil Quality Index (SQIR) (Doran and Parkin, 1994) equation using following formula (1);

$$SQIR = \sum_{i=1}^{n} (Wi.Xi)$$

Where; abbreviations are: SQIR: Rice soil quality index, Wi: Weighting of parameter i, Xi: Sub-criterion score of parameter i. The above formula is applied to each soil sample.

In the overall result, the higher SQIR value is the higher suitability of land-use for specified land-use type. SQI classes according to Moebius-Clune et al. (2011), taken into consideration in this study, are presented in Table 3. Grade V is considered most suitable or excellent for rice plant, grade IV is suitable for rice growth but with slightly limitations, grade III classified as moderate has more some limitations than grade II, and grade II soil has the most severe limitations for rice growth. Finally, grade I is not suitable for rice cultivation in terms of soil quality case.

Table 3. Soil quality index classes for rice

Class	Definition	Index value
I	Very low	<0.40
II	Low	0.40–0.50
III	Moderate	0.50–0.65
IV	High	0.65–0.85
V	Very high	>0.85

A total of fourteen soil quality parameters were grouped in three sub-criteria as physical parameters, chemical and nutrient element parameters, which means all the matrixes in the hierarchy A, B, and C were logically constructed (Figure 3).

Each of sub-criteria has importance level that differently in affect the land suitability for tea crop. The Weighting in soil quality is useful to know the importance level of soil parameters for each sub-criterion (Özyazıcı et al., 2013).

In this study, AHP method is selected and used for weighting the criteria and sub-criteria to the land suitability assessment for rice plant. The AHP is developed by Saaty (1980). The principles utilized in AHP to solve problems are to construct hierarchies. The hierarchy allows for the assessment of the contribution individual criterion at lower levels make to criterion at higher levels of the hierarchy.

Using Pair Wise Comparison Matrix (PWCM), factor weights were calculated by comparing two factors together. The PWCM were applied using a scale with values from 9 to 1/9 or 0.111 introduced by Saaty (1980). The comparison can be made using a nine point scale or real data, if available (Saaty and Vargas, 2001). The nine point scale includes: [9, 8, 7, . . ., 1/7, 1/8, 1/9], where 9 means extreme preference, 7 means very strong preference, 5 means strong preference, and so on down to 1, which means no preference (Table 4). This pair-wise comparison allowed for an independent evaluation of the contribution of each factor, thereby simplifying the decision making process (Rezaei-Moghaddam and Karami, 2008; Dengiz et al., 2015).

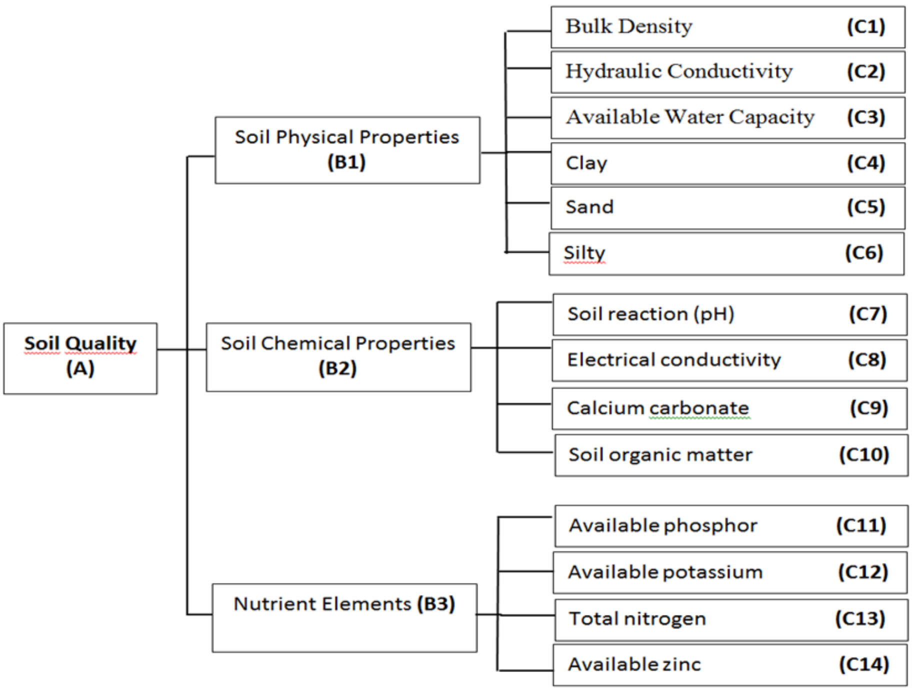

Figure 3. Hierarchical follow chart for the indicators weight assignments

Table 4. The comparison scale in AHP (Saaty, 1980).

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favour one activity over another
5	Essential or strong importance	Experience and judgment strongly favour one activity over another
7	Demonstrated importance	An activity is strongly favoured and its dominance is demonstrated in practice
9	Absolute importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed
Reciprocals of above nonzero	If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	

The pair-wise comparisons of various criteria were organized into a square matrix. The diagonal elements of the matrix were 1. The principal eigenvalue and the corresponding normalized right eigenvector of the comparison matrix gave the relative importance of the criteria being compared. The elements of the normalized eigenvector were weighted with respect to the criteria or sub-criteria and rated with respect to the alternatives (Bhushan and Rai, 2004). The consistency of the matrix of order n was then evaluated. If this consistency index failed to reach a threshold level, then the answers to comparisons were re-examined. The consistency index, CI, was calculated as (2):

$$CI = \lambda_{max}\text{-}n/n\text{-}1 \qquad (2)$$

Where; CI is the consistency index, λmax is the largest or principal eigenvalue of the matrix, and n is the order of the matrix. This CI can be compared to that of a random matrix, RI (Table 5), such that the ratio, CI/RI, is the consistency ratio, CR. As a general rule, CR ≤ 0.1 should be maintained for the matrix to be consistent.

Table 5. Values of Random index (RI)

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

In other words, the results indicated that all RIs for single and general hierarchy storing were lower than 0.1. Thus, homogeneity of factors within each group, a smaller number of factors in the group, and better an understanding of the decision problem improve the consistency index Saaty (1993).

Interpolation Analyses

In this present study, three main different interpolation methods (Inverse Distance Weighing-IDW, Radial Basis Function-RBF and Kriging) were performed for predicting the spatial distribution of SQIR. Kriging is a geostatistical technique similar to IDW in that it uses a linear

combination of weights at known points to estimate the value at an unknown point. Kriging uses a semivariogram, measure of spatial correlation between two points so that weights change according to the spatial arrangement of the samples. In contrast to other estimation procedures, kriging provides a measure of the error or uncertainty of the estimated surface. Several forms of kriging interpolation exist, including Ordinary Kriging (OK), Simple Kriging (SK), and Universal Kriging (UK).
Hereby, Root Mean Square error (RMSE) was used to evaluate the interpolation techniques. The lowest RMSE indicate the most accurate prediction. Estimates are determined by using the following formulae (3):

$$RMSE = \sqrt{\frac{\sum (z_{i^*} - z_i)^2}{n}}$$

Where; Zi is the predicted value, Zi* is the observed value, and n is the number of observations.

Results and Discussion

Soil Physicochemical Properties

The study area was located on the deltaic plain formed on alluvial deposit carried by the Yeşilırmak River. Main characteristic of the alluvial land and soils often shows large variations in their properties over short distances. Therefore, Dengiz (2010) and Birkeland (1999) indicated that the characteristics of alluvial soil vary from place to place or from region to region. However, it is well known that this change is not coincidental. Alluvial soils are the result of processes of erosion and deposition or sedimentation, and therefore exhibit various characteristics reflecting the composition and properties of the material transported (Weber and Gobat, 2006).
The some parameters of descriptive statistics such as minimum, maximum, mean, and coefficients of variation of physic-chemical properties and SQIR values of soil samples were presented in Table 6. The values of pH in soil samples ranged between 7.80 and 8.22, whereas electrical conductivity had a minimum value of 0.09 dS m-1 and a maximum value of 0.76 dS m-1. However, EC'values strongly increase closing to coast land because of water effect of sea. Soil texture class widely varies from sandy loam to clay and clay content of soil samples are between 12.8% and 64.9% while, sand content (%) varies between 6.5 and 76.2. The mean values of organic matter and CaCO3 content (%) were 2.68 and 5.59. As for, macronutrient element of samples, available P and exchangeable K showed high variation between minimum and maximum values. Total N varied between 0.01% and 0.58% and the average value of total N was 0.17%. In order to determine variability of some physico-chemical soil properties, many researchers offer to investigate coefficient of variation (CV). Wilding et al (1994), Mulla and McBratney (2000) reported that when the CV is lower than 15%, variability is classified as low; when it is between 15% and 35%, it is classified as moderate; and when it is greater than 35%, it is classified as high. In this sense, variables of pH, EC, BD, TN, AvZn and OM content have low CV. On the other hand, the variables of clay, sand, AvP and, ExcK content of soils had a high level of variability. Particularly, the accumulation of sediments that affects directly soil formation in alluvial young soils can show variations during transport/accumulation processes, especially as a result of agricultural practices, topographic properties or river flooding period. As a consequence of this case, distribution of spatial dependency of soil texture fractions can take place at different distances. In the study field, it was observed that sand sediments were observed on clay sediments whereas, clay sediments were seen to accumulate on sandy and loamy sediments in other areas. In addition, CV value was found as low class for SOIR.

Table 6. Descriptive statistical analysis of physical and chemical properties of soil samples

Parameters	Mean	SD	*CV	Varians	Min.	Max.	**Skewness	Kurtosis
TN	0,17	0,11	0,57	0,01	0,01	0,58	0,63	0,26
AvP	20,16	15,09	71,10	227,73	1,00	72,10	0,99	0,95
ExcK	29,43	19,76	145,95	390,65	2,00	147,95	1,38	6,73
AvZn	1,19	0,99	6,66	0,99	0,08	6,74	3,13	13,66
Sand	24,26	21,21	69,70	450,10	6,50	76,20	1,96	2,15
Silty	27,16	7,94	27,40	63,04	11,10	38,50	-0,79	-0,21
Clay	51,06	17,22	52,10	296,76	12,80	64,90	-1,39	0,60
BD	1,35	0,12	0,33	0,01	1,23	1,56	0,45	-1,43
HC	5,18	5,07	16,56	25,80	0,61	17,17	1,68	1,52
AWC	15,67	3,31	10,99	11,00	8,29	19,28	-1,33	0,70
OM	2,68	0,92	3,22	0,86	0,90	4,12	-0,54	-0,34
$CaCO_3$	5,59	4,47	13,65	19,99	1,82	15,47	0,87	-1,01
pH	8,00	0,14	0,42	0,02	7,80	8,22	0,20	-1,21
EC	0,53	0,23	0,67	0,05	0,09	0,76	-0,69	-0,76
SOI_R	0,59	0,17	0,59	0,03	0,19	0,78	-1,23	0,07

SD: HCStandard deviation, Min.: Minimum, Max.: Maximum, n: sample number (160),
*CV (Coefficient of Variation): < 15 = Low variation, 15-35 = Moderate variation, >35 = High variation
**skewness:< │+/-0.5 │= Normal distribution, 0.5- 1.0 = Application of character changing for dataset, and > 1,0 → application of Logarithmic change

Soil quality evaluation and distribution of SQIR with spatial variability

In this study, fourteen main indicators were selected for SQIR by taking into consideration of many literatures reviews. In order to assign the proper score for each soil sample, it is composed of three main steps. Firstly, AHP approach was performed to evaluate and evaluate scores or eigenvector. In this step, it was determined that the result of consistency ratio is far below at the value of 0.1 which is the maximum limit of a weighting can be said consistent. Meanwhile, the results of the study by (Wali et al., 2016) also stated that the method of AHP succeeds in weighting. Contribution weight of soil parameters to soil quality estimated by the AHP was given in Table 7. It was determined the highest value (0.5936) for Hierarchy B1 (soil physical parameters) whereas, the lowest value (0.1571) was found for soil nutrient element concentration (Hierarchy B3). In addition, the highest value of indicators for each Hierarchy B1, B2, and B3 were calculated as clay percentage (0.3831), OM (0.5083) and TN (0.5048), respectively.

These results can be said also consistence and it can be explained why the highest value of Hierarchy B1. Because, rice plant requires soil including high water holding capacity resulted from dominate clay fraction. Saglam and Dengiz (2015) stated in their study clay content is the first soil property selected as a potential quality indicator because of its importance in rice production. In B2 hierarchy, OM was found the highest value due to its several important functions in soil as well as for its influence on the biological and physic-chemical properties of the soils. This indicator, in fact, is contained in development of the soil structure or aggregation, improvement of soil fertility, storage and supply of nutrient elements and also affects cation exchange capacity. On the other hand, this parameter can be affected by soil and rice management practices. These two Hierarchy B1 and B2 can be defined as inherent or natural factors. On the other hand, Hierarchy B3, nutrient status of soils, can be defined as dynamic or artificial factor. In this context, dynamic indicators describe soil conditions due to current land use or management applications. In this case Wienhold et al. (2004) indicated that dynamic indicators are used to evaluate how soil management decision affects use dependent soil properties.

Table 7. Contribution weight of soil parameters to soil quality calculated by the AHP

Hierarchy A				
Hierarchy C / Indicators	Hierarchy B			Combine weight $\sum B_i \times C_i$
	B1	B2	B3	
	0,5936	0,2493	0,1571	
Sand (%)	0,0348			0,0206
Clay (%)	0,3831			0,2274
Silty (%)	0,0580			0,0344
BD (%)	0,0933			0,0553
HC (%)	0,1542			0,0915
AWC (%)	0,2766			0,1641
OM (%)		0,5083		0,1267
Ca_2CO_3 (%)		0,0752		0,0187
pH (1:2.5)		0,1512		0,0376
EC (dSm^{-1})		0,2653		0,0661
TN (%)			0,5048	0,0793
AvP			0,2876	0,0451
ExcK			0,0645	0,0101
AvZn			0,1431	0,0224
Total	1	1	1	1

Secondly, it was determined score values of all parameters by using the best soil functionality was joined with high, low or moderate (optimal range) values ranging between 0 and 1 based on their function on soil quality. Finally, after assigned of eigenvector for each indicator and scoring values to determine, weighted linear combination technique was used to estimate SQIR values for each soil sample.

Interpolation analysis for SQIR was used to identify the best predictive model from among nine different semivariogram models were tested and then, the variogram or function of each interpolation method yielding the best results was determined. Comparison of interpolation methods for SQIR is provided in Table 8. Finally, exponential model of Universal Kriging was used to estimate or predict SQIR at unsampled locations.

Table 8. Cross validation according to interpolation methods

Enterpolasyon model	Pover/Semivariogram	RMSE
IDW	1	0,0957
	2	0,0824
	3	0,0889
RBF	Thin Plate Spline	0,0838
	Spline with Tension	0,0819
	Completely Rugularized Spline	0,0889
Ordinary Kriging	Spherical	0,0829
	Exponential	0,0803
	Gaussian	0,0915
Simple Kriging	Spherical	0,0942
	Exponential	0,0964
	Gaussian	0,0956
Universal Kriging	Spherical	0,0829
	Exponential	**0,0804**
	Gaussian	0,0915

The distribution map of surface SQIR of the study area are illustrated in Figure 4 and classified as five levels according to Table 3.
As seen from the Table 9, it was determined distributions of SQIR for surface depth (0-30 cm). Results indicated that the land highly and moderately suitable for rice cropping covered an area of about 10404.2 ha (72.9%). Of the study area, 22.5% was unsuitable for rice, and those areas correspond to adverse soil physical and chemical properties. Özşahin (2016) studied a land suitability system for rice cultivation in the Hayrabolu Deresi Basin (1508 ha) based on the method described in Dengiz (2013) using the GIS program. According to his results, the suitable land for rice cultivation in the studied basin is distributed as follows: 48% is highly to moderately suitable and 26.1% is marginally suitable. About 25.9% of the study area was found to be currently unsuitable for rice cultivation, due to some limitation factors such as partly slope degree, shallow soil depth, sandy clay texture, saline, low water retention, and high hydraulic conductivity.

Table 9. Distribution of the SQI_R's classes

Description	Class	Index value	Area	
			ha	%
Very Low	I	<0.40	3209,4	22,5
Low	II	0.40–0.50	643,0	4,5
Moderate	III	0.50–0.65	5251,6	36,8
High	IV	0.65–0.85	5152,6	36,1
Very High	V	>0.85	-	-
Total			14256,6	100,0

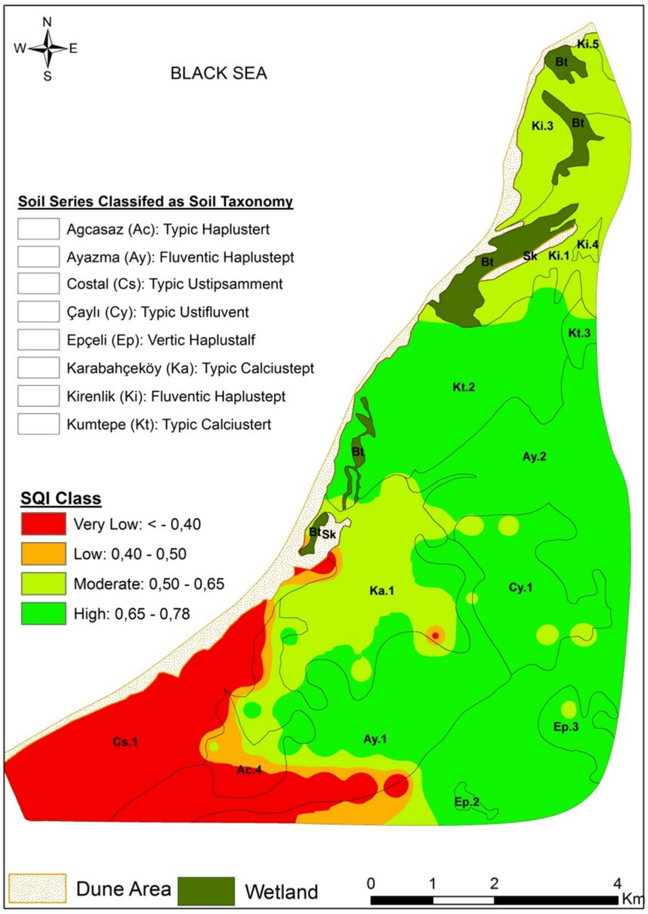

Figure 4. Spatial distribution map of the SQIR

Within this context, the mostly greatest values of the SQIR were determined in Vertisol Alfisol and Inceptisol soils, classified as Typic Calciustert (Kumtepe soil series), Vertic Haplustalf (Epçeli soil series) and Fluventic Haplustept (Ayazma soil series). However, it was found out that the areas where the SQIR was low were the areas that had Entisol (Typic Ustipsamment and Vertisol (some part of Typic Haplustert) soils with a dense sand content or high pH values that negatively affected the development of rice.

Conclusion

Soil quality evaluation supports a useful tool for agriculture managers and policy makers to obtain a better understanding of how different agricultural systems influence soil resources. Because, this tool took all related soil indicators into consideration and reflected the most consistent and logical results. According to soil taxonomy, in the study area where there are soils of Vertisol, Entisol, Alfisol and Inceptisol orders, located on alluvial lands formed as accumulated sediments have been used mostly for rice production. Therefore, alluvial characters can show large variation in their properties over short distances. Related this concept, farmers throughout the study area had conflicting opinions on yield reduction in rice fields. Some producers stated that yields were reduced on fine-textured clay soils, while others stated that their yields were only reduced on the coarser-textured soils such as loamy sand and sandy loams. The insufficient of information on the effects of the various alluvial soils compounded the conflicting local information that was available before this study. Therefore, the making of detailed soil survey and mapping studies are very important in alluvial areas. In addition knowledge of the changings in soil characteristics is significant for both soil classification and soil management and plant growth, which require detailed information on spatial distribution of soil quality indexes.

Consequently, soil quality map for rice generated using SSF, AHP, geostatistic and GIS techniques, can enhance the planning alternatives within an area with meaningful strategy in terms of location. Therefore, the present model will provide logical guidance for new land allocation for the cultivation of rice and potentially for other crops.

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Interpretation of soil urease activities along a topographic and textural gradient

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Abstract

The main objectives of this study were (i) to determine physico-chemical properties of six different soil profile (ii) to measure the range and degree of extracellular soil urease activities, (iii) to evaluate the influence of soil physico-chemical properties on soil urease activities in different slope gradient. Soil properties data of soils indicated significantly differences each other in terms of pedogenic processes which have been shaped by landscape position and parent material. According to soil taxonomy, 6 different soils were determined and classified as entisol, inceptisol and mollisol along transect. In addition, it was found that changes of landscape positions associated with erosion and organic matter content can alter the soil urease activity within the soil profile and along different slope.
Key words: Soil landscape, urease activity, soil genesis.

Introduction

Soils are essential natural resources with a broad range of environmental functions. They influence hydrologic and biogeochemical cycles, provide habitat to organisms, affect global change, and are a foundation of human civilizations. Recently, soil scientists and researchers in related fields have started to apply fundamental principles of soil science to the mapping and characterization of aquatic sediments (Demas and Rabenhorst, 1999, 2001). The definition of soil has been expanded to include shallow subaqueous sediments – we will use the term "subaqueous soil" (Soil Survey Staff 1999).
Some processes of soil formation that are well characterized in terrestrial landscapes also function in subaqueous soils (Demas and Rabenhorst, 1999, 2001). Soil is a complex system wherein physico-chemical and biochemical factors are held in dynamic equilibrium (Arunachalam et al., 1999). It is the medium form which plant root systems acquire water and nutrients and is host to an array of macro and micro-organisms. Soil contains a great diversity of organisms, the vast majority of which are microbes. In terrestrial ecosystems the greatest diversity of organisms are in the soil (Wardle, 2002).
There are many methods currently available for studying the microorganisms and their activities at the microhabitat level (Nannipieri et al., 1990). The dependence of the microbiological properties of agricultural soils on site and soil factors has been studied (Vekemans et al., 1989). Some soil microbiological properties, such as enzyme activities, respiratory activity and microbial biomass are used as bio-indicators for soil quality and health in environmental soil monitoring (Rogers and Li, 1989). Measurements of several enzymatic activities have been used to establish indices soil biological fertility. Urease is involved in the hydrolysis of urea-type substrates and its origin is basically microbial and its activity is extracellular (Bremner and Mulvaney, 1978).
The study area has specific properties in terms of different topographical positions and parent material that influence distribution of plant patterns on both sides of Aciçay river in Cankiri, Turkey. These cases are the main principal reasons for selection of this area. Therefore, the objectives of this study were (i) to determine physico-chemical properties of six different soil profile (ii) to measure the range and degree of extracellular soil urease activities, (iii) to evaluate the influence of soil physico-chemical properties on soil urease activities in the both sides of the Çankiri-Aciçay river associated with specific landforms and different slope gradient.

Materials and Methods

Study area

The study was carried out transect along both sides of the Çankiri-Aciçay river which is a prominent land form, parent material and vegetation. The study area is located between 557733E-4497924N, 557751E-4497889N and situated in vicinity of Çankiri province. It ranges in relief from 740 to 800 m and four landscape positions (floodplain, terrace, back-slope, shoulder), representing changes in geomorphology, topographic gradients and soil characteristics, were selected. The underlying bedrocks within the study area consist of primarily deposits while right side soils of the Aciçay river are formed on quaternary alluvial deposits that find on floodplain and terrace, left side soils are formed on quaternary alluvium, alluvial-collivial material spotted on floodplain and terrace oligomiocene gypsum and rock salt strata located on mid-slope and steep lands. Gypsum were commonly encountered with crystals, foliated (laminae) and mixing (not pure) forms. Vegetation cover varies through transect. Right side lands have been generally used for agriculture crops, while left side lands have covered three major plant community types (herb, shrub-grass and grass) and upper lands are generally barren due to overgrazing. According to meteorological data, the mean annual temperature and rainfall are 11.1ºC and 417.7 mm, respectively. In addition, the study site has mesic soil temperature regime and xeric moisture regime.

Soil sampling and soil physico-chemical analysis

On the basis of hypothesis that topography and parent material and also vegetation cover might be the main controlling factor in soil development. Soils have been studied on along transect (crosswise from East to West direction) with representative six profiles. Morphological properties of these six profiles in the field were identified and sampled by genetic horizons and classified according to soil survey staff (1993, 1999). Twenty five soil samples were taken to investigate for their physical and chemical properties at the laboratory. The soil samples were then air-dried and passed through a 2 mm sieve to prepare for laboratory analysis.
Soil samples were then air-dried and passed through a 2 mm sieve, particle size distribution was determined by the hydrometer method. Coarse fragments from 2 to 60 mm were separated by passing from 2 mm sieve and mass coarse fraction ration (CFm) was calculated. Organic matter was determined in air-dried samples using the Walkley- Black wet digestion method. pH, electrical conductivity (EC) were determined according to soil survey laboratory. Lime content by Scheibler calsimeter. Total gypsum by precipitation with $BaCl_2$. Cation exchange capacities (CEC) was measured using a 1 N NH4OAc (pH 7) method (Rowell, 1996).

Soil urease activity

Urease (EC 3.5.1.5) activity was measured by the method of Hoffmann and Teicher (1961). 0.25 mL toluene, 0.75 mL citrate buffer (pH 6.7) and 1 mL of 10 % urea substrate solution were added to the 1 g sample and the samples were incubated for 3 h at 37ºC. The formation of ammonium was determined spectrophotometrically at 578 nm and results were expressed as µg N g-1 dry sample Three replicates of each sample were tested, and a control sample without urea was prepared. Results were expressed as mg N g^{-1} dry soil.

Results and Discussion

Soil physical properties that have been taken into consideration in this study showed variability as a result of dynamic interactions among natural environmental factors such as climate, parent material, land cover-land use and topography. Especially, slope has been regarded as one of the most important abiotic factors that control the pedogenic process on a local scale. Steeper slope contributes to greater runoff, as well as to greater translocation of surface materials down slope through surface erosion and movement of soil mass. In left side soils, clay percentage of surface soils in low slope sides is more than on higher slope except floodplain top soil that is almost coarse recently alluvial deposits and the sand content for slopes with high gradient is higher than for low slopes. A logical reason of this event is that in low slope (2-4 %) accumulation processes and in upper slope (> 30 %) runoff processes are dominant. This case is similar to the coarse fragment ratio (CFr). While the lowest value (0.44 %) of CFr is for slopes ranging from 0 to 2 %, the highest values of CFr that are steadily increased with increasing slope gradient are 34.52 %. While right side floodplain of Aciçay river finer-textured soils, sand and coarser textured soils occupied the opposite bank (Table 1).

Topsoil textural classes that were affected by slope gradient have the following distribution with decreasing elevation: Coarse sandy loam, clay loam, clay. However, there is an abrupt textural transition from old river terrace soils to floodplain soils that contain loamy sand texture. There are common pebbles and cobbles within profiles of floodplain of both sides. Soil chemical properties on different slope position and parent material were significantly affected by the degree of soil development and leaching processing. Soil pH and EC are generally greater at depth than at the soil surface. This case was particularly observed in left side terrace soil that has significantly high pH values (7.80-8.75), whereas pH value of right side terrace soil varies between 7.28-7.83. It seems that this situation has significantly effect on distribution of land uses and plant pattern of both sides of Aciçay river.

According to their results, sand, silt, pH, EC, calcium carbonate generally increased down slope. Clay content, organic matter and CEC generally decreased down slope. On the other hand, in this study it was found that clay content, organic matter and CEC generally increased from upper slope to low slope lands. Soil organic matter content depends on the complex interaction of several factors including the quantity and quality of litter fall, climatic factor, soil properties (especially the amount and type of clay) and erosion32. Soils of the both sides of Aciçay river have consistently low organic matter ranging from 0.46 to 2.61 % (Table-1).

Table 1. Some physico-chemical properties for the six typical soil profiles

Horizon	Depth (cm)	Particle size				CFm > 2 mm (%)	pH	EC (ds m^{-1})	Organic matter (%)	$CaCO_3$ (%)	Gypsum (%)	CEC (cmol kg^{-1})
		C (%)	Si (%)	S (%)	Class							
Right side floodplain (PI) Aquic Xerofluvent												
Ap	0-14	31	44	25	CL	1.1	7.52	1.90	1.92	12.23	0.18	16.70
C1	14-40	18	46	35	L	23.1	7.53	1.13	0.78	11.53	0.21	15.43
2C2g	40-69	11	9	80	LS	64.6	7.66	1.80	0.33	7.78	0.21	10.75
2C3g	69+	15	24	61	SL	20.3	7.52	2.92	0.65	8.84	0.25	12.45
Right side old river terrace (PII) Typic Calsixeroll												
Ap	0-22	41	37	22	C	1.41	7.28	1.79	2.44	10.61	0.10	15.61
A2	22-53	32	44	24	CL	1.05	7.52	1.70	1.21	12.37	0.13	15.74
Bw	53-113	38	38	24	CL	0.96	7.47	2.61	1.11	13.14	0.24	22.08
Bk	113-149	43	39	18	SiC	0.54	7.80	3.22	1.05	17.34	0.74	25.08
BC	149-185	36	49	15	SiCL	0.13	7.83	3.85	0.98	12.08	0.66	19.45
C1	185-229	48	37	15	C	0.21	7.78	4.50	0.72	11.64	0.50	22.74
C2	229+	45	43	12	C	0.74	7.48	2.80	0.70	12.14	0.34	18.70
Left side floodplain (PI) Typic Xerofluvent												
A	0-6	5	22	73	LS	0.44	7.53	3.50	0.98	15.73	0.53	9.04
C1	6-15	9	53	38	SiL	1.33	7.77	4.71	0.72	15.19	0.62	9.35
C2z	15-26	9	43	48	L	2.16	7.93	9.32	0.78	14.66	1.33	11.65
C3z	26+	8	39	54	SL	5.31	7.82	8.71	0.59	14.66	1.44	10.62

Continuation of table 1

Horizon	Depth (cm)	Particle size C (%)	Si (%)	S (%)	Class	CFm > 2 mm (%)	pH	EC ($ds\ m^{-1}$)	Organic matter (%)	$CaCO_3$ (%)	Gypsum (%)	CEC (cmol kg^{-1})
						Right side old river terrace (PII) Typic Calsixeroll						
Ap	0-22	41	37	22	C	1.41	7.28	1.79	2.44	10.61	0.10	15.61
A2	22-53	32	44	24	CL	1.05	7.52	1.70	1.21	12.37	0.13	15.74
Bw	53-113	38	38	24	CL	0.96	7.47	2.61	1.11	13.14	0.24	22.08
Bk	113-149	43	39	18	SiC	0.54	7.80	3.22	1.05	17.34	0.74	25.08
BC	149-185	36	49	15	SiCL	0.13	7.83	3.85	0.98	12.08	0.66	19.45
C1	185-229	48	37	15	C	0.21	7.78	4.50	0.72	11.64	0.50	22.74
C2	229+	45	43	12	C	0.74	7.48	2.80	0.70	12.14	0.34	18.70
						Left side back slope (PIII) Typic Xerorthent						
A	0-20	28	39	41	L	26.90	7.45	7.52	0.78	11.31	1.76	18.16
Cy	20-44	26	33	51	SCL	15.30	7.56	5.11	0.52	13.29	13.43	16.11
2Cy	44-120	23	42	36	L	10.25	7.75	16.62	0.33	10.61	21.71	16.30
R	120+	-	-	-	-	-	-	-	-	-	-	-
						Left side shoulder (PIV) Lithic Xerorthent						
A	0-18	14	24	62	SL	34.52	7.42	9.79	0.46	6.36	20.13	18.09
R	18+	-	-	-	-	-	-	-	-	-	-	-

For all soils, the organic matter is the highest in the surface horizon and decreases sharply to its lowest level in the subsoil. In the study area, the reasons of the low level organic matter are attributable to rapid decomposition and mineralization of organic matter (especially, due to intensive agricultural activities for right side), to overgrazing and to soil erosion (due to high slope for left side). Cation exchange capacity in the soils ranged from 9.04 to 27.18 cmol kg-1. CEC values generally tended to be more related to the clay content (r = 0.901**), because organic matter content is generally low particularly in subsurface horizons. On the other hand, it was found statistically relation between organic matter and CEC (r =0.596*). The gypsum content, which is relatively high in the fresh parent material (from 13.43 to 21.71%) is low relatively low from 0.10 to 1.76 % in most surface horizons.

The urease activities are presented in Figure 1 for each landscape position and profiles. There were significant differences in extracellular urease activities among landscape positions and soil depth. Close observation suggests that there is a tendency for greater values in urease activities at the old river terrace for both sides of river. Moreover, urease activities on shoulder and backslope position in left side were significantly lower than the old river terrace in footslope position. This situation may be based on erosion and soil organic carbon deposition in footslope position. Because of the high in organic matter contents, it was assumed that organic matter and clay content might be affecting the enzyme activities of soils. For all landscape positions, urease activities showed similar trend in all profiles. In all positions and each sides, urease activities in soils decreased from the surface soil downwards indicating that the major part of the location is existed to the A horizon. On the contrary, the minority of extracellular urease enzymes has generally remained in the C horizon of the all profiles. The decrease in enzyme activities with depth can be mainly attributed to the diminution of biological activity down the profile. Inactivation of enzymes by clay minerals in the deeper horizons may be partly responsible for the different distribution patterns of the enzymes with depth. Additionally, all enzymes exhibited similar pattern on all profiles.

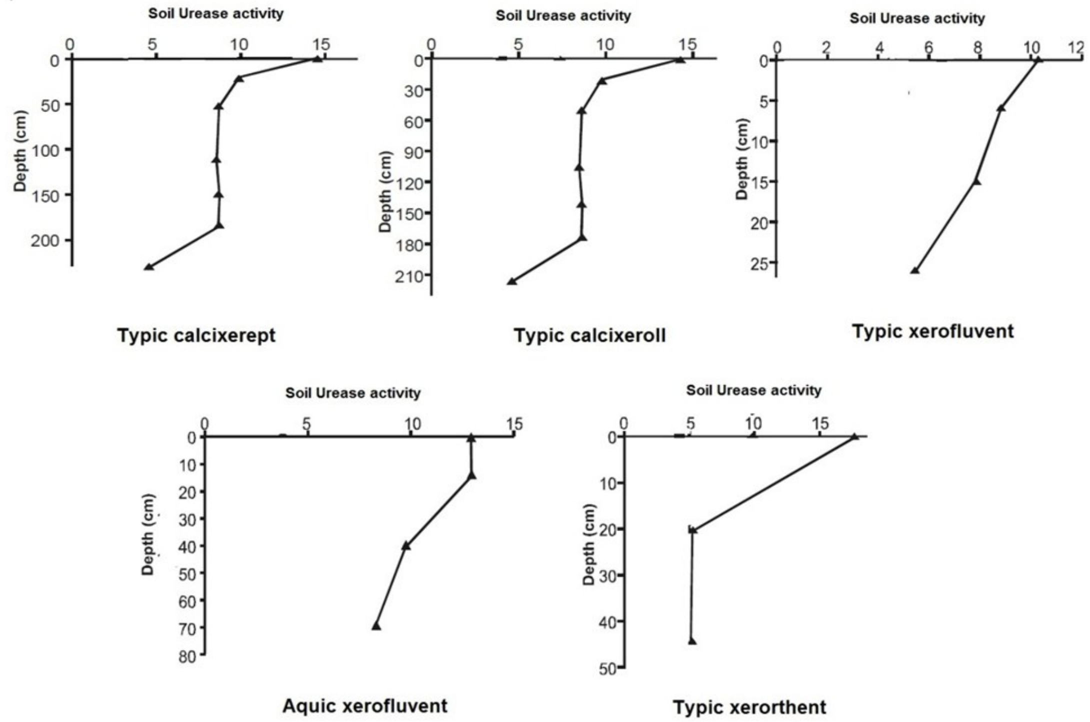

Figure 1. Distribution of urease enzyme activities in soil profiles

The soil organic matter gave the significant correlations with extra cellular urease activities at $p < 0.01$, but not significantly correlated with the other soil physico-chemical properties. In both sites, the microbial community of the highly skeleton has consumed relatively more organic matter than the other soil physico-chemical properties.

Conclusion

In conclusion, soil chemical and physical properties data of these both sides of Aciçay river soils indicate significantly differences each other in terms of pedogenic processes which have been shaped by landscape position and parent material. Another way to view this concept that these factors are keys on soil forming processes especially at the local region. In addition, the results also indicated the urease activities along a hillslope and soil profile had the great differences in the soils. The old river terrace in footslope position has greater organic matter contents compared the other positions, because the higher levels in the fine particles and organic matter content clearly show erosional depositing at the footslope and denudation of shoulder. The main effects of the organic matter on the urease activities may be welded the accumulation or decomposition of organic matter and erosion and deposition. The organic matter strongly correlated with urease activities suggests the number and activity of soil microorganisms depend on mainly of mineralizable substrate and enzyme synthesizing. In conclusion, this study demonstrated changes of landscape positions can alter the soil urease activities within the soil profile. Landscape position associated with erosion resulted in high variability of enzymes. It is, therefore, a special and interesting area for the performance of an integrated analysis of soil urease enzymes in relation to landscape position and soil profile.

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Successive two years treated sewage sludge applications: effect on corn and second crop wheat yield and some soil properties of sandy loam soil

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Abstract

In this study, effect of successive two years treated sewage sludge (TSS) applications on corn and second crop wheat yield and some soil properties of sandy loam soil (Typic Xerofluvent) were investigated. The field study was conducted in 20 parcels in a randomized-block design with four repetitions and five different applications including control, mineral fertilizer, treated sewage sludge 12.5 $t.ha^{-1}$, 25.0 $t.ha^{-1}$, 37.5 $t.ha^{-1}$ as dry matter during 2011-2012 in Menemen-İzmir, Turkey. Corn (*Zea mays*) and wheat (*Triticum vulgare*) were sown as the first and second crop respectively. During the experiment, soil samples were taken five times in two years. Increasing TSS applications to this soil resulted in significantly increased total biomass and grain yield of corn. Also increasing TSS applications to this soil significantly increased grain yield of wheat. Increasing TSS aplications were significiantly increased total N, available P and K, total salt, cation exchange capacity (CEC) and organic matter (OM) content of sandy loam soil. However, pH values of soil did not change significantly when compared with the control. Due to TSS applications of second year again, all soil properties were affected positively in five different soil sampling periods in two years. Also TSS applications of second year to experimental soil again significantly increased total biomass and grain yield of corn according to control. It is recommended that 37.5 $t.ha^{-1}$ TSS as dry matter can be added to sandy loam soil in Mediterranean region every year for improving soil properties, plant nutrients and crop yields.
Key words: Corn, Sandy loam soil, Sewage sludge, Soil properties, Wheat.

Introduction

Agricultural recycling of organic wastes is an interesting solution since it enables a reduction of the quantities of mineral fertilizers applied and an improvement of organic matter (OM) content of soil. Treated Sewage Sludge (TSS) is an ultimate product of municipal wastewater treatment plant and highly enriched in OM. Organic materials can differ considerably in terms of the extent to which they increase soil organic matter contents and alter soil physical and chemical properties (Barker et al., 2000). The beneficial effects of using sludge on agricultural soils have been proven by numerous researchers (Dede et al., 2015; Niewiadomska et al., 2015). The use of sewage sludge as agricultural soil amendments and fertiliser replacements is also relatively well researched (Tarraso´n et al., 2008; Delibacak et al., 2009a) and fertiliser advice is available for these materials (Defra, 2010). TSS contains macronutrients and trace elements. These attributes potentially make TSS an excellent fertilizer at very low cost for agricultural land in Turkey which is generally rich in lime, low in OM. The purpose of this work has been to evaluate the effect of successive two years municipal TSS applications on the corn and second crop wheat yield and some soil properties of sandy loam soil during five different periods in two years.

Materials and Methods

Experimental Site: The experiment was conducted at the research field of Aegean Agricultural Research Institute in Menemen plain, Izmir, Turkey (38°34′10.50″N; 27°02′ 8.65″E). The experimental site is in the Western Anatolia region of Turkey, where the Mediterranean climate prevails with a long-term mean annual temperature of 16.8 °C. Long-term mean annual precipitation is 542 mm (IARTC, 2012). The investigated soil is characterized by sandy loam texture with slightly alkaline reaction and classified as a Typic Xerofluvent (Soil Survey Staff, 2006). Some selected properties of experimental soil is given in Table 1 and some selected properties and total heavy metal concentrations in TSS used in the experiment is given in Table 2.

Table 1. Some selected properties of experimental soil

Sand	(%)	57.84	pH	(Saturation paste)	7.50
Silt	(%)	29.44	Salt	(%)	0.096
Clay	(%)	12.72	$CaCO_3$	(%)	4.52
Texture	Sandy loam		Organic matter	(%)	2.73

Table 2. Some selected properties and total heavy metal concentrations of TSS used in the experiment

EC	dS/m	16.35	Fe[1]	%	1.14	Co[1]	mg/kg	14.2
$CaCO_3$	(%)	10.24	Cu[1]	mg/kg	268.8	Cd[1]	mg/kg	4.1
Org. matter	(%)	70.32	Zn[1]	mg/kg	1335	Cr[1]	mg/kg	250.6
Org. C	(%)	40.79	Mn[1]	mg/kg	298.6	Ni[1]	mg/kg	115.4
N[1]	(%)	5,33	B[1]	mg/kg	35,2	Pb[1]	mg/kg	199,4

Field experiment: The field study was conducted in 20 parcels in a randomized-block design with four repetitions, during 2011-2012. The parcel dimensions were 3 m x 3 m. The TSS used in the experiment was obtained from the wastewater treatment plant of Metropolitan Region, Izmir city. Calcium oxide (CaO) was added to raise the efficiency of the dewatering process of sewage sludge (SS). In addition, the SS produced presented a pH varying between 10 and 13, what increased the pathogen control and decreased the heavy metal availability by added CaO. TSS was added to the soil at the rates of 12.5 $t.ha^{-1}$; 25.0 t. ha^{-1}; 37.5 $t.ha^{-1}$ as dry matter on July 8, 2011. Also 150 kg N, 150 kg P_2O_5, 150 kg K_2O ha^{-1} (1000 kg ha^{-1} 15.15.15. composed fertilizer) were applied to the only mineral fertilizer parcels at the same time and mixed with soil to 15 cm depth. Control parcels were not treated. Corn (*Zea mays*) seeds were sown with seeding machine on rows 18 cm and in rows 70 cm apart. Drop irrigation was provided when required. Harvest of corn was done by hands on December 15, 2011. Wheat (*Triticum vulgare*) seeds were sown with seeding machine on December 22, 2011 to 5 cm of soil depth as second crop. Also 80 kg N and 80 kg P_2O_5 ha^{-1} (400 kg ha^{-1}20.20.0. composed fertilizer) were applied to the only mineral fertilizer parcels at the same time and mixed with soil to 15 cm depth before wheat seeding. Wheat was harvested with machine on July 10, 2012. Second year, again TSS was added to the experimental soil under investigation at the same rates on July 18, 2012. Also mineral fertilizer were applied to the only mineral fertilizer parcels at the same rate and time and mixed with soil to 15 cm depth by rotary tiller before corn seeding. Corn seeds were sown with seeding machine on July 18, 2012. Harvest of second year's corn was done by hands on November 23, 2012.

Soil sampling and analyses: During the experiment, all soil samples were taken from Ap horizon in five different periods (1st, August 3, 2011-3 weeks after sowing of corn; 2nd, December 15, 2011-after corn harvest; 3rd, July 11, 2012-after wheat harvest; 4th, August 7, 2012-3 weeks after sowing of second year corn; 5th, November 23, 2012- after corn harvest of second year). The samples were air-dried and sieved using 2-mm sieve. Particle size distribution (Bouyoucos, 1962), total salt, OM concentration, $CaCO_3$, pH, total P, K, Ca, Mg, Na, Fe, Cu, Mn, Zn, Cd, Cr, Co, Ni, Pb and B concentrations of TSS; total salt, OM concentration, $CaCO_3$, pH of the soil (Page et al., 1982); cation exchange capacity (CEC) of soil (Chapman 1965);. total N content of soil and TSS (Bremner, 1965); available P in soil (Olsen et al., 1954); available K were analyzed (Kacar, 1994).

Statistical analysis: Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 17. Tukey test was used to find if differences in the treatments were significant at P≤0.01 or P≤0.05 (SPSS 17.0, 2008).

Results

Effect of successive two years TSS applications on yield of corn and second crop wheat grown in sandy loam soil

Effect of successive two years treated sewage sludge applications on total biomass and grain yield of corn and second crop wheat grown in sandy loam soil are given in Table 3, 4 and 5 respectively.

Table 3. Effect of successive two years TSS applications on total biomass of corn grown in sandy loam soil
Tukey: P≤ 0,01: P≤ 0,05

Applications	Average of 1st and 2nd year yield ($t.ha^{-1}$)	1st year yield ($t.ha^{-1}$)		2nd year yield ($t.ha^{-1}$)		
Control	38.22 b	41.69 a	A[2]	34.75 c	A	
Fertilizer	39.79 b	43.55 ab	A	36.04 bc	A	
12.5 $t.ha^{-1}$TSS	41.40 ab	43.46 ab	A	39.33 abc	A	
25.0 $t.ha^{-1}$TSS	44.81 ab	44.91 ab	A	44.70 ab	A	
37.5 $t.ha^{-1}$TSS	48.08 a[1]	50.28 a	A	45.87 a	A	
	**	*		**		

Significant differences between treatments at ** P≤ 0,01 or * P≤ 0,05 level indicated by different letters. [1]Small letter in column for applications, [2]capital letter in row for years.

Table 4. Effect of successive two years TSS applications on grain yield of corn grown in sandy loam soil
Tukey: P≤ 0,01: P≤ 0,05

Applications	Average of 1st and 2nd year yield ($t.ha^{-1}$)	1st year yield ($t.ha^{-1}$)		2nd year yield ($t.ha^{-1}$)		
Control	8.85 b[1]	9.54 b	A[2]	8.16 b	A	
Fertilizer	10.63 ab	12.77 ab	A	9.99 ab	A	
12.5 $t.ha^{-1}$TSS	11.29 ab	11.87 ab	A	10.72 ab	A	
25.0 $t.ha^{-1}$TSS	12.79 a	12.86 ab	A	12.73 a	A	
37.5 $t.ha^{-1}$TSS	13.08 a	14.54 a	A	11.61 ab	A	
	**	**		**		

Significant differences between treatments at ** P≤ 0,01 or * P≤ 0,05 level indicated by different letters. [1]Small letter in column for applications, [2]capital letter in row for years.

Table 5. Effect of successive two years treated sewage sludge (TSS) applications on grain yield of second crop wheat grown in sandy loam soil
Tukey: P≤ 0,05

Applications	Control	Fertilizer	12.5t.ha^{-1}TSS	25.0t.ha^{-1}TSS	37.5t.ha^{-1}TSS
Grain yield of second crop wheat (t.ha^{-1})	3.536 b[1]	4.961 a	4.233 ab	3.955 ab	5.149 a

[1]Significant differences between treatments at * P≤ 0,05 level indicated by different letters.

Effect of successive two years treated sewage sludge applications (TSS) on total N, plant available P and K content of sandy loam soil

Effect of successive two years treated sewage sludge applications on total N, plant available P and K content of sandy loam soil is given in Table 6, 7 and 8, respectively.

Table 6. Effect of successive two years TSS applications on total N content of sandy loam soil
Total N (%) Tukey: P≤ 0,01; P≤ 0,05

Applications	**Aver-age of 5**	**Soil sampling periods**										
		1		**2**		**3**		**4**		**5**		
Control	0.093 b[1]	0.141 b	A[2]	0.123 b	AB	0.079 a	BC	0.083 b	BC	0.041 a	C	**
Fertilizer	0.106 b	0.161 ab	A	0.130 b	AB	0.081 a	BC	0.106 ab	BC	0.052 a	C	**
12.5 t.ha^{-1}TSS	0.107 b	0.146 b	A	0.130 b	A	0.091 a	AB	0.113 ab	A	0.057 a	B	**
25.0 t.ha^{-1}TSS	0.117 ab	0.167 ab	A	0.139 b	AB	0.093 a	BC	0.117 ab	ABC	0.070 a	C	**
37.5 t.ha^{-1}TSS	0.144 a	0.207 a	A	0.209 a	A	0.107 a	BC	0.129 a	B	0.071 a	C	**
	**	**		**				*				

Significant differences between treatments at ** P≤ 0,01or *P≤ 0,05 level indicated by different letters. [1]Small letter in column for applications, [2]capital letter in row for periods.

Table 7. Effect of successive two years TSS applications on plant available ($NaHCO_3$-extractable) P content of sandy loam soil
Available P (mg.kg^{-1}) Tukey:P≤ 0,01

Applications	**Average of 5 peri-**	**Soil sampling periods**										
		1		**2**		**3**		**4**		**5**		
Control	89.07 c[1]	126.74 c	A[2]	86.30 d	B	79.92 b	B	77.02 b	B	75.39 b	B	**
Fertilizer	111.78 c	173.84 b	A	100.39 cd	B	106,39 ab	B	88.52 ab	B	89.76 ab	B	**
12.5 t.ha^{-1}TSS	125.89 bc	185.13 ab	A	130.60 bc	B	100.21 ab	B	110.00 ab	B	103.49 ab	B	**
25.0 t.ha^{-1}TSS	139.87 ab	204.38 ab	A	154.40 ab	B	108.76 ab	C	118.72 a	BC	113.09 ab	C	**
37.5 t.ha^{-1}TSS	154.53a	222.34 a	A	184.99 a	A	122.67 a	B	127.38 a	B	115.29 a	B	**
	**	**		**		**		**		**		

Significant differences between treatments at ** P≤ 0,01 level indicated by different letters. [1]Small letter in column for applications, [2]capital letter in row for periods.

Table 8. Effect of successive two years treated sewage sludge (TSS) applications on plant available (1N NH_4OAc- extractable) K content of sandy loam soil
Available K ($mg.kg^{-1}$)Tukey:P≤ 0,01

Applications	Average of 5 peri-	Soil sampling periods										
		1		2		3		4		5		
Control	480.92 b[1]	590.45 a	A[2]	497.04 a	AB	432.89 a	B	445.70 a	B	438.52 a	B	**
Fertilizer	552.89 a	643.42 a	A	511.66 a	B	496.25 a	B	622.65 a	A	490.45 a	B	**
12.5 $t.ha^{-1}$TSS	514.67 ab	611.46 a	A	509.22 a	BC	461.62 a	BC	551.44 a	AB	439.62 a	C	**
25.0 $t.ha^{-1}$TSS	527.46 ab	638.76 a	A	518.97 a	BC	470.89 a	BC	559.62 a	AB	449.09 a	C	**
37.5 $t.ha^{-1}$TSS	550.61 a	644.10 a	A	564.63 a	ABC	503.89 a	BC	571.57 a	AB	468.85 a	C	**
	**											

Significant differences between treatments at ** P≤ 0,01 level indicated by different letters. [1]Small letter in column for applications, [2]capital letter in row for periods.

Effect of successive two years TSS applications on some properties of sandy loam soil

Effect of successive two years TSS applications on pH, total salt, $CaCO_3$, cation exchange capacity (CEC) and OM content of sandy loam soil is given in Table 9, 10, 11, 12 and 13, respectively.

Table 9. Effect of successive two years TSS applications on pH of sandy loam soil
pH Tukey:P≤ 0,01

Applications	Average of 5 peri-	Soil sampling periods										
		1		2		3		4		5		
Control	7.79 a[1]	7.50 a	C[2]	8.00 a	A	7.78 a	B	7.66 a	B	8.01 a	A	**
Fertilizer	7.76 a	7.52 a	C	7.98 a	A	7.75 a	B	7.58 a	C	7.97 a	A	**
12.5 $t.ha^{-1}$TSS	7.79 a	7.59 a	C	8.00 a	A	7.76 a	B	7.67 a	C	7.94 a	A	**
25.0 $t.ha^{-1}$TSS	7.78 a	7.58 a	C	8.04 a	A	7.80 a	B	7.58 a	C	7.93 a	A	**
37.5 $t.ha^{-1}$TSS	7.79 a	7.56 a	C	8.10 a	A	7.78 a	B	7.59 a	C	7.96 a	A	**

Significant differences between treatments at ** P≤ 0,01 or * P≤ 0,05 level indicated by different letters. [1]Small letter in column for applications, [2]capital letter in row for periods.

Table 10. Effect of successive two years TSS applications on total salt content of sandy loam soil
Total salt (%) Tukey:P≤ 0,01; P≤ 0,05

Applications	Aver-age of 5	Soil sampling periods										
		1		2		3		4		5		
Control	0.067 c[1]	0.094 b	AB[2]	0.038 a	BC	0.026 a	C	0.101 b	A	0.078 c	ABC	*
Fertilizer	0.084 bc	0.135 ab	A	0.031 a	B	0.028 a	B	0.115 b	A	0.111 bc	A	**
12.5 $t.ha^{-1}$TSS	0.084 bc	0.105 b	AB	0.046 a	B	0.031 a	B	0.133 b	A	0.104 bc	AB	**
25.0 $t.ha^{-1}$TSS	0.113 ab	0.138 ab	A	0.056 a	B	0.033 a	B	0.170 ab	A	0.169 ab	A	**
37.5 $t.ha^{-1}$TSS	0.151 a	0.183 a	A	0.088 a	B	0.033 a	B	0.230 a	A	0.224 a	A	**
	**	**						**		**		

Significant differences between treatments at ** P≤ 0,01 or * P≤ 0,05 level indicated by different letters. [1]Small letter in column for applications, [2]capital letter in row for periods.

Table 11. Effect of successive two years TSS applications on $CaCO_3$ content of sandy loam soil
$CaCO_3$ (%) Tukey:P≤ 0,01; P≤ 0,05

Applications	Average of 5	Soil sampling periods										
		1		2		3		4		5		
Control	4.68 b[1]	4.49 ab	B[2]	4.48 b	B	5.06 a	A	4.49 a	B	4.89 ab	AB	**
Fertilizer	4.61 b	4.24 b	B	4.43 b	B	5.24 a	A	4.52 a	B	4.64 b	AB	**
12.5 $t.ha^{-1}$TSS	4.88 ab	4.43 ab	C	4.68 ab	BC	5.30 a	AB	4.61 a	C	5.36 a	A	**
25.0 $t.ha^{-1}$TSS	4.88 ab	4.50 ab	C	4.67 ab	BC	5.34 a	A	4.69 a	ABC	5.19 ab	AB	**
37.5 $t.ha^{-1}$TSS	5.14 a	4.85 a	B	5.23 a	AB	5.15 a	AB	4.95 a	AB	5.54 a	A	**
	**	*		**						**		

Significant differences between treatments at ** P≤ 0,01 or * P≤ 0,05 level indicated by different letters. [1]Small letter in column for applications, [2]capital letter in row for periods.

Table 12. Effect of successive two years TSS applications on cation exchange capacity (CEC) of sandy loam soil
CEC (meq/100g) Tukey:P≤ 0,01; P≤ 0,05

Applications	Average of 5	Soil sampling periods										
		1		2		3		4		5		
Control	11.67 b[1]	11.36 b	AB[2]	11.04 b	B	10.12 b	B	12.01 ab	AB	13.81 b	A	**
Fertilizer	12.00 b	11.54 ab	B	12.20 b	AB	10.30 b	B	11.63 b	B	14.31 ab	A	**
12.5 $t.ha^{-1}$TSS	12.66 ab	12.40 ab	AB	12.68 ab	AB	10.91 ab	B	12.52 ab	AB	14.81 ab	A	**
25.0 $t.ha^{-1}$TSS	12.95 ab	12.81 ab	AB	12.65 ab	B	11.03 ab	B	13.11 ab	AB	15.15 ab	A	**
37.5 $t.ha^{-1}$TSS	13.96 a	13.45 a	BC	14.67 a	AB	11.84 a	C	13.68 a	ABC	16.14 a	A	**
	*	*		**				*		*		

Significant differences between treatments at ** P≤ 0,01 or * P≤ 0,05 level indicated by different letters. [1]Small letter in column for applications, [2]capital letter in row for periods.

Table 13. Effect of successive two years TSS applications on organic matter (OM) content of sandy loam soil
OM (%) Tukey: P≤ 0,01; P≤ 0,05

Applications	Average of 5	Soil sampling periods										
		1		2		3		4		5		
Control	1.70 b[1]	2.38 b	A[2]	1.53 b	B	1.57 b	B	1.53 b	B	1.50 b	B	**
Fertilizer	1.76 b	2.31 b	A	1.64 b	AB	1.67 ab	AB	1.66 b	AB	1.51 b	B	**
12.5 t.ha^{-1}TSS	1.97 ab	2.54 b	A	1.72 b	B	1.847 ab	AB	1.93 ab	AB	1.81 ab	B	**
25.0 t.ha^{-1}TSS	2.11 ab	2.69 ab	A	1.83 b	B	1.90 ab	B	2.26 a	AB	1.86 ab	B	**
37.5 t.ha^{-1}TSS	2.56 a	3.28 a	A	2.88 a	AB	2.17 a	C	2.53 a	BC	2.11 a	C	**
	**	**		**		*		**		*		

Significant differences between treatments at ** P≤ 0,01or *P≤ 0,05 level indicated by different letters. [1]Small letter in column for applications, [2]capital letter in row for periods.

Discussion

The increasing TSS rates significantly increased average of 1st and 2nd year total biomass and grain yield of corn in the experiment. The higher yields in sludge-treated crops are usually attributed to an improvement in the soil conditions, by the supply of additional C from the sludge (Navas et al., 1998; Christie et al., 2001).

The highest grain yield of wheat as second crop was found with the highest TSS application. It can be said that nutrient concentration and good physical conditions (like good aeration and water holding capacity) in the soil increased grain yield of second crop wheat. Tamrabet et al. (2009) reported that sewage sludge increased the grain yield and straw production of wheat. Ailincăi et al. (2010) also mentioned highest increase in the grain and straw yield of wheat treated with sewage sludge.

Successive two years TSS applications significantly increased total N concentration of the average of 5 sampling periods of soil compared with the control. Total N concentration in the soil decreased particularly in the 3rd period in the first year and in the 5th period in second year because of the plant uptake of N in soil. Brofas et al. (2000) stated that N concentration increased with sludge applications. Magdoff and Amadon (1980) estimated that 55% of organic N in sludge incorporated in soil was mineralized during the first year. A good N balance is a critical factor in any land application program. Over application of N can result in groundwater contamination. Under application can lead to less than optimum crop yields and consequently to farmer dissatisfaction. It is important that sufficient sludge is applied to obtain optimum crop response without excessive NO_3-leaching.

Applications of increasing TSS rates significantly increased the plant available P concentrations of soil in 5 different soil sampling periods according to the control. In the course of time, depending on decomposition of OM and using of plant available P in soil by produced plants, the effect of TSS rates on plant available P concentrations in soil decreased especially in the last periods. Brofas et al. (2000) also reported a remarkable increase in plant available P in soil after the application of sewage sludge.

Increasing TSS rates significantly increased available K concentration of the average of 5 sampling periods of soil compared with the control. In the last period (5), all available K concentrations of soil samples were nearly the same. Delibacak et al. (2009a) found that, plant available K increased with TSS rates from 340 mg kg^{-1} in the control parcels to 419 mg kg^{-1} with the 90 t ha^{-1} application rate.

The increasing TSS rates did not significantly affect pH values of the average of 5 sampling periods of soil compared with the control. It is recommended that soil pH should be maintained above 6.5 for sludge amended soils (Henning et al., 2001).

Successive two years TSS applications significantly increased total salt content of the average of 5 sampling periods of soil compared with the control. The highest total salt was found as 0.151% with 37.5 $t.ha^{-1}$TSS application. This was followed by 25.0 (0.113%) and 12.5 $t.ha^{-1}$ TSS (0.084%) levels and mineral fertilizer application (0.084%), respectively (Table 10). First and 4th soil sampling periods had highest salt content. These periods were TSS applications periods for 1st and 2nd years.

Effect of successive two years TSS applications were significantly increased $CaCO_3$ content of the average of 5 sampling periods of soil compared with the control. It can be said that high $CaCO_3$ content of TSS (10.24%) caused this situation. Also Delibacak and Ongun (2016) determined that $CaCO_3$ content of soil was significantly affected by the TSS applications in their research.

It was found that, effect of successive two years TSS applications were significantly increased CEC of soil in all periods. Alcantara et al. [(2009) 47] observed that the concentrations of phosphorus, nitrogen, sulfate, and CEC, organic carbon were positively correlated with sewage sludge dose applied to the soil.

Treatments of successive two years TSS significantly increased OM content of soil samples in all periods. It can be said that high OM content of TSS (70.32%) caused this situation. Analogously to our study, Delibacak et al. [(2009b) 48] found out an increase in the concentrations of OM in soil caused by increasing doses of sewage sludge introduced to soil.

It is recommended that 37.5 $t.ha^{-1}$ TSS as dry matter can be added every year for improving plant nutrients and soil properties of sandy loam soil under Mediterranean climate, which are characterized by low OM content and high pH. Sewage sludge application to agricultural land has been a widely accepted practice during recent years. Its use in agricultural land is promoted because it is considered that it will solve not only the problem of disposal but also will increase productivity in agriculture. Further investigations are necessary to quantify the fertiliser replacement value of plant nutrients. In particular, accurately characterising the P fertilizer replacement value of sewage sludge will become an increasingly important issue for effective P recycling in agricultural production and food security in future as geological P reserves are depleted and P fertiliser costs increase. More continuous long-term experiments are needed to improve the understanding of the effects of sewage sludge on soil fertility and crop yield to contribute to the development of sustainable agricultural practices. However, negative effects of sewage sludge such as elevated heavy metal levels resulting from the usage of sewage sludge must also be taken into consideration. Sewage sludge containing pathogenic organisms should be handled and applied in a proper manner to reduce the risks to human and animal health. Finally, the application of TSS to soil must obey the limited regulations. After the analysis of sewage sludge and soil, a governmental permission is needed to apply them to agricultural lands in Turkey.

Acknowledgements

We thank the Scientific and Technical Research Council of Turkey for financial support (Project no: 108G167).

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The effect of biochar on the intensity of soil respiration: model experiment

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Abstract

The aim of the work was to estimate the duration of pre-incubation of soil:biochar model mixtures (in a ratio of 20: 1) on the intensity of basal respiration (BR) and substrate-induced respiration (SIR) of soils. For the experiment we used 10 biochar samples prepared from various wood and herbaceous residues in different slow pyrolysis regimes at temperatures below 400°C and in the interval 490-590° C. At different stages of incubation there is a positive and negative effect of biochar on the SIR and BR in comparison with the control. In the early stages of the model experiment (3 days) the biochar effect on the soil respiration is multidirectional, during the incubation for 3 and 6 months the effect on the SIR and BR becomes positive. For all variants of the incubation experiment during 6 months there is the general tendency to reduce the intensity of BR compared to the control.
At short-term incubation were obtained 3 statistically significant regression coefficients which show the effect of the biochar properties on the value of the SIR: the content of medium-oxidizable fraction of organic matter (b1=0,317), the water pH (b2=0,536) and sodium content in acetate extract (b3=-0,15). When incubated for 3 months only the content of the medium-oxidizable fraction of organic matter (b1=0.277) significantly affects the intensity of SIR, when incubated for 6 months - the ash content (b1=0,062).
Key words: biochar, soil respiration, model experiment, basal respiration, substrate-induced respiration

Introduction

The introduction of biochar to the soil allows in the future to solve the most important problems of our time - long-term improvement of soil fertility, waste utilization, and the sequestration of atmospheric carbon. Efficiency of biochar use to prevent global climate change is based on its resistance to microbial degradation and the slow return of organic matter to the atmosphere (Lehmann 2007). However, many studies indicate that the pyrogenic organic matter in soils can affect the stability of the soil carbon pool. The authors studies (Crow et al., 2009, Cross and Sohi, 2011, Luo et al., 2011; Jien et al., 2015; Luo et al., 2011; Jien et al., 2015) showed that when added to soils of biochar there is the increase in soil respiration due to the decomposition of soil organic matter - a positive priming effect. Some authors in the researh works (Kuzyakov et al., 2009, Zimmerman et al., 2011) show that the biochar addition on the contrary reduces the rate of mineralization of soil organic matter-a negative priming effect. Also, the authors (Zavalloni et al., 2011, Rizhiya et al., 2015) noted the absence of the significant effect of biochar on soil respiration. In review (Lehmann et al. 2011) the author notes that there are numerous studies on the effect of biochar on soil properties and on the state of soil biota, but little is known about the mechanisms of the effect of biochar on the composition and abundance of the microbial community of soils.
The aim of the work was to estimate the duration of pre-incubation of soil:biochar model mixtures (in a ratio of 20:1) on the intensity of basal respiration (BR) and substrate-induced respiration (SIR) of soils.

Materials & Methods

For the experiment we used 10 biochar samples prepared from various wood and herbaceous residues in different slow pyrolysis regimes at temperatures below 400°C and in the interval 490-590°C (Valeeva et al., 2014; Giniyatullin et al., 2015). For the model experiment the sample of humus horizon from Luvisoil selected in June under the broadleaf forest was used. The soil with biochar was mixed in a ratio of 20:1 in Petri dishes. Petri dishes with model mixtures are stored in a thermostat with periodic ventilate to provide free access of oxygen. The initial moisture of model mixtures maintained gravimetrically. The determination of SIR and BR was performed in four replicates via 3, 95 and 187 days of pre-incubation on a Clarus 580 gas chromatograph (PerkinElmer) with a catrometer as a CO_2 detector. Regression analysis was used to evaluate the biochar properties affecting the intensity of SIR.

Results & Discussion

The results of the study showed that, depending on the duration of the incubation the effect of biochar on the soil respiration is multidirectional. In the early stages of incubation (3 day) there is the positive and negative effect of biochar influence on SIR compared to control (fig.1). At the incubation of 3 and 6 months the effect of biochar influence is positive in all variants.

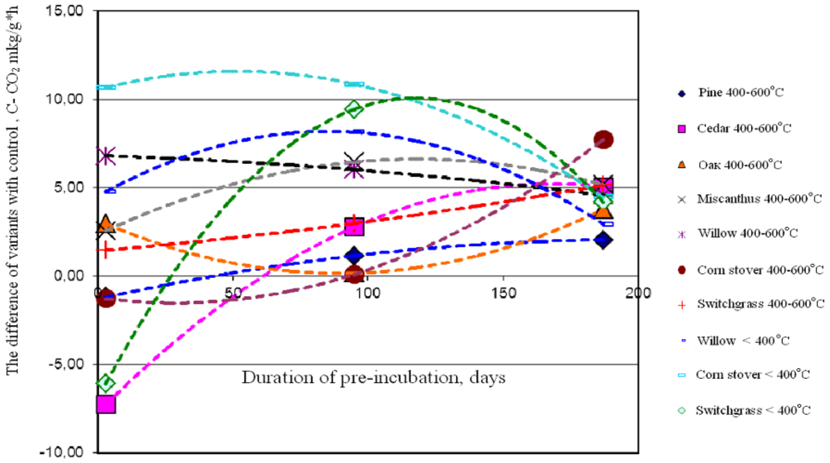

Fig.1. Difference of SIR intensity (data approximated by polynomial curves of the second order)

The effect of biochar addition on the dynamics of changes of BR in comparison with the control has the same character as the effect on SIR (fig.2). In contrast to SIR for all variants of incubation experience within 6 months there is a decrease in BR compared to the control.

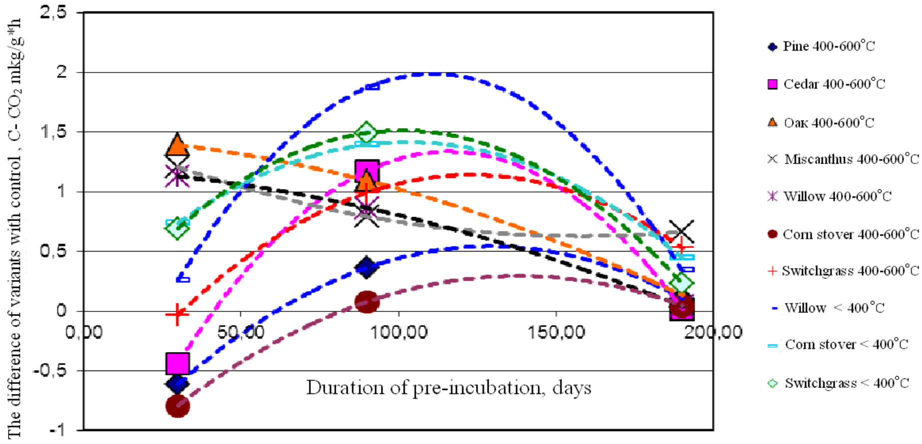

Fig.2. Difference of BR intensity (data approximated by polynomial curves of the second order)

Thus, the 3-month pre-incubation leads to the establishment of equilibrium relations in the complex model system of soil:biochar which provides the reliability of determining the parameters of soil respiration.
The results of the regression analysis showed that at short-term incubation were obtained 3 statistically significant regression coefficients which show the effect of the biochar properties on the value of the SIR: the content of medium-oxidizable fraction of organic matter (b1=0,317), the water pH (b2=0,536) and sodium content in acetate extract (b3=-0,15). When incubated for 3 months only the content of the medium-oxidizable fraction of organic matter (b1=0.277) significantly affects the intensity of SIR, when incubated for 6 months - the ash content (b1=0,062).

Acknowledgement

The part of this project was supported by the Russian Foundation for Basic Research (project № 17-04-00869).

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Heterogeneity of typical chernozem productivity in Ukraine

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Abstract

The article considers the spatial heterogeneity of the water regime and soil productivity of the flat areas of the Right-bank Forest-Steppe of Ukraine, where typical chernozems are widespread. The most important factor of this heterogeneity is the presence of micro- and mesodepressions of topography, in which spring meltwater is flooded with various depths and duration of flooding. . In the conditions of such a feature of the relief and the water regime of the territory, the formation of a complex soil cover with significant differences in soil properties was revealed, and especially with the manifestations of leaching and gleying of soils on the slopes and bottoms of depressions . The decrease in the yield of soils on the bottom and slopes of relief depressions and the total yield loss from the fields of about 22-23% have been experimentally revealed in the field experiment. The expediency and effectiveness of the use of UAVs (drones), the GPS receiver and space images Landsat-8 and Sentinel-2 for remote studies of the dynamics of the water regime of microdepressions and the state of vegetation was confirmed. It is recommended to use these tools and methods in compiling detailed soil maps of plains with microdepressions of the relief.
Key words: spatial heterogeneity, productivity, soil, water regime, microdepressions.

Introduction

For the introduction of accurate farming in typical chernozems in Ukraine, as well as in other regions, it is important to take into account the spatial heterogeneity of their properties and fertility. Even in the classic works of Fridland V.M. [1] and other well-known pedologists, and in Ukraine - especially in the works of V.V. Medvedev [2], the main regularities of the heterogeneity and complexity of the soil cover were shown depending on the properties, morphological features, lithological structure of soils and other indicators.
But the spatial heterogeneity of the soil cover and the productivity of soils in the Forest-steppe zone with the presence of numerous micro- and mesodepressions has a special significance for soil science and for production. And if in the Left-bank Forest-steppe of Ukraine the formation of a complex soil cover on plains with such relief depressions was mainly associated with the processes of salinization, alkalinity and solodization, then the situation in the Right-bank Forest-steppe is different. Here, soils of microdepressions (Fig. 1) are formed with the participation of leaching and gleying processes under the influence of flooding (up to 2-3 weeks) by melt waters in the spring, as well as redistribution of rainfall water during the vegetation period by the relief . Therefore, on different morphological elements of depressions, a different water regime of the soil is created and, consequently, with different morphological features, soil properties, depth of occurrence of carbonates [3, 4].
At the same time, geological and geomorphological data show that the role of micro- and mesodepressions on the plains of the Forest-Steppe is much more diverse than just the formation of a complex soil cover. In particular, when surface waters are filtered in them, agrochemicals, radionuclides, pollutants enter deep horizons. Such depressions are not silted for centuries, either because part of the solid phase of the soil penetrates deep with filtering waters. A simplified (production-economic) approach to the role of such lowering of relief in the plains prevails in the United States and in the "western" countries, where under the name "potholes" are considered depressions of different depths and sizes.

Figure 1. Lowerings of the relief, filled with thawed water for 2-3 weeks after intensive snowmelt, on the Sentinel 2A satellite image (resolution 10 m)

Materials and Methods

We have been conducting research on this problem since 2008 in the Right-bank Forest-steppe soil province of Ukraine on typical chernozems. Detailed studies are carried out on an area of 32.5 hectares, and estimated - on an area of 400 ha within the educational facilities of the NULES of Ukraine near the town of Fastov. In the plain, as well as on the slopes and bottom of micro- and mesodepressions with different depths, soil sections up to 200 cm were dug out. To determine the depth of occurrence of the carbonate horizon, the experimental field was covered by a network of wells approximately 50 x 50 m grid and not more than 500 cm deep, that is, to a depth occurrence of groundwater. To accurately position the location of the wells, the GPS receiver Garmin vista HCX was used. The spatial heterogeneity and seasonal dynamics of flooding of microdepressions by meltwaters were observed with the help of UAV (quadrocopter), and the water regime of soils was sampled by boring and drying at 105 degrees. The development of plants in the experimental field (in 2017 - winter wheat of the variety "Marlene") was observed from space images Landsat-8 and Sentinel-2a and 2b, as well as visually. The yield of wheat was determined on different elements of the relief of the depressions and on the plain (control) by the method of mowing the "meters" in 4 replicates and drying to an air-dry state.

Results and Discussion

The distribution of melt water over the surface of the plain with micro- and mesodepressions has been investigated since March 1, 2017, that is, from the second day after the massive intensive melting of snow. The water layer in the depressions was predominantly 30-50 cm. The nature of the distribution of thawed water in depressions with still frozen soil is shown in Fig. 2. Further observations of the water regime and the state of the plants of winter wheat were carried out at key sites (Fig. 3). Water gradually absorbed into the soil in cool weather for three weeks. As of March 20, that is, 21 days after flooding, water remained only on the bottom of the deepest (up to 50-60 cm) depressions, as on key 5 (Fig. 3). The condition of the wheat plants clearly reflected the duration of the flooding - on the flat bottom of the depression the plants died (wetted), and on the slopes their status reflected the duration of flooding: after 1 week flooding the growth-inhibiting was moderate, and after 2 weeks - severe. During the growing season, the state of the plants on the slopes was partially restored, but the spatial heterogeneity of the productivity of the soil remained very clearly (Fig. 4).

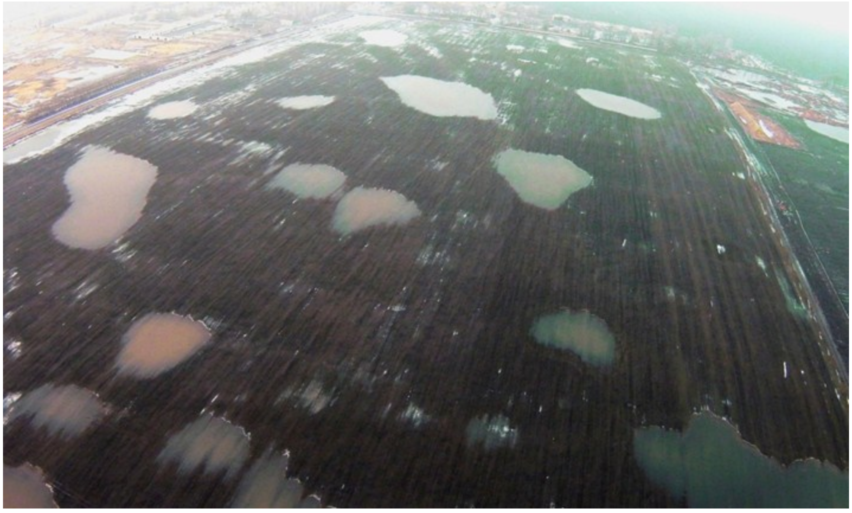

Figure 2. Depressions filling with melted water on the experimental field on March 1, 2017

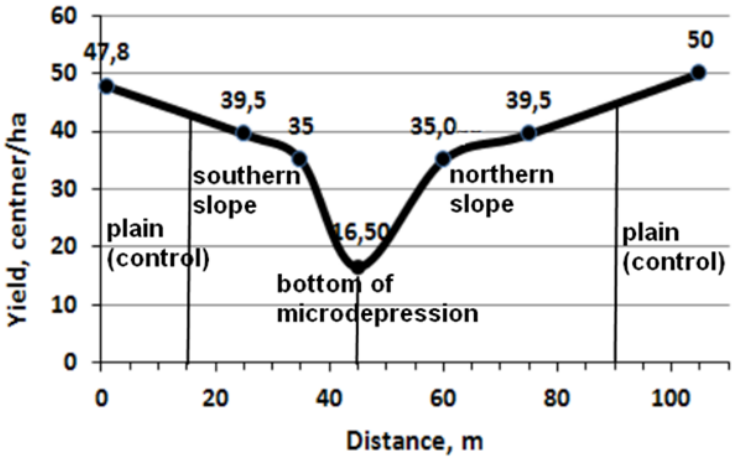

Figure 3. State of plants of winter wheat on slopes, depending on the duration of flooding (from 1 to 3 weeks). Pictures taken by UAV on 1 and 20 March 2017

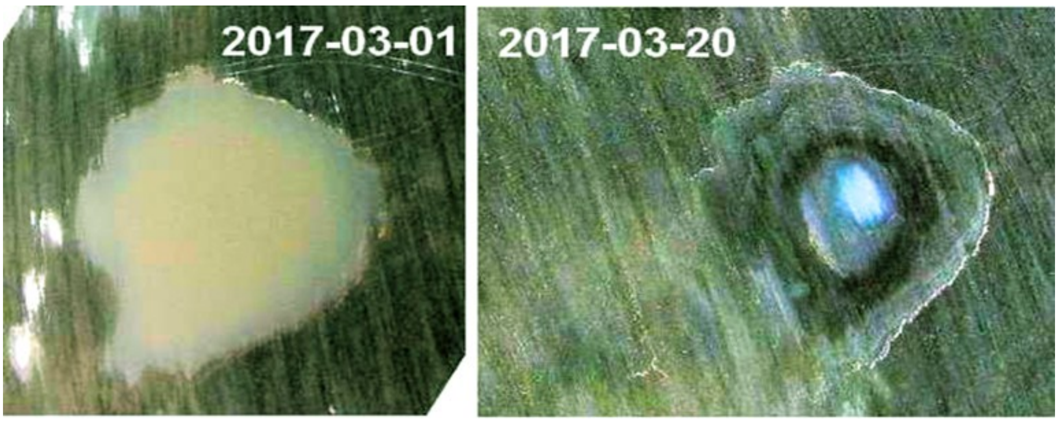

Figure 4. Differentiation of winter wheat productivity on elements of relief of microdepression in length 75 and width of 40 m

Figure 5. State of the field of winter wheat on the eve of harvesting

And the general view of the experimental field shows that on the eve of wheat harvesting all depressions of the field relief turned out to be overgrown with weeds (Fig. 5). In addition, the preserved wheat plants lagged behind in development and the grain was in milky wax ripeness.

Conclusion

The productivity of chernozem soils on the plains with micro- and mesodepressions decreases substantially due to melting water overmoistening in spring. The greatest yield of winter wheat was recorded on the plain with chernozem typical light loam (51.2 c / ha). On the slopes of the depressions, occupied mainly by leached chernozems, the yield was not more than 39.5 centner / ha, and on the bottom of depressions only 16.5 centner / ha. In general, the decrease in yields in the field studied was about 12 centner / ha, and the total yield was 38 tons less than it could have been on the plain with a uniform soil cover. Applied to the whole farm with a wheat area of 633 hectares, the yield was 740 tons less than it could be on a plain with typical chernozems. At the same time, studies have shown the validity and effectiveness of the use of UAVs (drones), the GPS receiver and space images Landsat and Sentinel to study the spatial heterogeneity of the water regime and soil productivity of fields with microdepressions of the relief. The use of these tools and methods in the compilation of detailed soil maps is suggested.

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Structure of typical chernozem of different biosystems

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Abstract

We have investigated the structure of the typical chernozem on the aggregate level of its organization. The differences in the aggregate composition and in the properties of the picked-out aggregates are closely connected with the content and transformation of the organic matter inside aggregates. The location of the chernozem under the forest has led to the accumulation of the organic carbon and, as the result, to the increasing of the content of agronomically valuable aggregates in the upper horizon from 74,5% to 95,6%. Profile under the forest in comparison with profile under the arable land is much more hydrophobic. The general trend of the metamorphism of the chernozem under the prolonged fallow is the reduction of the share of hydrophobic humic substances and the increasing of content of hydrophobic substances. The general trend of the metamorphism of the chernozem under the prolonged fallow is the reduction of the share of hydrophobic humic substances and the increasing of content of hydrophobic substances. The content of the organic carbon in the soil under the prolonged fallow for the last 60 years has decreased. It has reached the constant value (about 2,6%) in the last twenty years.

Key words: soil's structure, aggregates, soil's organic matter, waterstability. wettability.

Introduction

The formation of soil aggregate is the result of the set of complex processes of the structure formation. Its composition and properties reflect all changes occurring in the soil in the annual and perennial cycles of soil's development. The soil's structure and soil aggregates are the essence of the soil, and that is the thing, which distinguishes it from the parent material, and which is the basis of sustainable functioning of soil [4]. Soil structure determines water, salt, heat and nutrient regimes of the soil, that's why the special attention must be payed to studying of soil structure and soil aggregates - the unique soil formation.
The aim of this work is to study the aggregate composition of the typical chernozem under different biocenosis.

Materials and Methods

The objects of study are typical chernozems, located in the territory of the Kursk research institute of agriculture production (KRIoAP) (Russian Federation, Kursk region). There are profiles under the arable land (~ 250 years of tillage), under the forest (~ 50 years old), and two profiles in the Streletskaya steppe (Central Chernozem National Park named by V. V. Alekhin (CCNP)) - under the virgin and the prolonged fallow land. The Experimental fields of KRIoAP are located near the CCNP (the distance is about 15 km). The KRIoAP soils are a genetic analogue of the soils of the National Park, but they have different history of agriculture usage. These soils were under the arable land until the middle of the last century, i. e. more than 200 years. In the fifties of the last century the realization of the Stalin's plan of the transformation of the nature has been started and forest belts, protecting from drought, were created.
The estimation of soil's aggregate composition was conducted on the Vibratory Sieve Shaker AS 200 control, the particle size distribution – by the laser diffraction method. For all samples was determined the content of organic carbon by dry combustion in oxygen flow [5]. To

asses soil-water contact angle by sessile drop method digital drop shape analyze system (DSA100, KRUSS) was used.

Results and Discussion

According to the morphological characteristics, after the 50 years of growth of the forest the structure of typical chernozem has been improved. There is the deterioration of the aggregate structure in typical chernozem of the Streletskiy part of the National Park, located under the prolonged fallow, compared with the virgin land. The analysis of the aggregate composition (the dry shifting method) has shown (table 1), that the greatest content of agronomically valuable aggregates is under the forest and the smallest - at the site of the prolonged fallow.

Table 1. The aggregate composition (dry shifting) of typical chernozem from different biocenoses (horizons A 10-20 cm and A_{arable} 0-20 cm)

Fractions' diametr, mm	> 10	10-7	7-5	5-3	3-2	2-1	1-0,5	0,5-0,25	< 0,25	10-0,25
Virgin land	1,2	1,9	3,8	12,8	17,4	22,7	15,2	9,3	15,7	83,1
Fallow	15,6	8,1	6,8	7,8	6,7	11,6	14,6	11,7	17,1	67,3
Forest belt	0,2	1,4	8,8	25,2	25,0	22,4	9,0	3,8	4,2	95,6
Arable land	7,1	6,8	6,9	9,4	8,9	14,4	16,5	12,7	18,0	74,9

The differences in the aggregate composition and in the properties of the picked out aggregates are close connected with the content and transformation of the organic matter inside aggregates. The location of the chernozem under the forest has led to the accumulation of the organic carbon (figure 1) and, as the result, to the increasing of the content of agronomically valuable aggregates in the upper horizon from 74,5% to 95,6% (table 1). In the lower horizons of these soils there is the opposite tendency. Such decreasing of the content of organic matter in the arable horizon with its accumulation in the lower horizons of the profile can be the result of vertical migration of the hydrophilic compounds of the humic substances. Also, it can be the result of its formation in the lower part of profile, where the zone of the arboreal plants' roots distribution has been marked.

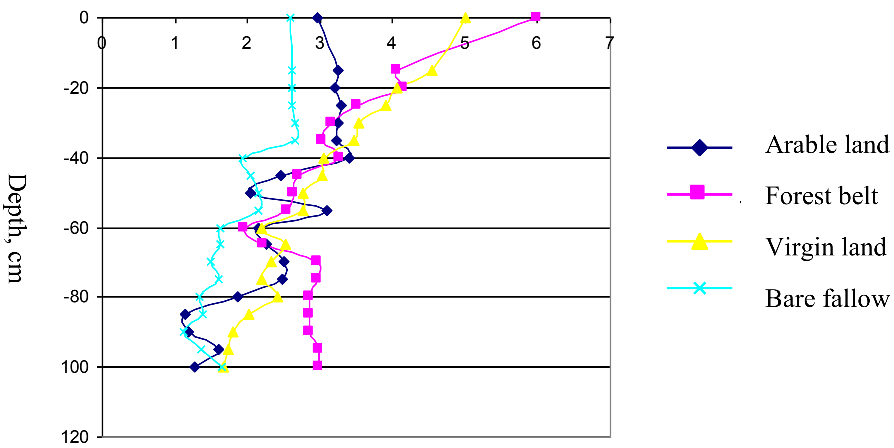

Figure 1. The content of organic carbon (%) in chernozems under different biosystems

In case of typical chernozem the absence of the plants leads to the changing of the thermal, water, gaze and salt regimes, and to the changing of biological cycle of substances in the soil-plant system. All researchers have observed the deterioration of the structure and the reduction of humus content in the topsoil during the tillage. In our case the most significate decreasing of content of the organic matter was occurred on the prolonged fallow land (figure 1), as the result – the dramatic reduction of the amount of water stable aggregates under the prolonged fallow and arable land (table 2).

Table 2. The content of water stable aggregates in typical chernozem from different biocenoses (horizons A 10-20 cm and A_{arable} 0-20 cm)

Fractions' diametr, mm	>10	10-7	7-5	5-3	3-2	2-1	1-0,5	0,5-0,25	<0,25
Virgin land	1,7	2,6	12,4	16,5	14,1	16,4	9,3	5,8	21,2
Fallow	0	0	0	0	0,1	1,5	7,5	28,0	62,9
Forest belt	0	0	0	0,1	0,6	1,2	2,5	20,7	74,9
Arable land	0	0	0	0	0	0	0,3	3,8	95,8

The general trend of the metamorpism of the chernozem under the prolonged fallow is the reduction of the share of hydrophobic humic substances and the increasing of content of hydrophobic substances. The lack of the heterotrophic microorganisms' sources of nutrition like fresh plant residues causes the microbiological mineralization of hydrophilic components of humic substances, forming the high and light fractions, and the relative accumulation chemically and microbiologically stable carbonized hydrophobic compounds. The mineralization of hydrophobic humic substances, which are the mediator between high-molecular hydrophobic compounds and mineral particles of heavy fractions, leads to the disfunction of their interaction. The result of the mineralization of hydrophilic components of humic substances is their carbonization and hydrophilisation in light fractions, which makes the aggregate not stable in the presence of water [3]. There is some information in literature, that water stable aggregates in comparison with aggregates, obtained after the dry shifting, contain less amount of the organic matter. Our research has shown that water stable aggregates have the higher content of organic matter. The particle size distribution in chernozem under the forest and under the arable land have the similar bimodal pattern with peaks at 2 and 20 µm, this fact indicates that these soils have the similar particle size distribution.

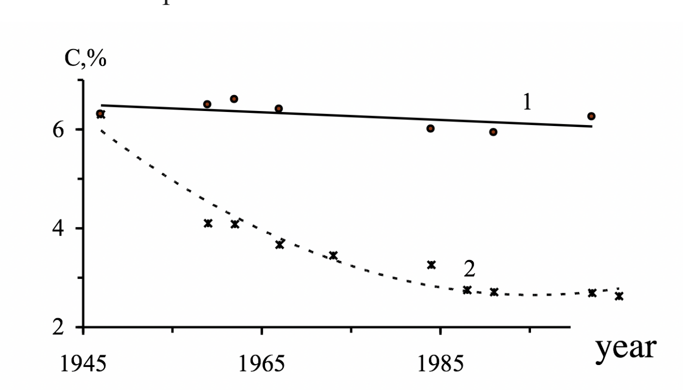

Figure 2. The content of organic carbon in the topsoil of typical chernozems under the virgin land (1) and under the bare fallow (2)

The literature data analysis [2, 3] and our researches have shown, that the content of the organic carbon in the soil under the prolonged fallow for the last 60 years has decreased. It has reached the constant value (about 2,6%) in the last twenty years (figure 2).
Bellamy et all. [1] have shown that all soils in England and Whales with the high content of organic matter, regardless of their type of usage for 25 years, have lost the organic carbon with the average speed about 0,6% (from the total content of organic carbon) per year. When the content of organic carbon was higher than 10% the loss rate had reached 2% per year. At the same time, in soils with 2-3% of organic carbon, its content was particularly constant and even increased in soils with the smaller content of organic carbon. Thus, the presence of a certain limiting amount of organic matter (2-3%), resistant to natural climatic and anthropogenic changes, on a wide time scale, in the soil is confirmed.

Conclusions

The dynamic of the soil structure and its water resistance are the function of the content and transformation of the organic matter inside the structure elements. The location of the chernozem under the bare fallow for a long time has led to the total decreasing of content of organic matter and the amount of the water stable aggregates in the soil profile. So, we can notice, an increasing of the structure's waterstability in the profiles under the forest and the accumulation of the organic matter there is the predicted result.

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Impact of the long-term application of phosphoric fertilizers on accumulation and concentration of mobile phosphorus in the light chestnut soil in sugar beets crop rotation and its growing without rotation

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Key words: Phosphorus fertilizer, sowing without rotation, sugar beets crop rotation, systematic application of fertilizers, mobile phosphorus, herbal link.

Introduction

The research works of a number of researchers deal with the studies of the influence of long-term and systematic application of mineral fertilizers on quantitative and qualitative changes of specific elements of soil fertility [1, 2, 4]. The soils of the irrigated zone of the Southeast of Kazakhstan have not been adequately studied in this respect. The available works discuss only certain aspects of this work, the results of which are mainly focused on the influence of the explored factors on productivity of crop rotation.
The impact of the duration of application of phosphorus fertilizers on the quantitative and qualitative composition of phosphates and the study of the role of some predecessors has not been studied sufficiently [3, 4, 6, 7]. In this connection, we performed soil chemical analyzes which were selected from stationary experiments of 8-field beet crop rotation conducted on light chestnut soil with sugar beet in 1961.
In this paper, we show the effect of the factors studied on the accumulation and composition of mobile phosphorus when phosphorus fertilizer is applied to various predecessors of sugar beet and in its permanent seeding at the end of second rotation.

Materials and Methods

Experimental studies were carried out on the basis of analysis of soil samples taken at the end of the second rotation of 8-field beet crop rotation and in cultivation of sugar beet without rotation. Crop rotation crops was as follows: 1. Alfalfa; 2. Alfalfa; 3. Sugar beet; 4. Sugar beet; 5. Sugar beet; 6. Winter wheat; 7. Sugar beet; 8. Winter wheat + alfalfa.
In the second rotation and on the field of sugar beet crops without rotation, soil samples were selected for analysis from the following options: 1) Control; 2) NK background 3) NK + P (1961 g); 4) NK + 1.5 P (1961). Phosphoric fertilizers were applied in the forms of simple and double superphosphate, nitrogen - ammonium nitrate and urea, potash - potassium chloride and potassium salt. Single dose of fertilizers for sugar beet: N - 90, P - 120, K - 100, - on alfalfa layer////, N - 100, P - 100, K - 100 - in rotation of alfalfa layer and N - 120, P - 60, K-60 - in the third year of plowing alfalfa layer, and on the field of sugar beet crops without rotation was N-100, P-80, K-70. The repeatability of the analysis was 4-fold.
The agrochemical characteristics of the light-chestnut soil in the experimental section were as follows: humus concentration of soil layer 0-20 cm - 2.60%, total nitrogen 0.227, phosphorus 0.221%, K_2O- 1.9%, mobile phosphorus by Machigin method-24 mg / kg, exchange potassium - 558 mg /kg, CO_2 of carbonates - 3.0-4.3%.
In soil samples, total phosphorus was determined by the META method; mobile phosphorus - by method of B.P. Machigin.

Results and Discussion

The data of chemical analyzes (Table 1) show that concentration of mobile phosphorus in soil during vegetative period of plants is subject to considerable fluctuations and depended both on the dose of long-term application of phosphorus fertilizers and on the degree of its uptake by plants.

Table 1. Accumulation of mobile phosphorus in light chestnut soil under sugar beet crops in long-term and systematic application of phosphorus fertilizers in the layer, in rotation of alfalfa layer, in the third year of plowing alfalfa and in the sowing of sugar beets without rotation

Predecessor	Experiment options	Applied P_2O_5		Accumulation P_2O_5	
		kg/ha	%	kg/ha	%
Alfalfa layer	NK + P c 1961 г.	620	100	4,5	100
	NK + 1,5 P 1961 г.	930	150	21,8	484
Alfalfa layer rotation	NK + P c 1961 г.	720	100	12,0	100
	NK + 1,5 P 1961 г.	1080	150	31,1	259
The third year of plowing alfalfa	NK + P c 1961 г.	780	100	5	100
	NK + 1,5 P 1961 г.	1170	150	15,5	312
Sowing of sugar beet without rotation since 1962.	NK + P c 1961 г.	1120	100	29,2	100
	NK + 1,5 P 1961 г.	1680	150	33,2	113

It should be noted that a significant impact on phosphate regime of light chestnut soil has the crop which is predecessor to sugar beet. The concentration of mobile phosphorus in the grass link of sugar beet crop rotation and on the field with sowing of sugar beet without rotation was the lowest in the alfalfa layer. In terms of rotation and the third year of plowing of alfalfa layer, the concentration of mobile phosphorus has significantly increased, which is due to the accumulation of phosphorus in systematic application of phosphorus fertilizers, as well as mineralization of organic phosphates in soils associated with the duration of interrow cultivation. Thus, when sugar beet is growing on alfalfa layer, the concentration of mobile phosphorus increased to 30-32 mg kg of soil in systematic application of the rotation of one and a half dosages of phosphorus, whereas in terms of rotation of the layer, in the third year of plowing, and also in planting without rotation, it was achieved by introducing single doses of phosphorus fertilizers.

Particular these circumstances explain the relatively greater concentration of mobile phosphorus in soil on the field of sugar beet planting. It should be noted that concentration of mobile phosphorus in soil increases at a faster rate (in percentage) than the growth in the dose of phosphorus fertilizers.

Thus, if the size of accumulation of mobile phosphorus in the variant with long-term use of phosphate fertilizer application in single dosage (NK + P 1961) is taken as 100%, then in application of the same dose in the second crop rotation, the accumulation of mobile phosphorus in alfalfa layer is equal to zero, in rotation of alfalfa layer is 36.6%, and in the third year of plowing of alfalfa - 118%, i.e. there is a gradual increase in it as the sugar beet place is far from the alfalfa layer.

We carried out approximate empirical calculations of the coefficients of accumulation of mobile phosphorus in soil, which shows the value of increased concentration of mobile phosphorus in soil, from every 100 kg of applied phosphorus.

The results of the calculations show that the value of accumulation coefficient of mobile phosphorus in soil in systematic application of phosphorus fertilizers is directly dependent on the dose of phosphorus fertilizers.

In long-term and intensive use of phosphorus fertilizers in sugar beet crop rotation during cultivation of sugar beet in its herbaceous link in the second rotation, every 100 kg of applied phosphorus increased the stocks of mobile phosphates in the arable layer of soil: in alfalfa layer from 0.78 to 2.34, in alfalfa layer rotation - 1,15-2,88 and in the third rotation of alfalfa - 0,30 -2,10 mg per 1 kg of soil.

The coefficient of accumulation of mobile phosphorus on the field with cultivation of sugar beets without rotation with a single dose (1120 kg/ ha during 1962-1975) was 2.60 and in a one-and-a-half (1,680 kg/ ha since 1962) phosphorus dose - 1.97 mg / kg soil.

Conclusion

Systematic application of phosphorus fertilizer (over 16 years) contributes to a significant increase in the concentration of mobile phosphorus in light chestnut soil which are directly dependent on their norms. In systematic application of single doses of phosphate fertilizers in the rotation, the soil by the content of phosphates available to plants by the end of the second rotation of the crop rotation transfers from the category of low-supplied to the category of medium-supplied, and in application of a one-and-a-half dose - to the category of highly-supplied. In sowing of sugar beets without rotation, soil when applying a single dose of phosphorus, in the end of second rotation, transfers to the category of highly-supplied, and in application of one and a half dose, the soil is significantly enriched with the assimilated form of phosphorus, significantly reducing the coefficient of phosphorus application.

The obtained empirical data on the increase in the concentration of mobile phosphorus in soil from every 100 kg of phosphorus fertilizers applied can be used to determine the optimum doses of planned sugar beet yields.

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Environmental aspects of using mineral fertilizers in Kazakhstan and prospects of biologization of agriculture at the present stage

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Key words: Fertility, mineral fertilizers, ecology, organic farming, biologization, yield capacity.

Introduction

Optimization of the application of agrochemicals is the main condition for solving the problems of preservation and reproduction of soil fertility, improvement of ecological state, and achieving high productivity of agroecosystems.
The main strategic task of modern agriculture is the preservation and increase of fertility of soil surface, its ecological cleanliness, as the main wealth of any State, material basis for the existence of mankind on our planet. The life on Earth is impossible without soil surface and its ecological functions. Intensive exploitation of arable lands without taking measures to preserve and reproduce soil fertility has always led to a violation of the ecological balance of agroecosystems [1-3].
Current land cultivation of the republic, as a complex multi-vector link in agriculture, is aimed to ensure production of the required amount of ecologically friendly plant products, the increase and preservation of soil fertility
According to Kazakhstan scientists, the underestimation of environmental unfavorable effects in agriculture resulted in recent years in a significant deterioration in the quality of used land.
Since the beginning of the development of virgin lands, more than 1/3 of the initial humus concentration was lost, which is the main indicator of soil fertility. In the conditions of land cultivation, losses are more than 30%, and in irrigation conditions more than 50%. On average, the annual decrease in humus concentration of arable land in Kazakhstan is 0.5-1.2 t / ha.
The deterioration of soil humus state had a negative effect on the concentration of nutrient elements, which contributes to a simultaneous deterioration of soil agrochemical, agrophysical, agroecological properties.
In current conditions, we are faced with the fact that new economic entities are involved in extensive farming and they are not able to introduce crop rotations. The farmers don't use modern technologies of soil tillage, the systems of protecting plants against diseases, pests, weeds and the system of fertilizer application, which cause damage of soil fertility, crop cultivation using simplified technologies, decrease of crop rotation, and domination of monocrops. All of these facts in combination resulted in the intensive decline in fertility of agricultural land and consequently crop yields.

Materials and Methods

The data of scientific experimental studies of the RI, as well as statistical indicators of application of mineral fertilizers and the state of development of biological land cultivation in Kazakhstan have been summarized.

This article includes the data from the results of scientific research institutions of the Republic on the study of the effectiveness of mineral fertilizers and organic farming systems, as well as statistical data on intensive application of mineral fertilizers and crop yields.

Results and Discussion

World experience shows that the share of mineral fertilizers increases the yield of agricultural crops by 45-48%, and in scientifically grounded application, it ensures preservation and restoration of soil fertility, obtaining ecological-pure organic products [4-6].

The issues of the need for the application of mineral fertilizers in agriculture in Kazakhstan have been launched since 1965. During this period, the supplies of agricultural mineral fertilizers amounted to 170.4 thousand tons of as, per 1 hectare of arable land 3.6 kg of NPK were used. The average yield of the main crops, including spring wheat, was 6.1 c /ha; rice -19.1; maize for grain - 20.8; sugar beet - 235.8; cotton - 17,9; potatoes - 75.0 and vegetables - 66.1 c/ha.

The most intensive use of mineral fertilizers in the Republic was in 1986, where the total volume of fertilizer application was 1039 thous. tons, and the amount of fertilizer applied to a hectare of arable land was 29 kg. At the same time, phosphate fertilizer accounted for 56.9%, nitrogen - 39.7% and potash fertilizers - 3.4%.

With the increased volume of application of mineral fertilizers in the mentioned periods, the average yield of main agricultural crops increased: spring wheat from 6.6 to 10.1 c /ha; rice to 45.1 c / ha, maize for grain to 38.8 c / ha, sugar beet to 288.0 c /ha, cotton to 25.8 c / ha, potatoes to 106.2 and vegetables - up to 170.0 c / ha.

In connection with economic reform since 1986, production and supply of mineral fertilizers to agriculture have decreased sharply. So, the amount of mineral fertilizers used was: in 2010 - 78.4 thous.tons, in 2015 - 83.4 thous.tons, in 2016 - 100.4 thous.tons, in 2017 - 112.2 thous. tons, versus 1039 thous. tons.

At the same time, the volume of organic fertilizers decreased sharply, in 2010 -825.9 thous. tons, in 2015 - 1256 thous. tons, in 2016 - 1186 thous. tons, in 2017 - 1197 thous. tons versus 33.1 mln tons in 1986. At the same time, the intensity of application of fertilizer per 1 ha of arable land decreased to 4 kg/ha, and fertilized areas amounted to only 9%. All this led to a decrease in crop yields by an average of 30-35%.

These indicators convincingly show that use of organic and mineral fertilizers serves as the material basis for conservation and reproduction of soil fertility.

According to the calculated data of scientists of Kazakhstan, the annual demand for agriculture in mineral fertilizers should amount to 1350 thous. tons, including 405 thous. tons of nitrogen fertilizers, 921 thous. tons of phosphorus, and 24 thous. tons of potassium. Annual volumes of organic fertilizer use should be brought to the level of 24.5 mln tons.

Positively assessing the need to increase the use of mineral fertilizers, we should note a number of its negative aspects, in non-observance of scientifically based technologies for their use - without taking into account the level of soil fertility, biological features of crop nutrition, the level of planned yield and quality. In particular, the use of high doses of fertilizer reduces the utilization of nutrients from fertilizers, reduces the activity of biological activities of microflora, and reduces the quality of organic products. Taking into account these and other shortcomings, a number of scientists are promoting the refusal to use mineral fertilizers, suggesting a transition to a biological farming system.

These directions of maximum extent are based on the use of crop rotations, legumes, siderates, plant residues and organic wastes of non-agricultural origin, the use of minerals containing strains and microbial preparations, with minimal application of mineral fertilizers and plant protection products.

By 2025 the Government of the Republic of Kazakhstan plans to increase the area of biological farming lands to 2.5% of the total area of agricultural lands, including arable land - 3%, pastures and hayfields - up to 2%, and perennial plantations (horticulture, viticulture, berries) - 20%, potatoes, vegetables - up to 5% of their total area.
However, the production of organic products has not been properly development, both in production aspect and in scientific research. The main reasons restraining the development of organic agriculture in Kazakhstan are the lack of accessible information on the potential of this direction and the lack of ready-to-use, integrated technologies adapted to local conditions. The existing knowledge base in Kazakhstan, which is based on the results of applied research, does not contain enough information about the possibilities of organic agriculture.
Scientists of the Department of Agrochemistry and Soil Science have recently begun to conduct scientific and experimental work on the comparative evaluation of the effectiveness of biological and intensive farming systems for production of friendly organic products.
However, it is impossible to evaluate the advantages of a system based on the results of short -term field experiments. In the long-term perspective, it is necessary to carry out a nationwide inventory of agricultural lands on the republican scale, develop and involve the most fertile land into agricultural turnover. For cultivation of environmentally friendly production.
It is necessary to develop and improve the system of fertilizers application in organic farming. Identification of optimal parameters of agrochemical, agroecological, agrophysical properties of soils used for agronomical agriculture.
Currently, ensuring the land cultivation of Kazakhstan with necessary quantities of mineral fertilizers is a key problem. As for the development of organic production based on biologization, this is a great prospective issue of today and the future.

Conclusion

In the long term, it is necessary to further improve the adopted intensive farming systems, to find ways to optimally combine all soil fertility resources, and to correctly combine natural and artificial fertilizers. Use biological farming systems in specific conditions should be based on a scientific analysis.
Developing biological farming should not be opposed to existing traditional intensive farming systems. Biological agriculture in perspective should fit into existing traditional intensive farming and become its important part.

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The effects of different growing media on plant growth of Stevia (*Stevia rebaudiana)* and its nutrient content

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Abstract

The study investigates the effects of different growing media on the growth and nutrient content of Stevia rebaudiana. The experiment was conducted using six different growing media as Soil (S), Peat (P) and Soil:Peat:Farmyard Manure (S:P:FYM), Soil:Sand:Farmyard Manure (S:Sand:FYM) in the ratios of 1: 1: 1 and 2: 1: 1 for each combined growing media both with and without the application of basic fertilizer and carried out in three replications according to the randomized experimental design. As a basic fertilizer 100 mg kg-1 P2O5, 150 mg kg-1 K2O and 250 mg kg-1 N were applied as triple super phosphate K2SO4 and (NH4)2SO4, respectively. The highest mean plant growth values were obtained in the peat growing media with and without basic fertilizer application. The highest macro and micro nutrient contents were obtained in the basic fertilizer applications. The highest phosphorus (0.71 %), potassium (5.04 %), magnesium (1.16 %) and calcium (2.92 %) contents were obtained in the P, S:P:FYM (1:1:1), S:Sand: FYM (2:1:1) growing media, respectively. The highest zinc content (91.17 mg kg-1) was obtained in the S:Sand:FYM (1:1:1) media, while the highest copper (15.60 mg kg-1) and manganese contents (350.92 mg kg^{-1}) were obtained in the peat and soil growing media with basic fertilizer application . The highest iron content was found in the peat growing media without basic fertilizer application.

Key words: Growing media, Nutrient, Plant growth, Soil, Stevia.

Introduction

Today, the agriculture of medicinal and aromatic plants is carried out worldwide and varieties of many plant species can be developed to possess the desired properties. Medicinal and aromatic plants which are more prevalently used as spices and have a significant share in the export market were also growth in Turkey (Bayramoğlu, 2009).

The debate over the negative effects of artificial sweeteners, which are used in the food industry and especially in dietary products, on human health has led consumers to seek for natural sweeteners (Turgut, 2011). Stevia is a branched busy shrub from the Asteraceae family of South American origin and can be cultivated in large areas around the world (Soejarto, 2002). Stevia (Stevia rebaudiana) is found to contain high concentrations of sugar components, which resulted in its replacement of aspartame as a sweetener and reaching a global market share of 20% (Anonymous, 2017b). Stevia (Stevia rebaudiana) is successfully grown worldwide under different climatic conditions. Sandy, loamy and well-ventilated soils are reported to be suitable for the growth of stevia and nitrogenous fertilizers have a positive effect on its yield (Anonymous, 2017a).

The use of soil conditioners and organic fertilizers has become widespread both to enhance the availability of the nutrients that are, albeit present in soils, not available to the plants due to factors such as low pH and soil moisture with insufficient organic matter content and high lime content and to improve plant nutrition and development (Cooperband, 2004).

The aim of this study investigates the effects of different growing media on the development and yield of stevia (Stevia rebaudiana), which has been reported to be susceptible to the physical properties of soils (Anonymous, 2017a). Like other medicinal plants, stevia has a large market share (Anonymous, 2017b) and thus, the study aims to contribute to the production of the plant, which has recently received considerable attention, by increasing its yield using appropriate growing media.

Materials and Methods

This study was carried in a chamber room of Soil Science and Plant Nutrition Department in Agricultural Faculty of Van Yuzuncu Yil University under controlled conditions at 25±1°C. The experiment was conducted out in six different growing media as Soil, Peat, Soil: Peat: Manure, Soil: Sand: Manure in ratio of 1:1:1 and 2:1:1 for each combined growing media with and without basic fertilization according to randomized experimental design with three replication. As a basic fertilizer 100 mg kg^{-1} P_2O_5, 150 mg kg^{-1} K_2O and 250 mg kg^{-1} N were applied as triple super phosphate K_2SO_4 and $(NH_4)_2SO_4$, respectively. Two stevia (*Stevia rebaudiana*) seedlings were sown each plastic pot having 3 kg growing media. Then the seedlings were thinned to one. The experiment was ended after the eight week of the sowing. The growing media used in the experiment are given in Table 1.

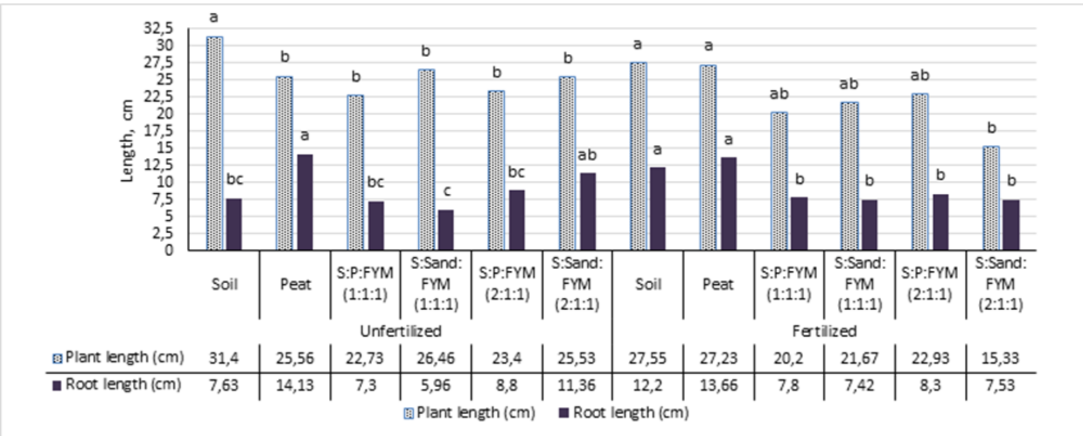
Table1. The growing media used in the experiment and applications

With basic fertilization	Without basic fertilization
1) Soil	1) Soil
2) Peat	2) Peat
3) Soil:Peat:Farmyard Manure (1:1:1)	3) Soil:Peat:Farmyard Manure (1:1:1)
4)) Soil:Sand:Farmyard Manure (1:1:1)	4)) Soil:Sand:Farmyard Manure (1:1:1)
5)) Soil:Peat:Farmyard Manure (2:1:1)	5)) Soil:Peat:Farmyard Manure (2:1:1)
6)) Soil:Sand:Farmyard Manure (2:1:1)	6)) Soil:Sand:Farmyard Manure (2:1:1)

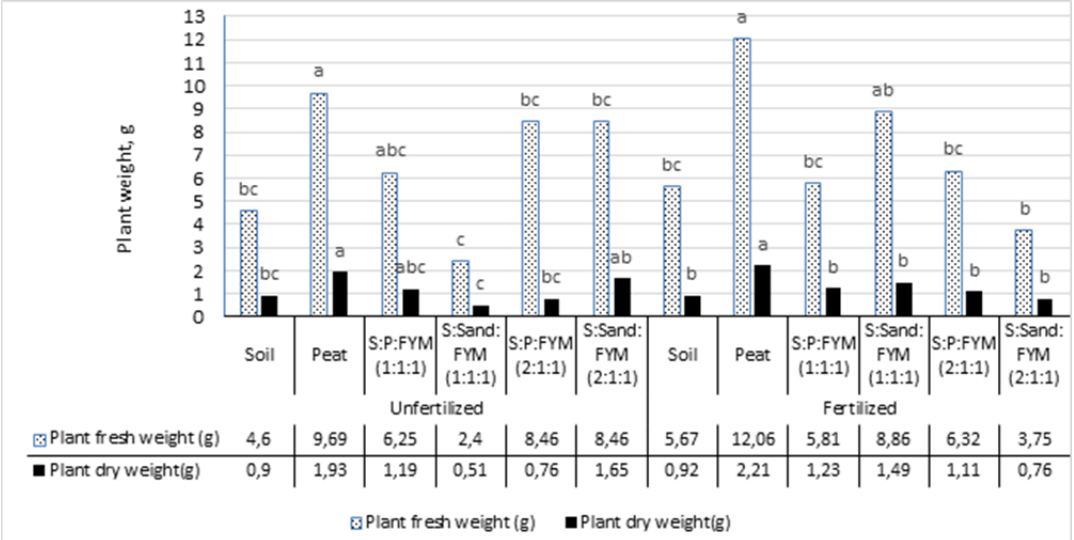
Some physical and chemical soil properties were determined by using standart soil analyses methods reported by Kacar (2011).The nutrient contents of the harvested plant samples were analyzed in dried and grinded plant samples according to following methods reported by Kacar (1984). The N content was determined by the Kjeldahl method, the P level was analyzed by the spectrophotometric method, and K, Ca, Mg, Fe, Mn, Zn, and Cu levels were determined by using an atomic absorption spectrophotometer (Themo ICE 3000 series).
Statistical analyses were done using SPSS package programs to show difference among the mean values of obtained data from the different applications (SPSS, 2018).

Results

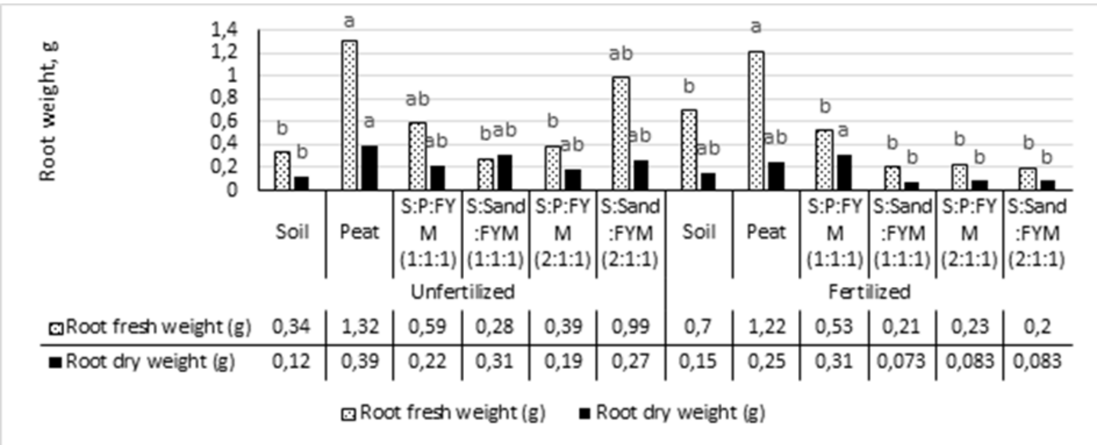
The highest mean plant length values were obtained in the soil growing media and determined as 31.40 cm for the application without basic fertilizer and 27.55 cm for the application with basic fertilizer. The lowest mean plant length was determined as 22.73 in S:P:FYM (1:1:1) growing media without basic fertilizer application, while it was 15.33 cm in S:Sand:FYM (2:1:1) growing media with basic fertilizer application.



The highest mean plant root length values were 14.13 cm and 13.66 cm and obtained in peat growing media without basic fertilizer application and with basic fertilizer application, respectively, while the lowest mean plant root length values were obtained in S:Sand:FYM (1:1:1) growing media without basic fertilizer application and S:Sand:FYM (1:1:1) growing media with basic fertilizer application and determined as 5.96 cm and 7.42 cm, respectively.



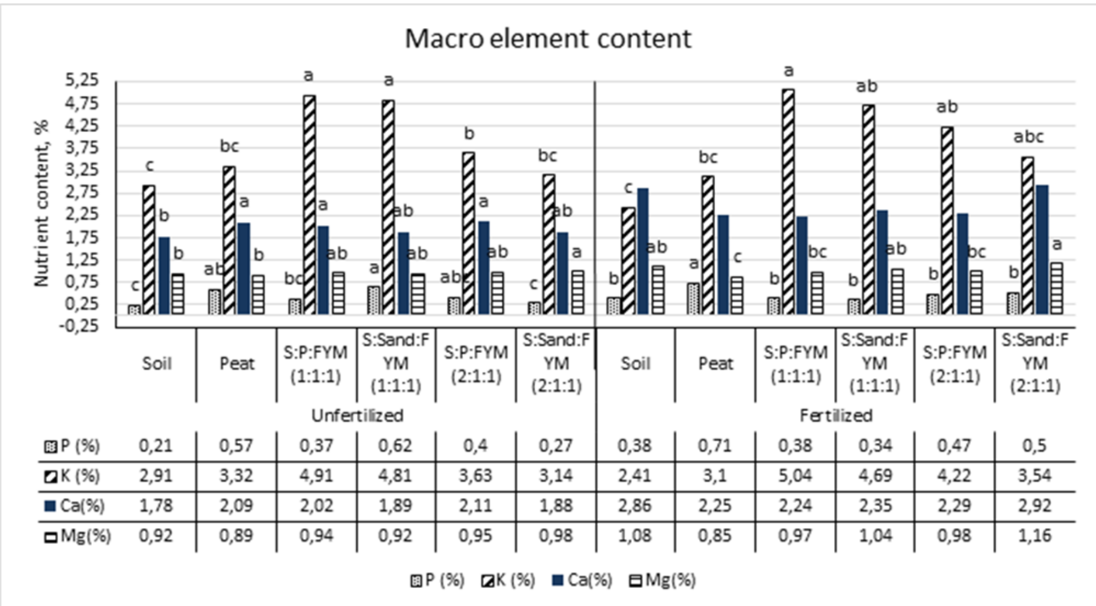
The highest mean plant fresh weight values were obtained in peat growing media without basic fertilizer application and with basic fertilizer application and determined as 9.69 g and 12.06 g, respectively. The lowest mean plant fresh weight values were obtained in S:Sand:FYM (1:1:1) growing media without basic fertilizer and S:Sand:FYM (2:1:1) growing media with basic fertilizer and determined as 2.40 g and 3.75 g, respectively.
The highest mean plant dry weight values were 1.93 g and 2.21 g and obtained in the peat growing media without basic fertilizer and with basic fertilizer application, respectively, while the lowest mean dry weight values were obtained in S:Sand:FYM (1:1:1) growing media without basic fertilizer application and S:Sand:FYM (2:1:1) growing media with basic fertilizer and determined as 0.51 g and 0.76 g, respectively.



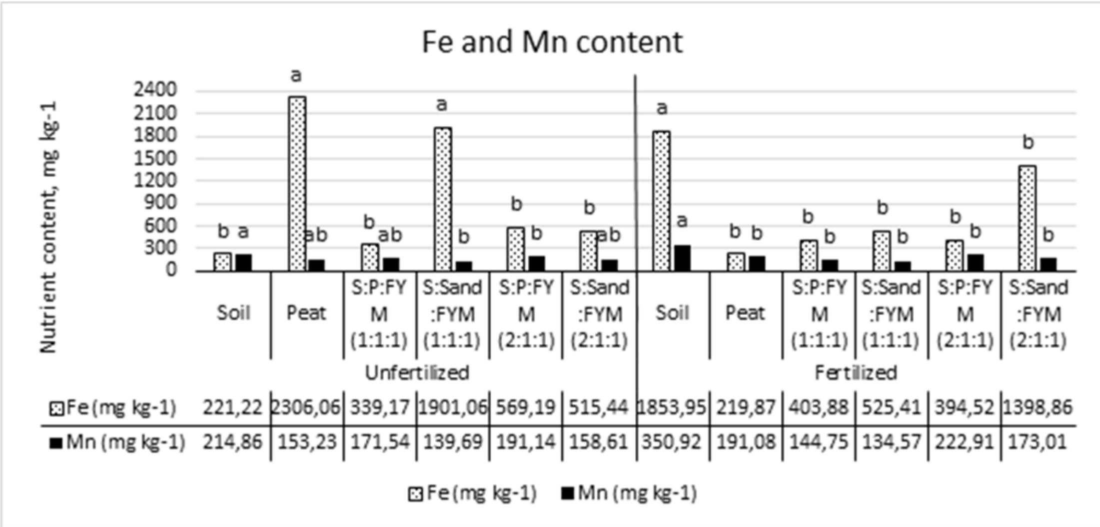
In general, the lowest mean root fresh weight values were 0.28 g and 0.20 g and obtained in S:Sand:FYM (1:1:1) growing media without basic fertilizer application and S:Sand:FYM (2:1:1) growing media with basic fertilizer application, while the lowest mean root dry weight values were 0.12 g and 0.083 g and obtained in the soil growing media without basic fertilizer application and S:P:FYM (2:1:1) and S:Sand:FYM (2:1:1) growing media with basic fertilizer application.

Although the highest mean plant length values were determined in the soil growing media, the mean plant fresh weight and dry weight values were higher in the peat and peat-containing growing media. This indicates that branching and leaf yield occurred at a higher rate in these growing media. The studies have revealed that the maximum leaf yield of stevia is obtained at pH values from 4 to 6 and leaf yield is reduced at pH values ranging from neutral to alkaline (Kafle, 2011). Thus, the greater development of the stevia plant in the peat growing media was attributed to the lower pH levels of the peat growing media (4.97-5.27) than the pH levels of other media (6.99-7.88). Moreover, reports have also shown the positive effects of organic materials on the physical, chemical and biological properties of soils and plant development (Bender et al., 1998).

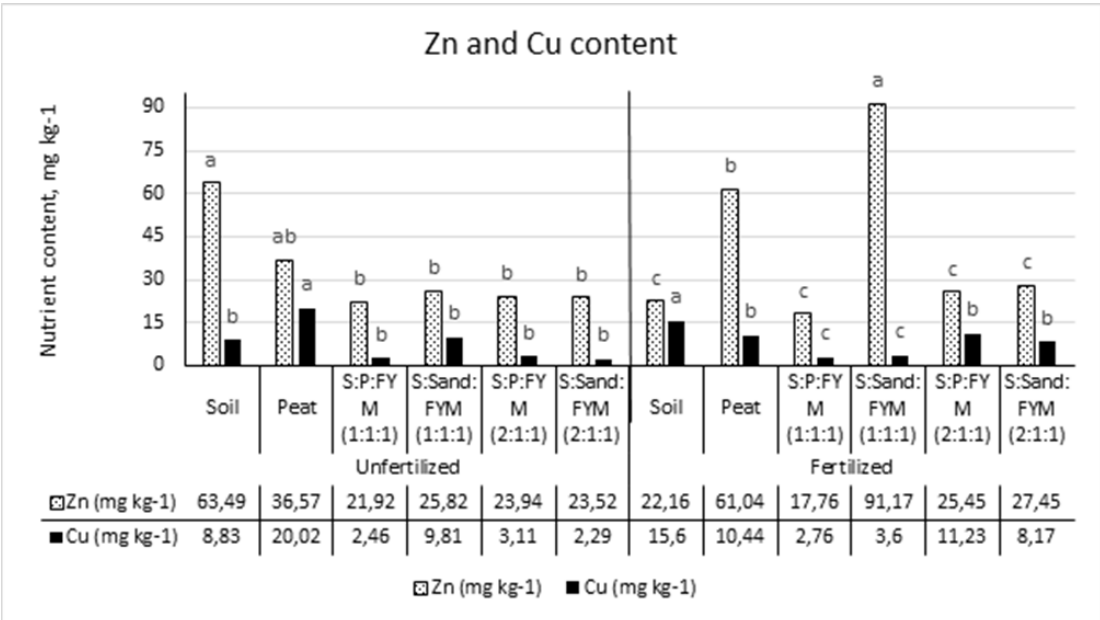
In general, the plant length, root fresh weight and root dry weight values were higher in the applications without basic fertilizer, while the mean plant fresh weight, plant dry weight and root length values were higher in the applications with basic fertilizer. It was reported that chemical fertilizer applications increase yield by 100% or more in plant production (Aydeniz, 1985). Kulasekaran et al. (2006) reported that the nutrient requirement of stevia ranged from low to moderate and the plant can adapt to the nutrient-poor, low-quality soil conditions. Liu et al. (2011) applied chemical (N-P-K) and organic fertilizers to stevia and found that organic fertilizers promoted the growth of the aerial organs and root of the plant. Rashid et al. (2013) reported that the highest nitrogen uptake, leaf number and dry leaf yield values were obtained in the 0-15-30-45 t/ha farmyard manure and 0-20-40-60 kg/ha nitrogen applications. Mengesha (2014) determined the suitable fertilizer doses for stevia as 50 ton/ha farmyard manure and 60 kg N, 30 kg P_2O_5 and 45 kg K_2O /ha. The researchers also recommended the use of slow-release nitrogen sources to allow nitrogen uptake when needed by the plants. The fertilizer doses used in this study are in accordance with the doses recommended by the researchers.



When it was noticed that macronutrient contents of the stevia plants (*Stevia rebaudiana*), the highest phosphorus content was determined as 0.71% and obtained in the peat growing media with basic fertilizer application. The highest potassium content was 5.04% and obtained in the S:P:FYM (1:1:1) growing media with basic fertilizer application. The highest magnesium content was 1.16% and obtained in the S:Sand:FYM (2:1:1) growing media with basic fertilizer application. The highest calcium content was 2.92 % and obtained in the S:Sand:FYM (2:1:1) growing media with basic fertilizer application.



The highest iron and copper contents were determined as 2306.06 mg kg^{-1} and 20.02 mg kg^{-1} and obtained in the peat growing media without basic fertilizer application. The highest zinc and manganese contents were found as 91.17 mg kg^{-1} and 350.92 mg kg^{-1} and obtained in the S:Sand:FYM (1:1:1) growing media with basic fertilizer application and soil growing media with basic fertilizer application, respectively. Thus, the application of basic fertilizer was determined to generally increase the nutrient contents of the stevia plants.



Conclusions

The study revealed that peat growing media and media containing peat mixtures were suitable for use in the growing of stevia, a plant susceptible to the physical properties of soil (Anonymous, 2017a), due to the properties of peat as a well-ventilated, well-drained, nutrient-rich organic material with a high water-holding capacity and low nutritional element loss (Raviv et al., 1998). Furthermore, the study showed that the addition of the appropriate doses of chemical fertilizers can enhance the positive effects of peat. The study can serve as a reference for similar studies about the effects of fertilizer applications on the stevia plants grown under field conditions.

Acknowledgements

This study was financially supported by the Van YYU Scientific Research Project Coordination Unit (Project no: FYL-2017-6291).

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Agrochemical efficiency of the multifunctional fertilizers produced from Kara-Kalpak's glauconites

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Abstract

At present modern agriculture, one of the way to produce highly effective and economically profitable mineral fertilizers is involved local agro-minerals. For our region, it can be such natural friable mineral -ionites as quartz-glauconite sands (Kara-Kalpak's glauconites) of Khodjakul deposit. Producing of multifunctional fertilizers from Kara-Kalpak's glauconites and assessment of their influence on the growth and development of agricultural crops is an actual and promising direction for modern efficient, environmentally friendly and resource-saving agriculture.
To establish the agrochemical efficiency of these new glauconite-containing nitrate fertilizers were conducted vegetative experiments. Agrochemical researches of mineral fertilizers had shown that the most effective variant with applied of fertilizers in the ratio of 100: 20. Availability nutrients and physical-chemical properties of mineral fertilizers granules had increased the harvest of cotton plants compared to the control variant.
Key words: Glauconites, ammonium nitrate, mineral fertilizers, cotton plant, agrochemical properties, phenology indicators, harvest.

Introduction

The large areas of glauconite-containing sands on the Kara-Kalpak territory, their accessibility, containing different compounds and great reserves could be basis for detailed study and develop physicochemical principles for obtaining mixed microelement-containing fertilizers [1]. The total predicted reserves of glauconite-containing sands are 30-45 million tons, and prospective reserves of these sands are about 70-80 million tons.
Due to glauconite has such properties and contain considerable quantity of macro- and microelements, it can applies as multifunctional fertilizers to enrich soil by the potassium, phosphorus and various of microelements and also enhance the soil structure and moisture-retentive property, stimulate growth and reduce the disease of plants. [2].
New Jersey, Delaware and Maryland states (the USA) are mined the earth for glauconite green sands in the middle part of the Atlantic Coastal Plain, at present time these sands are used for fertilization of soils. [3-5].
Authors consider [6] that high content of K_2O and P_2O_5 in glauconites (almost 9.5%), their ability rapidly destruct in the soil with the release of potassium and phosphorus in the form of easily digestible compounds might apply as potash-phosphorus manure in agriculture.
Besides, glauconite rock composition contain a number of valuable elements, such as potassium, magnesium and trace elements. Therefore, it could considered as one of the components for the production of chlorine-free potassium and phosphate-potassium fertilizers [7]. Chlorine-free potassium fertilizers are not salted the soil and have popular demand in agriculture, in particular in hothouse farm.
N.L. Gorenkov et al. [8] developed technology for obtaining conditional ground phosphate rock (20-25% P_2O_5) and high-quality glauconite concentrate (55% mineral), as components of complex mineral fertilizers from phosphorite-glauconite sands of the Ukolovskoye deposit.
Ryshchenko and others [9] had carried out researches producing of nitrogen-phosphorus-containing fertilizers based on the phosphate-glauconite concentrate of Ukraine. Scientists

proposed to obtain NP fertilizer with a high content of nutrients by activating low-grade phosphate ore by selective dissolution of carbonates and silicates method.
At the Gegeneral and inorganic chemistry scientific research institute the new multifunctional fertilizers from Kara-Kalpak's glauconites and ammonium nitrate salts were developed.
In order to establish the effectiveness of developing fertilizers, that one of components are glauconite-containing sands, it is necessary to carry out studies on their effect on the agricultural plants productivity.

Materials and Methods

To obtain new fertilizers were mineral ore one of the glauconite deposits and it concentrated by mechanical method. Thus, object of researchers was glauconites of Khodjakul deposit that has contain (weight in %): SiO_2- 53,57; Al_2O_3 -15,11; Fe_2O_3 - 8,57; MgO-3,33; CaO - 0,84; K_2O - 2,41; Na_2O -6,74. In order to establish the agrochemical efficiency of the new nitrogen mineral fertilizers in comparison with the control variant ($N_{200}P_{140}K_{60}$) were carried out in a vegetative experiment. The objects of research were also cotton plants and typical sierozem. The main indicators of the efficiency the applied fertilizers were: growth of the main stem, the formation of the sympodial branches and the number of bearing elements. Phenological observations of vegetation experiment were on the cotton-plant development phases: 2-4 true leaves, budding, flowering bearing and maturation.
As a result of complex physic-chemical researches were selected next variants: ammonium nitrate and glauconite (AN:Gl) in ratio 100:20; carbamide with glauconite (C:Gl) in ratio 100:25; ammonium nitrate and glauconite (AN: Gl) in ratio 100:5.
Annual rate of nitrogen is 7 g / vessel, phosphorus - 5 g / vessel, potassium - 3.5 g / vessel. The annual rate of phosphorus and potassium applied once time during the filling, at the beginning of the experiments. Phosphorus apply like ammophos, and potassium - like potassium chloride. Because of, glauconite fertilizers had obtained from ammonium nitrate and carbamide, applying like as nitrogen fertilizers, and their used at the basic phases, 2-4 true leaves, budding and flowering bearing.

Results and Discussion

In cotton growing considered, that germinating seed does not use nitrogen of nitrogen-containing fertilizers, and own needs it has occurs with the sprout of 2-4 leaflet of plants. Therefore, in the article phenological data has given starting at the 2-4 sprout of leaflet phase, when the development of plants occurs directly under the influence of glauconite-containing nitrogen fertilizers.
The stem is part of the plant, morphologically and functionally are connecting the main organs of nutrition - the root and leaves. In its tissues are laid various lateral buds, and because of which it is capable of branching and the formation of a large number of leaves, thereby increasing the overall assimilative surface of plants. At the 2-4 true leaf phase, growth of plants has observed in all the investigated variants. So in variants with the using of glauconite -containing nitrogen fertilizers, the height of the main stem reached up 7.8 cm to 9.2 cm, and in the control variant it was equal 8 cm.
To the budding phase, the best rate of the main stem growth showed the variant where applied ammonium nitrate with glauconite in the ratio (100:5), and it was equal to 17.8 cm, that in 1.5 times higher than this parameter in the control variant. In other test variants, the height of the main stem reached 13.3 cm and 17.0 cm - C: Gl (100: 25) and AN: Gl (100: 20), respectively.
At the flowering-bearing and maturation phases, the application of nitrogen fertilizers content glauconites were continuing to have a positive effect on the growth of the main stem. So at

the flowering-bearing phase in comparison with the previous development phase of the plant in glauconite-containing nitrogen fertilizers variants, the height of the main stem increased in 4.7-5.4 times. In the maturing phase, this indicator in the variants where were used AN: Gl 100:20, C:Gl 100:25 and AN:Gl 100:5, reached 100.3; 98.5; 101.3 pc. respectively. All the test variants where applied multifunctional glauconite-containing nitrogen fertilizers in this phase of plant development had an effective influence on the growth of the main stem and were higher than the NPK-control variant (12.0 pc.).

At the first on the cotton-plant observed monopodial branching, but before the flowering emerge sympodial branches, which has characterized by formation flowering and bearing. The formation of large number of sympodial branches promotes the development on the leaf crown, i.e. increasing the photosynthetic surface of plants. The data are presented on the second figure clearly shows the dynamics formation of the sympodial branches during the vegetation period. Observations of the growth and development of cotton-plant in the budding phase showed that the formation of sympodial branches on plants in all the investigated variants was very intensive.

In the flowering-bearing phase, the number of sympodial branches was maximal in the variant with applying of ammonium nitrate with glauconite, taken in the ratio of 100: 5 and reached 10.8 pc. which is higher in 1.2 times than the control variant.

In the cotton-plant maturation phase, the intensity formation of the sympodial branches decreased, although their number in variants with the nitrogen fertilizers with glauconite is not much, but exceeds the indications of the control plants. Based on the data obtained can concluded that in the maturation phase, the development of plants is clearly in the direction of reproductive organs accumulation, i.e. bearing elements.

Sufficient supply plants with nitrogen is enhanced synthesis of organic nitrogenous in them. Plants form powerful leaves and stems with an intensively green color, grow well and bush; also is improved the formation and development of fruiting organs. As a result, yield and content of protein are significantly increased [10, 11, 12].

The main criterion determining the effectiveness of applied fertilizers on cotton is the formation of bearing elements, i.e. yield of raw cotton.

It has revealed that in the weight ratio per a boll, the plants of the experimental groups were not infer to the plants of the control variant (NPK), were on the same level: the weight a box was about 4.1-4.4 grams, in the control version - 4.4 grams.

The researchers showed that the harvest of raw cotton in the tested variants, where were used AN:Gl 100:20 and AN:Gl 100:5 exceeded the yield data in the control variant plants (NPK): 145.3 and 136.7 vs. 111.8 g respectively. Whereas the variant with using of 40% carbamide and glauconite 100:25 this indicator is not much, but exceeds the yield data of the control variant. It should be noted that in this variant determined the highest number of bolly cotton - the unopened bolls.

Judging by a number of the mature bearings in all experimental variants with using glauconite -containing fertilizers observed identity to the weight yield data. The maximal number was detected in the variant application to AN:Gl (100:20) – 33.75 pcs./vessel; in variant with using AN:Gl (100:5) it was 31.75 pcs./vessel and in variant where applied carbamide this factor was lower and it was 28.75 pcs./vessel.

It was results of the first year researches, at present time study of the agrochemical efficiency of the glauconite containing nitrogen fertilizers are continued.

Conclusion

According to the obtained total results of phenological observations, the most effective fertilizer during the whole vegetation season of the growing cotton plant where using, ammonium nitrate and glauconite in the ratio 100:20. The effectiveness of this fertilizer explained by the quality of the granules, i.e. glauconite introduced into melt of ammonium nitrate thus changing its structure gives strength fertilizer granules. This, in turn, reduces the rate of dissolution of the granules when applied to the soil, due to this fertilizer acquires the property of prolonged action. Reducing the rate of dissolution of granules allows a gradual release of nutrients in fertilizer and plant security so necessary for the growth and development of macro- and microelement.

Thus, glauconite nitrogen fertilizer on their nutritional value is not only not inferior to traditional nitrogen fertilizer - ammonium nitrate, but also help to reduce the intensity of mineralization of nutrients, but due to the long-acting fertilizer rate increased fertilizer use.

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Effect of N fertilization on changes of nutrient concentrations in soils

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Abstract

Nitrogen (N), phosphorus (P) and potassium (K) fertilization is decisive for correct plant nutrition and adequate crop yields. This research was aimed at evaluating the effect of different levels of nitrogen fertilization on the availability of nutrients in soils from a long-term field experiment established in 1984 at two experimental sites with different pedo-climatic conditions in the Czech Republic.The field experiment consists of mineral, farmyard manure (FYM) or straw, and four different applied doses of mineral N given to each of the basic fertilization systems (0-40-80-120-160 kg N ha^{-1}). P and K is given to each treatment (with the exception of the unfertilized control) in annual doses of 35 kg P ha^{-1} and 83 kg K ha^{-1}. The level of N fertilization increased the average yields during the experiment. The mineralization processes induced by the N supply also led to a decrease of soil pH of about 0.3-0.45. Both factors affected the nutrient availability in the soils. Generally, the nutrient contents (mainly P, K, Ca) decreased with increasing N dose, however differences depending on the soil type at each experimental site were noted. The content of S increased proportionally with N dosage at both experimental sites. Considering all obtained results, the N showed to be the important factor affecting the nutrient contents in agricultural soils. Optimized soil fertilization should lead to the harmonised plant nutrition which is important and necessary for adequate crop yields and plant health.

Key words: long-term experiments, soil, nitrogen, nutrients, microelements.

Introduction

Nitrogen fertilization, as well as the use of other nutrients, is decisive for correct plant nutrition and adequate crop yields. Long-term field experiments provide one of the means for measuring sustainable management systems in agriculture as they contribute to a better understanding of the effects of soil fertilization on nutrient availability and crop yields (Rasmussen et al., 1998). Optimal fertilization based on scientific understanding can contribute to improved soil quality, sustainable soil use and to better understanding of the nutrient availability in soils and their uptake by grown crops.

This research was aimed at evaluating the effect of N fertilization on the availability of nutrients in soils from a long-term field experiment established in 1984 at two experimental sites with different pedo-climatic conditions in the Czech Republic. Main soil nutrients (P, K, Ca, Mg,) are discussed.

Material and Methods

The long-term field international experiment (Körschens et al 2012) is conducted in the Czech Republic since 1984 at two sites with different pedo-climatic conditions: Ivanovice in Moravian lowland, mean annual temperature of 9.4°C, annual precipitation of 558 mm, soil type -degraded chernozem; Lukavec the Bohemian-Moravian highlands, mean annual temperature 8.7°C, annual precipitation 633 mm, soil type - cambisol. Three basic systems of fertilization are conducted: mineral, farmyard manure (FYM) and straw, and four different applied doses of nitrogen fertilizer are given to each of the basic systems in doses of 0-40-80-120-160 kg N ha^{-1}. 43 kg P ha^{-1} and 83 kg K ha^{-1} are given annually to each treatment (with the exception of the control). The crop rotation of 3 crops is carried out on the field experiment: sugar beet (Ivanovice) or potatoes (Lukavec) – winter wheat – spring barley. In 2016, the nutrient content in soils was determined by Mehlich 3 method in all treatments. The winter wheat was sampled for the purpose of the evaluation of field experiment separately for each experimental plot by harvestor. The grain and straw was weighed. The nutrient content in soils was determined by Mehlich 3 method (Mehlich, 1984). Briefly, 10 g of soil and 100 ml of Mehlich 3 extract (0,2 mol.l^{-1} CH_3COOH, 0,015 mol.l^{-1} NH_4F, 0,013 mol.l^{-1}HNO_3, 0,25mol.l^{-1} NH_4NO_3, 0,001 mol.l^{-1} EDTA) was shaked at 200 rpm for 10 min. and the suspensions were filtred. The plant samples were digested by means of the Milestone 1200 microwave in conc. HNO_3 and 30% H_2O_5. All extracts were determined by ICP-OES Thermo Jarrel Ash (USA).

Results and Discussion

The winter wheat yields at Ivanovice and Lukavec increased with the increasing N dose up to 120 kg N/ha (Fig. 1 a,b). The FYM positively affected the winter wheat yields mainly in less fertile soils at Lukavec. The effect of FYM at Ivanovice was observed in soils with lower doses of mineral fertilizers. The straw affected winter wheat yields similarly as only mineral fertilizers, however it can serve as a source of organic matter for soils. The level of N fertilization increased the average yields during the experiment, which affected also the nutrient uptake by winter wheat. Nutrient uptake (K, Mg, P, Ca, S) increased in soils which at the end had an important effect on the nutrient contents in soils. The mineralization processes induced by the N supply also led to a decrease of soil pH of about 0.3-0.45 (Lukavec: from pH 6.7 down to 6.4; Ivanovice: pH 7.25 to 6.8). Both, pH and N fertilization, affected the nutrient availability in the soils.

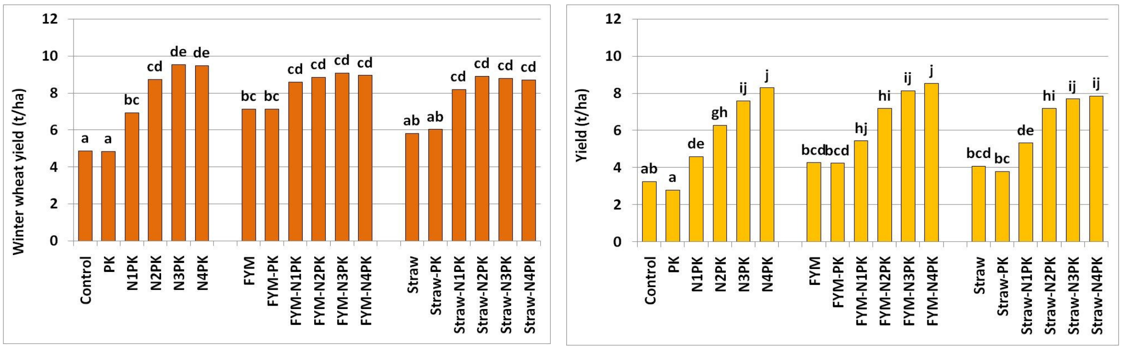

Figure 1. Winter wheat yields in long-term field experiment at Ivanovice (a) and Lukavec (b)

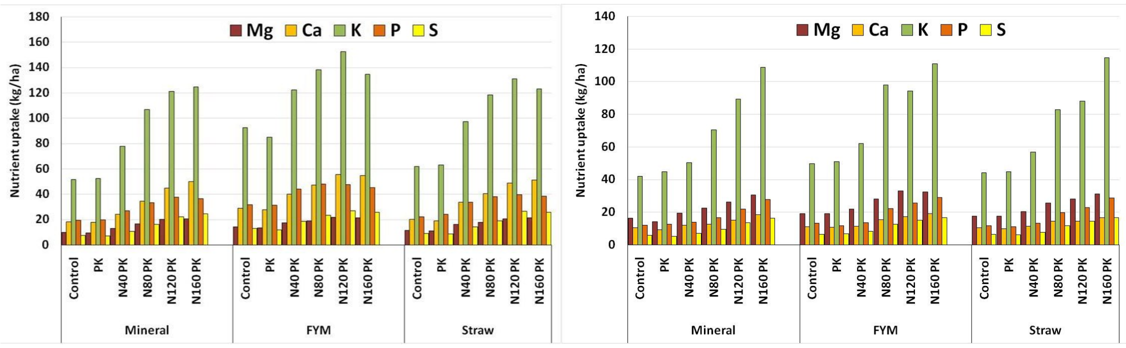

Figure 2. Nutrient uptake by winter wheat in the long-term field experiment at Ivanovice and Lukavec (Czech Republic)

Differences in nutrient contents in experimental soils depending on the soil type at each experimental site were noted (Table 1). At Lukavec, the contents of Ca, K, Mg and P decreased with increasing N dose by about 39%, 25%, 11% and 15%, respectively. The nutrient contents

at Ivanovice showed a quite different trend: a clear decrease was noted for Ca (10%), whereas for K (22%), Mg (31%) and P (10%) an increase was observed. Our finding are quite consistent with Liu et al. (2010), who in a 30-year field experiment found a rapid decrease of K without straw or manure additions. In our experiments significantly lower soil K and P contents were at Lukavec with basically lower nutrient contents.
The availability of S, due to its presence in the soil as SO_4^{2-}, increased proportionally with N dosage at both experimental sites (40% at Lukavec and 150% at Ivanovice). In this case the increase of sulphur contents is not a sign of the increasing supply, but sulphur fractions available not only for plants, but they can be easily leached to groundwaters.

Table 1. The nutrient contents in soils from long-term experiment at Ivanovice (Iva) and Lukavec (Luk)

Treatment		Mg		K		Ca (mg/kg)		P		S	
Min/org	N dose	Iva	Luk	Iva	Luk	Iva	Luk	Iva	Luk	Iva	Luk
Mineral	Control	245.6	143.9	451.7	236.9	3564	1537	117.1	118.8	11.9	10.8
	PK	241.6	136.9	512.6	313.5	3486	1557	148.3	140.3	15.8	11.2
	N40 PK	244.4	130.6	493.6	275.1	3446	1658	145.8	138.6	15.8	12.2
	N80 PK	253.2	111.8	452.8	257.1	3464	1411	142.1	135.4	25.9	13.5
	N120 PK	266.9	104.2	452.5	228.8	3416	1400	135.0	130.0	26.0	15.2
	N160 PK	262.9	117.5	423.1	190.6	3389	1437	125.0	114.9	29.5	14.6
FYM	Control	295.4	160.4	835.3	372.8	3387	1770	192.8	167.2	16.7	12.2
	PK	289.0	148.2	910.9	409.1	3374	1655	219.1	190.4	17.9	11.7
	N40 PK	286.3	139.3	861.1	411.4	3381	1599	210.1	194.1	25.4	13.2
	N80 PK	297.4	137.0	841.8	397.0	3290	1561	205.4	212.1	29.0	15.6
	N120 PK	303.5	127.2	832.1	371.5	3232	1540	197.9	200.9	30.4	16.8
	N160 PK	301.3	132.6	798.2	256.7	3206	1550	194.7	160.3	34.5	14.9
Straw	Control	245.0	138.1	506.0	231.4	3361	1465	106.8	123.5	16.8	12.2
	PK	239.9	126.9	572.8	313.2	3290	1435	137.2	154.0	17.1	12.6
	N40 PK	243.4	112.4	584.5	278.6	3116	1354	139.1	159.1	24.3	13.9
	N80 PK	250.8	98.4	574.7	263.0	3022	1319	134.6	160.0	31.8	16.4
	N120 PK	260.5	95.6	504.6	263.1	2926	1308	130.1	160.3	34.7	19.3
	N160 PK	275.9	109.5	484.6	255.3	3076	1329	119.9	144.3	35.0	16.5

Conclusions

Contents of majority of studied nutrients (P, K, Mg, Ca) in soils from long-term field experiment decreased partly due to the nutrient export from the field and due to combination mineral N fertilization which leaded also to the decrease of soil pH. This caused a decrease of nutrient reserve in the soils. The different trend was observed for the sulphur extractable contents which increased under nitrogen fertilization. An appropriate nutrition, with nutrients is important for adequate crop nutrition, particularly under nitrogen fertilization when higher yields and nutrient uptake by plants can be expected. Individual soil characteristics have also to be taken into consideration when deciding about soil fertilization.

Acknowledgement

The research was carried out with the support of project NAZV CR no: QJ1530171.

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Effect of water-saving irrigation on rice growth and micronutrients concentrations under different levels of organic and chemical fertilizers

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Abstract

In a greenhouse research, the integrated effects of poultry manure, sewage sludge and chemical fertilizers (CF) on rice plant (cv. Ali Kazemi) growth and concentrations of copper (Cu), iron (Fe), manganese (Mn), zinc (Zn), cadmium (Cd), and lead (Pb) in rice shoot and root were studied in a loamy sand soil under different irrigation regimes. The study was performed as a factorial experiment with three replications in a randomized complete blocks design including irrigation regime at three levels (continuous waterlogging, alternate waterlogging and alternate saturation) and source and amount of fertilizers at 10 levels of control, 100% CF, sewage sludge (20 g kg^{-1}), sewage sludge (20 g kg^{-1}) + 50% CF, sewage sludge (40 g kg^{-1}), sewage sludge (40 g kg^{-1}) + 50% CF, poultry manure (20 g kg^{-1}), poultry manure (20 g kg^{-1}) + 50% CF, poultry manure (40 g kg^{-1}), poultry manure (40 g kg^{-1}) + 50% CF. The results showed that the continuous waterlogging increased the rice shoot concentrations of Fe and Mn compared to alternate waterlogging and alternate saturation. The rice shoot and root dry matters in the continuous waterlogging and alternate waterlogging were greater than the alternate saturation. The rice shoot concentrations of Cu and Zn in the alternate saturation were significantly greater than the continuous waterlogging. Application of sewage sludge with and without CF increased concentrations of Cu, Fe, Mn and Zn and dry matter of rice shoot and root. In all treatments, Cd and Pb concentrations in rice shoot were not measurable by atomic absorption spectrophotometry. The Mn concentration in rice shoot was greater than that of root while the Cu, Fe, and Zn concentrations in rice shoot were less than those of root. The highest rice growth and concentrations of Cu, Fe, Mn and Zn were observed in treatments of sewage sludge (40 g kg^{-1}) + 50% CF under continuous waterlogging and alternate waterlogging conditions.
Key words: Copper, Iron, Manganese, Poultry manure, Sewage sludge, Zinc.

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops in the world (Wangda et al. 2003). Rice grain is the important food for more than half the people in the world and is generally cultivated under waterlogged conditions (Sudhalakhsmi et al. 2007). Continuous waterlogging provides a favorable environment for rice production under most soils and climatic conditions (Sah and Mikkelsen, 1983). Also, rice growth has been observed higher, when rice plant was grown on waterlogged conditions. Beneficial effects of waterlogging on rice growth mostly have been attributed to increased micronutrients availability such as iron (Fe) and manganese (Mn) (Cherian et al. 1968). However, shortage of irrigation water existed in some regions of Asia and Iran, is threatening the usual system of lowland rice cultivation. Hence, there is a need for researching alternate water management practices that save water and at the same time increase water productivity (Sahrawat, 2012). Micronutrients (Fe, Mn, Zn and Cu) are essential elements and deficiency of them is discussed as one of the major causes of the declining rice productivity (Pirzadeh et al. 2010). Rahmatullah et al. (1976) observed that the concentrations of Ca, Mg, Fe, Mn and total soluble salts in soil solution were significantly increased in waterlogged conditions. Alam and Ansari (2001) reported the greater growth and nutrients concentrations of rice plants in waterlogged conditions compared to non-waterlogged conditions.

In order to develop the high intensive agriculture, more chemical fertilizers are applied to the soil that results in soil degeneration and environment deterioration. On the other hand, low organic matter content of soils especially in Iran is responsible for the poor physical and chemical conditions and fertility of these soils. So, application of organic wastes in soil to supply at least a part of the plant nutrient requirement and improve the physical, chemical and biological properties of soil is important (Maftoun and Moshiri, 2008; Ming-gang et al. 2008; Mahmoudi et al. 2015). Soils with moderate to high content of inherent or added organic matter can help bring soil pH to a neutral range, favoring nutrient uptake by wetland rice (Sahrawat, 2012). Application of organic residues and manures, such as poultry manure and sewage sludge improves soil organic matter content, soil structure, water holding capacity and nutrients status of soil and also increases microbial activity in soil (Kabir et al. 2008; Mahmoudi et al. 2015). However, the long-term use of organic wastes on soils may lead to the accumulation of soluble salts and heavy metals (such as Cd and Pb) in the soils and causes a nutrient imbalance in the soil (Maftoun and Moshiri, 2008). So, combined application of organic matters and chemical fertilizers is important approach to maintaining and improving the soil fertility and increasing fertilizer use efficiency (Ming-gang et al. 2008). Therefore, the objective of this study was to investigate the integrated effects of organic and chemical fertilizers on some micronutrients and heavy metals concentrations of rice shoot and root under different soil water regimes at greenhouse conditions.

Materials and Methods

This experiment was carried out in the greenhouse of the Faculty of Agriculture, University of Tabriz, Iran. A soil with loamy sand texture was sampled from 0-25 cm depth, air-dried, grounded and passed through a 2 mm sieve for physical and chemical analysis (Page et al.1982). Also, chemical properties of organic fertilizers were determined by methods of Page et al. (1982) and Peters (2003). The study was performed as a factorial experiment in a randomized complete blocks design in three replications, including irrigation regime at three levels (continuous waterlogging, alternate waterlogging and alternate saturation), and organic and chemical fertilizers at 10 levels (L_1=control, L_2=100% chemical fertilizers (434.8 mg urea, 66.1 mg KH_2PO_4, 40 mg KCl, 50 mg $FeSO_4.7H_2O$, 38.5 mg $MnSO_4.H_2O$, 21.3 mg $ZnSO_4.7H_2O$ and 7.9 mg $CuSO_4.5H_2O$ kg^{-1} soil), L_3=20 g sewage sludge kg^{-1}, L_4=20 g sewage sludge kg^{-1}+ 50% chemical fertilizers, L_5=40 g sewage sludge kg^{-1}, L_6=40 g sewage sludge kg^{-1}+ 50% chemical fertilizers, L_7=20 g poultry manure kg^{-1}, L_8=20 g poultry manure kg^{-1}+ 50% chemical fertilizers, L_9=40 g poultry manure kg^{-1}, L_{10}=40 g poultry manure kg^{-1}+ 50% chemical fertilizers. Sewage sludge and poultry manure were prepared from Mianeh city Waste Water Refinery and Azartoyog Corporation, East Azerbaijan province, Iran respectively. Sewage sludge and poultry manure were passed through a 2 mm sieve and added to 3 kg soil and mixed well and filled in the pots before plant cultivation. Chemical fertilizers were added to treatments based on soil test results as solution and prior to planting. Urea fertilizer was applied to soil at three times during plant growth period. Soil was kept flooding for two weeks with one centimeter standing water on the soil surface to achieve the relative equilibrium. The rice seeds (*Oryza sativa* cv. Ali Kazemi) were germinated at 26±2 $^{\circ}C$ in incubator. Ten germinated rice seeds were planted in each pot and after the establishment of seedlings, plants were thinned to four per pot and then different irrigation regimes were imposed. At the end of growth period, shoot and root parts of plants were harvested separately and weighted. Then, shoot and root rinsed with distilled water and consequently dried at 75 $^{\circ}C$ for 3 days and weighted again. Shoot and root were ground to pass a 0.5 mm sieve and concentrations of Fe, Mn, Zn, Cu, Cd and Pb in shoot and root were measured by wet digestion method. The Fe, Mn, Zn, Cu, Cd and Pb concentrations in extracts were measured by atomic absorption spectrophotometer (Waling et al. 1989). Statistical analysis of data was performed using the MSTATC software and means were compared using Duncan's multiple range test at $p \leq 0.05$.

Results and Discussion

Shoot dry weight

The results indicated that application of 20 and 40 g poultry manure kg^{-1} increased soil solution salinity and prevented the rice growth. In these treatments, electrical conductivity (EC) of soil solution was increased up to 20 dS m^{-1} during the rice growth period. So, the rice shoot dry weight in these treatments was negligible because of salt stress and phytotoxicity. Therefore the poultry manure containing treatments were excluded from statistically data analysis. These results showed that the rate of poultry manure must be reduced if it applied in lowland rice fields. The rice shoot dry weight was statistically similar in different irrigation regimes (continuously waterlogged, alternately waterlogged and alternate saturation) indicating that water consumption can be reduced without a significant reduction in rice growth by selecting alternately waterlogged system for irrigation of rice crop (Figure 2). This result is very important with regard to the water deficit in Iran and other countries because alternately submerged-unsubmerged system saves water compared with the continuous submergence (Belder et al. 2004; Abbasi et al. 2012). These results are similar to Belder et al. (2004) and Abbasi and Sepaskhah (2011). Irrigation experiments conducted by Tripathi et al. (1986) on wetland rice paddies for two years showed that intermittent submergence three days after water vanished from the surface of the soil produced grain yield similar to continuous submergence. Comparison of means showed that the rice shoot dry weight was significantly increased by application of 20 and 40 g kg^{-1} soil compared with the control. Also, application of 50% chemical fertilizers with both levels of sewage sludge significantly increased shoot dry weight relative to the control (Figure 1). Asagi et al. (2007) observed that application of sewage sludge increased rice growth indices in comparison with the control treatment.

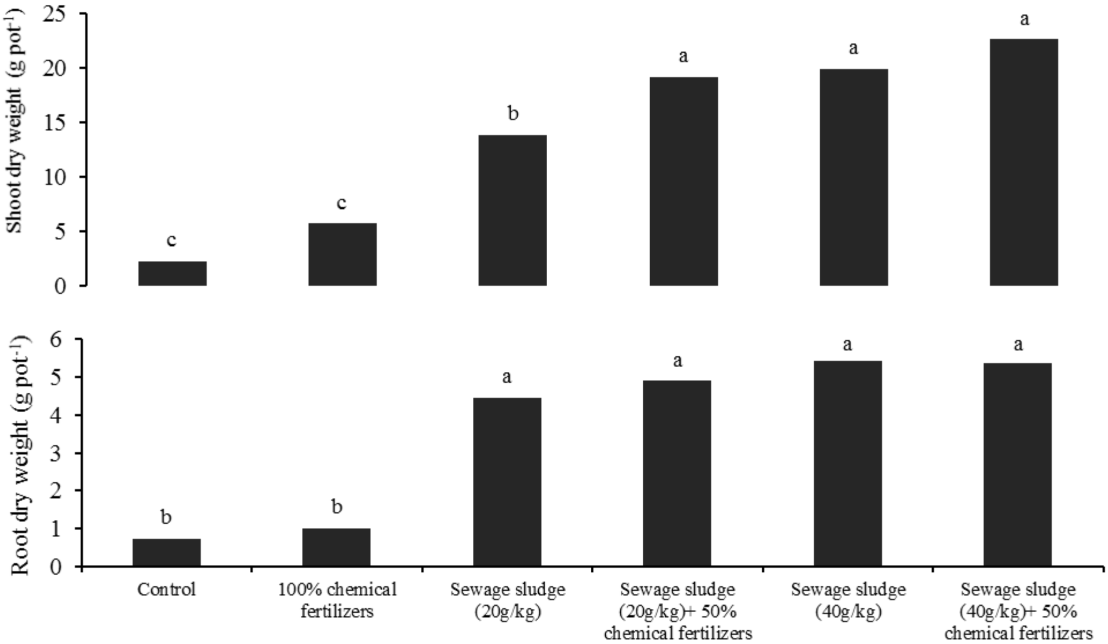

Figure 1. Effects of sewage sludge and chemical fertilizers on rice shoot and root dry weights

Root dry weight

Means comparison showed that the rice root dry weight at alternately waterlogged conditions was statistically greater than continuously waterlogged and alternate saturation conditions (Figure 2). Water consumption at alternately waterlogged conditions was significantly lower than continuously waterlogged conditions (Abbasi et al. 2012). Also, the implementation of alternate waterlogging method is easier than alternate saturation. So, due to the water deficit in Iran and other countries, alternately waterlogged can be recommended. Comparison of means showed that the rice root dry weight was significantly increased by application of 20 and 40 g sewage sludge kg^{-1} soil compared with the control. Also, application of 50% chemical fertilizers with both levels of sewage sludge significantly increased root dry weight relative to the control treatment (Figure 1).

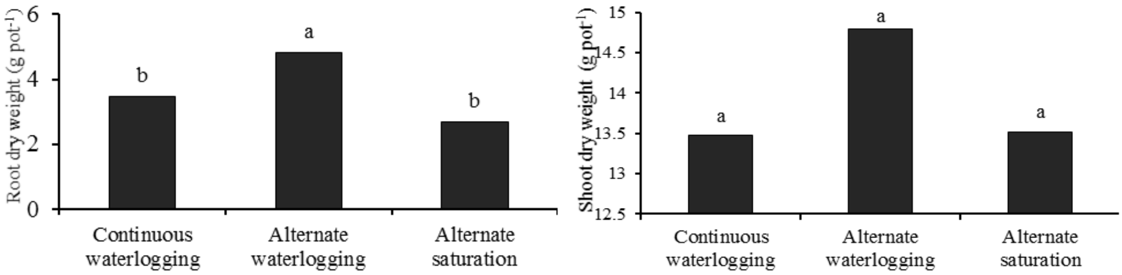

Figure 2. Effect of irrigation regime on rice shoot and root dry weights

Shoot Fe concentration

Comparison of means showed that the shoot Fe concentration in the continuous waterlogging was significantly greater than the alternate saturation and alternate waterlogging (Figure 3). Alam and Ansari (2001) reported similar results. The better rice growth and yield was attributed to higher uptake of nutrients under waterlogged conditions (Islam and Islam, 1973). The oxygen concentration in soil drops with soil waterlogging. It creates reduction conditions in soil and the redox potential of soil decreases. All of these factors cause to the reduction of Fe^{3+} and increasing water soluble Fe in soil. Applications of chemical and organic fertilizers increased shoot Fe concentration compared to the control. Shoot Fe concentration was significantly increased by increasing level of sewage sludge and addition of 50% chemical fertilizers. The higher shoot Fe concentrations in rice were observed at 100% chemical fertilizers (102 mg kg^{-1}), 20 g sewage sludge kg^{-1} soil + 50% chemical fertilizers (100 mg kg^{-1}) and 40 g sewage sludge kg^{-1} soil with (101.0 mg kg^{-1}) and without 50% chemical fertilizers (101 and 100 mg kg^{-1}, respectively) levels. The similar results were reported by Kabir et al. (2008). The increase in micronutrients, especially Fe and Mn, and organic carbon seemed to be responsible for increased rice yields. Optimal range of Fe concentration in rice plant tissue is 75-150 mg g^{-1} dw, and the critical concentration for the occurrence of Fe toxicity is >300 mg Fe g^{-1} plant tissue (Dobermann and Fairhurst, 2000). So, in all treatments, shoot Fe concentration was optimum and was highest at 40 g sewage sludge kg^{-1} soil + 50% chemical fertilizers treatment. Shoot Fe concentration was significantly increased in continuous waterlogging relative to other irrigation regimes. In all three irrigation regimes, application of chemical and organic fertilizers caused more increasing in shoot Fe concentration compared to control treatment. Therefore, the highest Fe concentration in rice shoot was observed in continuous waterlogging with 20 g sewage sludge kg^{-1} soil + 50% chemical fertilizers treatment (Figure 3).

Root Fe concentration

Means comparison showed that the root Fe concentration in the continuous waterlogging had not significant difference with alternate waterlogging but in alternate saturation conditions it was significantly decreased compared to other irrigation regimes. Application of sewage sludge and increasing its level increased the root Fe concentration. Addition of 50% chemical fertilizers only at high level of sewage sludge (40 g kg^{-1}) enhanced root Fe concentration compared to its use alone. The highest root Fe concentration was observed at the control (4671 mg kg^{-1}) and the lowest of that was in 100% chemical fertilizers (3036 mg kg^{-1}) treatments (Figure 3). Average ratio of Fe concentration in shoot to that in root was 0.03. So, rice plant accumulated the most of Fe in its root. The high root Fe concentration especially in control treatment may be due to lower dry weight and the concentration effect and Fe^{2+} oxidation in the rice rhizosphere. The precipitation of Fe^{3+} hydroxide in the rhizosphere and rice roots (indicated by reddish brown coatings on the roots) prevents excessive Fe^{2+} uptake (Dobermann and Fairhurst, 2000). Use of sewage sludge and chemical fertilizers increased root Fe concentration in continuous and alternate waterlogging conditions and decreased it at alternate saturation conditions. The highest root Fe concentration was observed in alternate saturation conditions (Figure 3).

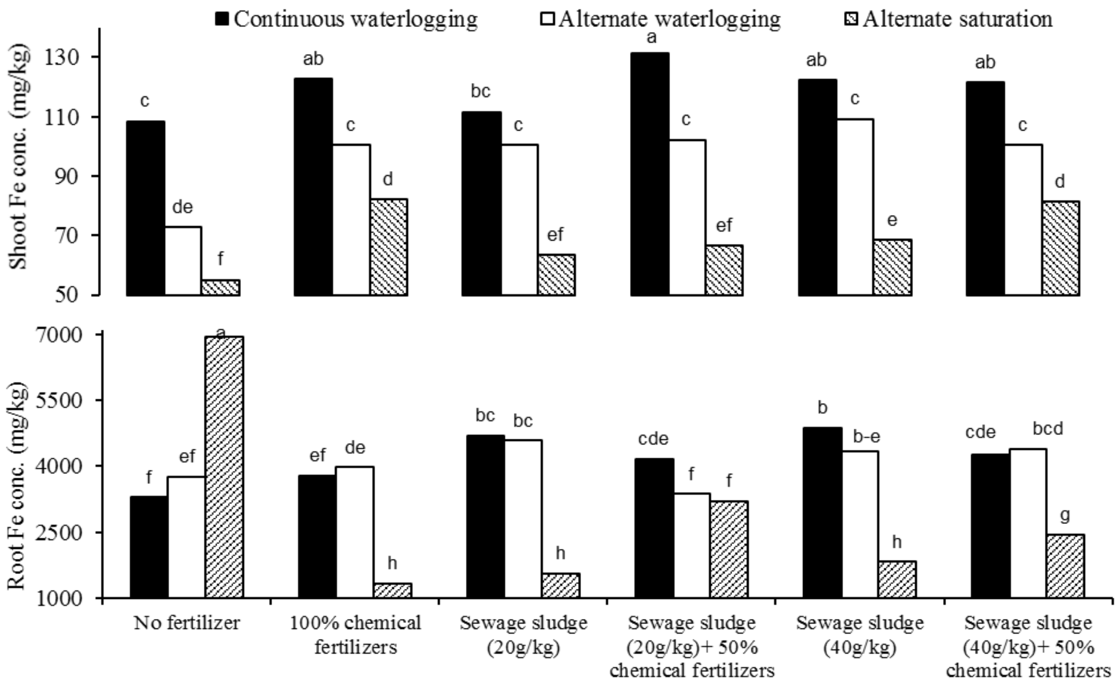

Figure 3. Effects of sewage sludge and chemical fertilizers on rice root and shoot Fe concentration under different irrigation regimes

Shoot Mn concentration

Comparison of means showed that the rice shoot Mn concentration in the soil with continuous waterlogging and alternate saturation conditions was significantly greater than the alternate waterlogging (Figure 4). Ghoneim et al. (1974) reported that rice shoot Mn concentration affected by the various water treatments and the highest values was obtained under continuous waterlogging conditions. The similar results were observed by Alam and Ansari (2000) and Tao et al. (2007). Waterlogging of soil improves the availability of ammonium-N, P, K, Fe and Mn (Sahrawat, 2012). Shoot Mn concentration was increased by application of chemical fertilizers and sewage sludge compared to the control. Increasing level of sewage sludge from 20 g kg^{-1} (T_3) to 40 g kg^{-1} (T_5) decreased shoot Mn concentration at continuous waterlogging conditions but increased it under alternate saturation conditions (Figure 4). Maftoun and Moshiri (2008) observed that Mn concentration in rice plants declined with increasing vermicompost and poultry manure levels. Baker (2009) reported similar results. Optimal range of Mn concentration in rice plant tissue is 40-700 mg kg^{-1} dw (Dobermann and Fairhurst, 2000). The rice shoot Mn concentration was higher than the optimum under sewage sludge using conditions. That may be due to the competition between Fe and Mn for uptake by plants and transport of most Mn from root to shoot of rice plant compared to Fe. Application of sewage sludge in all three irrigation regimes, especially alternate waterlogging, caused to increase shoot Mn concentration compared to control. Addition of 50% chemical fertilizers at both levels of sewage sludge increased shoot Mn concentration in alternate saturation conditions compared to the control and 100% chemical fertilizers. The highest shoot concentration of Mn was observed at continuous waterlogging with 20 g sewage sludge kg^{-1} and alternate saturation with 40 g sewage sludge kg^{-1} soil treatments (Figure 4).

Root Mn concentration

Comparison of means showed that the root Mn concentration in continuous waterlogging was significantly greater than the alternate waterlogging and alternate saturation conditions. Application of sewage sludge increased the root Mn concentration but increasing its level decreased root Mn concentration. It seems that decrease in root Mn concentration with increasing rate of sewage sludge was due to the high Fe concentration in root and competition between Fe and Mn for uptake by rice plant and also dilution effect. Also, addition of 50% chemical fertilizers in both levels of sewage sludge increased root Mn concentration compared to the use of sewage sludge alone. The highest rice root Mn concentration was observed at 20 g sewage sludge kg^{-1} soil+ 50% chemical fertilizers (957.6 mg kg^{-1}) and it was lowest in the control (660.5 mg kg^{-1}). The similar result was observed by Mahmoodabadi et al. (2010) in soybean plant. The ratio of Mn concentration in rice shoot to that in rice root (translocation factor) was 1.02. Chemical fertilizers and sewage sludge applications increased root Mn concentration in all irrigation regimes especially in the alternate saturation conditions. Addition of 50% chemical fertilizers caused to high increasing Mn concentration in root. The highest root concentration of Mn was observed at alternate waterlogging and saturation with 20 g sewage sludge kg^{-1} soil and continuous waterlogging with 40 g sewage sludge kg^{-1} soil + 50% chemical fertilizers treatments (Figure 4).

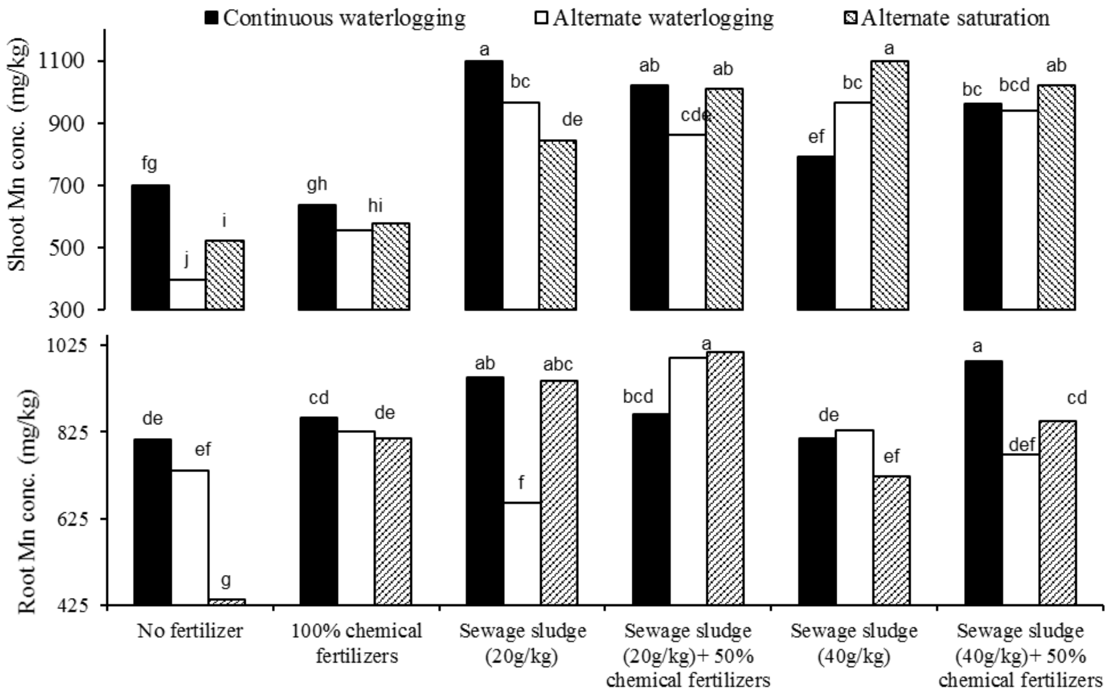

Figure 4. Effects of sewage sludge and chemical fertilizers on rice root and shoot Mn concentration under different irrigation regimes

Shoot Zn concentration

The shoot Zn concentration under the alternate saturation was significantly higher than the continuous and alternate waterlogging conditions (Figure 5). Tao et al. (2007) reported that the rice shoot Zn and Cu concentrations in non-waterlogged plants showed no significant difference with waterlogged plants. Under flooded conditions, Zn availability decreases because of the reduction in Zn solubility and Zn precipitation as ZnS in sodic and calcareous soils. Zn is also strongly adsorbed on $CaCO_3$ or $MgCO_3$ and on oxides of Fe and Mn (Dobermann and Fairhurst, 2000; Najafi et al. 2012). Application of chemical and organic fertilizers increased rice shoot Zn concentration. Increasing the level of sewage sludge and also use of 50% chemical fertilizers significantly increased shoot Zn concentration compared to its use alone. The highest Zn shoot concentration was obtained at 40 g sewage sludge kg^{-1} soil + 50% chemical fertilizers (102.3 mg kg^{-1}) and it was lowest (19.8 mg kg^{-1}) at the control (Figure 5). Prasad and Sinha (2000) reported that the Zn, Cu, Fe and Mn requirement of rice and wheat could be supplied by the addition of crop residues. The increasing of rice shoot Zn concentration by application of organic fertilizer with or without chemical fertilizers was also reported by Kabir et al. (2008) and Maftoun and Moshiri (2008). In addition to having a much available Zn, sewage sludge can decrease soil solution pH and increase Zn-organic matter chelate formation that cause to increase the solubility and mobility of Zn in soil and its uptake by rice plant (Najafi et al. 2012). Optimal range of Zn concentration in rice plant tissue is 25-50 mg kg^{-1} dw and the critical concentration for Zn toxicity is >500 mg Zn kg^{-1} plant tissue (Dobermann and Fairhurst, 2000). So, Zn concentration in rice plant shoot was optimum in all studied treatments. Application of chemical fertilizers and sewage sludge increased shoot Zn concentration in all irrigation regimes particularly at alternate saturation. Also, use of 50% chemical fertilizers increased Zn concentration in rice shoot greater than its application alone. The highest shoot concentration of Zn was obtained in alternate saturation with 40 g sewage sludge kg^{-1} soil treatment that was significantly different with other treatments (Figure 5).

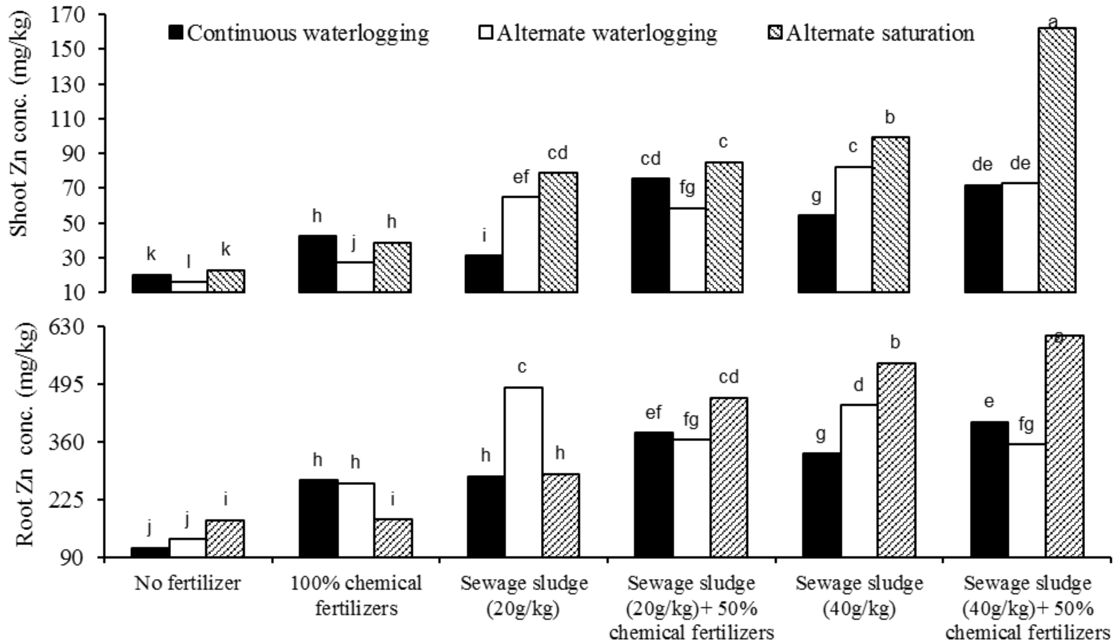

Figure 5. Effects of sewage sludge and chemical fertilizers on rice root and shoot Zn concentration under different irrigation regimes

Root Zn concentration

The rice root Zn concentration in different irrigation regimes was as follow: alternate saturation> alternate waterlogging> continuous waterlogging**.** The root Zn concentration was increased by application of chemical and organic fertilizers. Increasing level of sewage sludge and addition of 50% chemical fertilizers increased root Zn concentration. The highest root Zn concentration was observed in 40 g sewage sludge kg^{-1} soil + 50% chemical fertilizers (456.4 mg kg^{-1}) and the lowest of that was in control (140.4 mg kg^{-1}) (Figure 5). Mahmoodabadi et al. (2010) observed the similar results for soybean plant. Average ratio of Zn concentration in shoot to that in root (translocation factor) was 0.17. So, rice plant keeps the most of absorbed Zn in root and does not transport it to that shoot. In waterlogged calcareous soils, HCO_3^- is the important anion, which mainly decreases Zn transport from root to shoot. Zn uptake is reduced by an increase in the concentration of organic acids that occurs under waterlogged conditions immediately after flooding. Zn also forms insoluble Zn-phosphates under anaerobic conditions (Dobermann and Fairhurst, 2000). Applications of chemical fertilizers and sewage sludge and combined application of 50% chemical fertilizers at both rates of sewage sludge increased root Zn concentration compared to the control at all irrigation regimes. The highest rice root Zn concentration was observed in alternate saturation with 40 g sewage sludge kg^{-1} soil + 50% chemical fertilizers treatment (Figure 5). There was positive relationship between shoot and root concentrations of Zn: $Zn_{shoot}=0.221(Zn_{root})–12.288$**,** $r=0.88^{**}$. Therefore, the shoot Zn concentration was increased with increasing root Zn concentration. The result showed that root Zn concentration was 3-4 times higher than that in shoot (Figure 5).

Shoot Cu concentration

The shoot Cu concentration in alternate saturation conditions was greater than the continuous and alternate waterlogging conditions (Figure 6). A similar result was reported by Tao et al. (2007). The availability of Cu decreases at flooding conditions, because of the formation of insoluble Cu sulfides and Cu ferrite ($Cu_2Fe_2O_4$), and complexes with organic matter. The plant availability of Cu decreases with increasing pH and organic matter content (Dobermann and Fairhurst, 2000). Applications of chemical fertilizers and sewage sludge increased shoot Cu concentration. Increasing level of sewage sludge from 20 to 40 g kg^{-1} soil and its combination with 50% chemical fertilizers caused to increase shoot Cu concentration. According to the results, shoot Cu concentration was significantly increased from 35.8 mg kg^{-1} in the control to 74.8 mg kg^{-1} in the treatment of 40 g sewage sludge kg^{-1} soil + 50% chemical fertilizers (Figure 6). Prasad and Sinha (2000) observed similar results. Optimal range of Cu concentration in rice plant tissue is 7-15 mg g^{-1} dw and the critical concentration for Cu toxicity is more than 25 mg Cu g^{-1} dw plant tissue (Dobermann and Fairhurst, 2000). So, the rice shoot Cu concentration was higher than the optimum level. The high Cu concentration in shoot may be due to the high level of available Cu in used sewage sludge, which can be released with organic matter decomposition and absorbed by plant. Also, solubility and availability of Cu in soil increases with Cu-organic matter chelate formation (Najafi et al. 2012). Application of chemical fertilizers and sewage sludge increased rice shoot Cu concentration in the continuous waterlogging and alternate saturation irrigation regimes compared to the control (Figure 6), but use of sewage sludge in the alternate waterlogging conditions caused to decrease the shoot Cu concentration. The higher shoot Cu concentration was observed in the alternate saturation with 20 and 40 g sewage sludge kg^{-1} soil with and without 50% chemical fertilizers treatments (Figure 6).

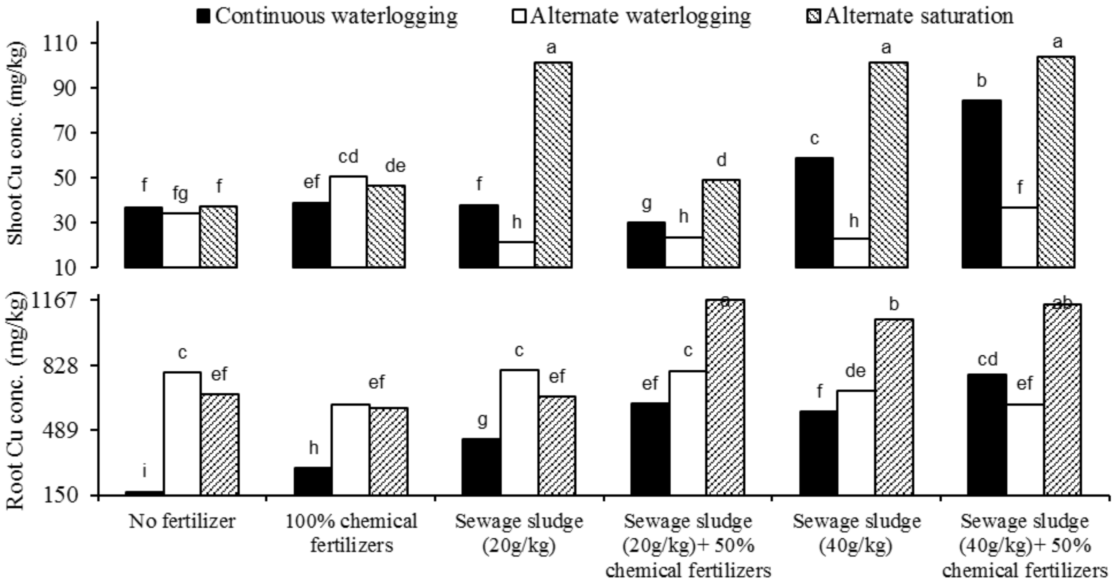

Figure 6. Effects of sewage sludge and chemical fertilizers on rice root and shoot Fe concentration under different irrigation regimes

Root Cu concentration

The root Cu concentration in the alternate saturation conditions was greater than other irrigation regimes. Application of sewage sludge and increasing level of that increased root Cu concentration and addition of 50% chemical fertilizers at both levels of sewage sludge increased its more. The highest root concentration of Cu was observed in soil treated with 20 and 40 g sewage sludge kg^{-1} soil + 50% chemical fertilizers and it was lowest in the control and 100% chemical fertilizers (Figure 6). Mahmoodabadi et al. (2010) observed similar results for soybean plant. Average ratio of Cu concentration in shoot to that in root was 0.08. So, rice plant keeps the most of Cu in root and does not transport it to the shoot. Application of sewage sludge and increasing level of that increased root Cu concentration in the alternate waterlogging and saturation and the highest rate was observed in alternate saturation with 20 g sewage sludge kg^{-1} soil + 50% chemical fertilizers (Figure 6). There was positive linear relationship between shoot and root concentrations of Cu: $Cu_{shoot}=0.045(Cu_{root})+19.17$, $r=0.42^{**}$.

Shoot and root Cd and Pb concentrations

In all treatments, Cd and Pb concentrations in shoot and root of plant were too low and were not measurable with atomic absorption spectrophotometry.

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Vermiremoval of zinc in various composition of feed mixtures by utilising *Eisenia foetida*

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Abstract

This study on the duration of zinc removal from the various composition of feed mixtures also investigates the change of zinc content in vermicompost after its removal period. Therefore, this work aimed to study the removal of zinc in anaerobically digested sewage sludge (SS) amended with hazelnut husk (HH) and cow manure (CM) in different proportions under laboratory condition (in darkness at 25°C ± 0,5 ^{0}C) for *Eisenia foetida* via vermicomposting and to investigate the effect of zinc content until 90 days of the vermicomposting process. Three approaches investigated in the study were: (i) to find the best medium for growth and reproduction of *E. foetida* in different feed mixtures, (ii) to analyze the zinc concentrations in different feed mixtures of SS-HH-CM before and after vermicomposting, and (iii) to explore Zn accumulation of earthworms in sewage sludge with different feed mixtures. Number and biomass of earthworms and Zn contents in feed mixtures and earthworms were periodically monitored. The results indicated that maximum earthworm biomass was attained in feed mixture of 20% SS + 40% CM + 40% HH while the earthworm number was highest in feed mixture of 30% SS + 35% CM + 35% HH during the vermicomposting period. Zinc concentration in all feed mixtures decreased associated with the increasing vermicomposting time. Zn content in the feed mixtures was lower than that of initial mixtures. Zn analysis of earthworms revealed considerable bioaccumulation of Zn in their bodies' tissue. Zinc analysis of earthworm body showed that increasing proportion of SS in the feed mixtures promoted the Zn content of earthworm body.
Key words: Bioaccumulation, enrichment factor, zinc, sewage sludge, vermicompost *Eisenia foetida.*

Introduction

Earthworms are a key indicator of ecosystem health and many studies have been performed on the response of earthworms to metals (Nahmani et al., 2007). Vermiremoval is an enhancement of the natural process that integrates earthworms' and microbes' role as an efficient tool in accumulating heavy metal in the earthworms' tissues. Moreover, its ability to safely remove metals in polluted environments is widely known. Earthworms ingest, grind and digest organic waste with the help of aerobic and anaerobic microflora in their gut, converting it into much finer, humified, microbially active material (Maboeta and Van Rensburg, 2003). Vermicompost or vermicast produced from the process is stable and homogenous, has desirable aesthetics, may have reduced levels of contaminants, and furthermore is a valuable, marketable and superior plant growth medium (Aranda et al., 1999).

In recent years, earthworms have been widely used in the breakdown of sewage sludge and other organic wastes in producing vermicomposts (Jain et al., 2003). Some species of earthworms are known to be potential accumulators of heavy metals and therefore they have been successfully demonstrated in mitigating the toxicity of industrial and municipal waste by vermicomposting technology (Saxena et al., 1998). This simple and low-cost technique can be used in the removal of toxic metals and the breakdown of complex chemicals to non-toxic forms (Jain and Singh 2004). Substantial evidence indicates that earthworms accumulate heavy metals from polluted soils and other media (Neuhauser et al., 1985; Kızılkaya 2004, 2005). The most common earthworm used for vermicomposting is *Eisenia feotida*, commonly well known as red wigglers. Advantages of *E.feotida* are that it grows rapidly, and uses almost any organic matter as feeds. It has also wide temperate tolerance a high reproductive rate and has the capability of accumulate heavy metal accumulation in the sewage sludge vermicompost (Saxena et al, 1998; Edwards and Bater, 1992).

The main objectives of the present study were (i) to study the removal of zinc in the appropriate proportion of anaerobically digested sewage sludge (SS) – hazelnut husk (HH) – cow manure (CM) for sustainable and the best medium for growth of *E. feotida*, (ii) to analyze zinc content in different feed mixtures of SS-HH-CM before and after vermicomposting, and (iii) to explore Zn accumulation of earthworms in sewage sludge with different feed mixtures.

Materials and Methods

Organic wastes and earthworm

Sewage sludge (pH 7.35, conductivity 1.82 dS m^{-1}, C:N ratio 9) was obtained from the wastewater facility set up by the Ankara Wastewater Treatment Plants, Ankara, Turkey. The sludge was anaerobically digested with a mixture of primary and waste activated sludge typically entering the digester. Hazelnut husk (pH 5.81, conductivity 1.93 dS m^{-1}, C:N ratio 47) collected from hazelnut trees in the Eastern Black Sea Region, Turkey. Cow manure (pH 8.46, conductivity 2.35 dS m^{-1}, C:N ratio 12) mixed with minor amounts of bedding and feed refusals from different cows in Tokat, The sewage sludge (SS), hazelnut husk (HH) and cow manure (CM) on an average contained 22.9%, 53.9%, and 20.7% organic C; 2.54%, 1.14%, and 1.70% total N; 2.43%, 0.34%, and 2.66% total P; 1.14%, 2.19%, and 3.94% total K, respectively. The organic wastes (SS, HH and CM) in this experiment was digested and air dried and sieved to less than 0.5 mm and stored in polyethylene bags at 5 ^{0}C until used. The *Eisenia feotida* were collected from the same CM. Earthworms were washed with distilled water and kept for 2 weeks before starting the experiment in containers with CM at 25 ± 0.5 ^{0}C.

Experimental design

A randomized complete plot design with five replicates per treatment and organic wastes were used. The experiment was performed with the following 11 treatment and given in Table 1.

The organic wastes (SS, HH and CM) were thoroughly mixed (Table 1) on air-dried weight basis by a mixer. These mixtures (500 g dry weight) were placed in a 1-L cylindrical plastic container. Then, three clitellated earthworm *Eisenia foetida* each weighing between 0.6 and 0.7 g, were placed in the mixed material. Each treatment was replicated three times. The samples were first adjusted to 50% of the soil water holding capacity by adding distilled water and then pre-incubated at 25 ^{0}C for one day (conditioning period). After conditioning, the moisture content of the mixture was maintained at 70% throughout the vermicomposting period and the containers were maintained in darkness at 25°C ± 0,5 ^{0}C. Substrate samples collected every 15 days during vermicomposting period (90 days) to determine the heavy metal distribution, and were stored in plastic vials at 4°C until analysis. Earthworm numbers and biomass gain were recorded for every vermicomposting period.

Table 1. Composition of treatments used for experimentation

Mixture	Mixture	SS		HH		CM	
number	Description	(g)	(%)	(g)	(%)	(g)	(%)
1	0% SS + 50% HH + 50% CM	0	0	250	50	250	50
2	10% SS + 45% HH + 45% CM	50	10	225	45	225	45
3	20% SS + 40% HH + 40% CM	100	20	200	40	200	40
4	30% SS + 35% HH + 35% CM	150	30	175	35	175	35
5	40% SS + 30% HH + 30% CM	200	40	150	30	150	30
6	50% SS + 25% HH + 25% CM	250	50	125	25	125	25
7	60% SS + 20% HH + 20% CM	300	60	100	20	100	20
8	70% SS + 15% HH + 15% CM	350	70	75	15	75	15
9	80% SS + 10% HH + 10% CM	400	80	50	10	50	10
10	90% SS + 5% HH + 5% CM	450	90	25	5	25	5
11	100% SS + 0% HH + 0% CM	500	100	0	0	0	0

Changes in the total earthworm mass and the number within each maturity category were determined 15 days. All worms and vermicompost were taken from the core and placed onto a tray. Under red light (to minimise stress) the worms were separated from the vermicompost. Worms separated from the vermicompost were washed thoroughly under slow running water. Most vermicompost separated from the worms freely and was easily removed; however some vermicompost clung to the worms and required further washing. The worms were classified by maturity category into adults, subadults and juveniles. Adults were classified by the presence of a large and clearly visible clitellum. Subadults had no clitellum and tended to be smaller than the adults. Juveniles were very small and transparent. Each category was counted, weighted and immediately stored at -80 ^{o}C to use during the heavy metal analysis.

Total Zn contents in vermicompost

The total Zn contents of the vermicomposts were determined by atomic absorption spectrophotometry following a digestion with a mixture of Aqua Regia-HNO_3 and HCI.

Zn contents in earthworms body

Earthworms were oven-dried in glass flask at 105^{0}C. The dried earthworms were digested overnight in nitric acid at a rate of 1 ml HNO_3 per mg dry weight of earthworm. After heating at 120^{0}C and evaporation, 1 ml HNO_3/H_2SO_4/HCI (10/2/3; v/v/v) was added. The solution was heated at 180^{0}C; after cooling, samples were diluted with deionized water up to 25 ml. The concentrations of zinc in earthworms were determined by flame atomic absorption spectrophotometry using and air-acetylene-flame device (Scaps et al., 1997).

Bioaccumulation Factor

The Bioaccumulation Factor (BAF) for earthworm E.feotida were estimated based on the Zn in earthworm tissues and substrate materials using the method described by Pearson et al., 2000. The BAF is defined as follows: BAF = $C_{biota}/C_{substrate}$, where C_{biota} and $C_{substrate}$ were the total Zn concentrations (in mg.g^{-1}) in taxa (earthworm) and substrate (used for vermicomposting experiment), respectively. It was possible to obtain BAF estimates for Zn since the earthworm concentrations for Zn reached steady state levels during the testing period.

Statistical analysis

All data were analyzed using SPSS 11.0 (Statistical Package for Social Science) statistical software. Analysis of variance (two-way ANOVA) was carried out using two factors randomized plot design (mixture ratio and vermicomposting period). The means were compared using by the LSD (Least Significant Difference) test, with a significance level of $P< 0.01$. All the figures presented include standard deviation of the data. The asterisks, *, ** and *** indicate significance level at $P<0.05$, 0.01 and 0.001 respectively.

Results and Discussion

Earthworm production and reproduction

Increasing proportion of SS in the feed mixtures caused the decrease in survival and growth of *E.foetida* (Figure 1 and 2). Mortality was recorded in ³ 60% SS feed mixtures (mixture no 7, 8, 9, 10, 11) at all vermicomposting period. This indicated that a greater percentage of SS in the feed mixture was significantly toxic for the production and reproduction of *E.foetida*. This situation may be related high NH_4-N and Zn concentrations of anaerobically digested SS.

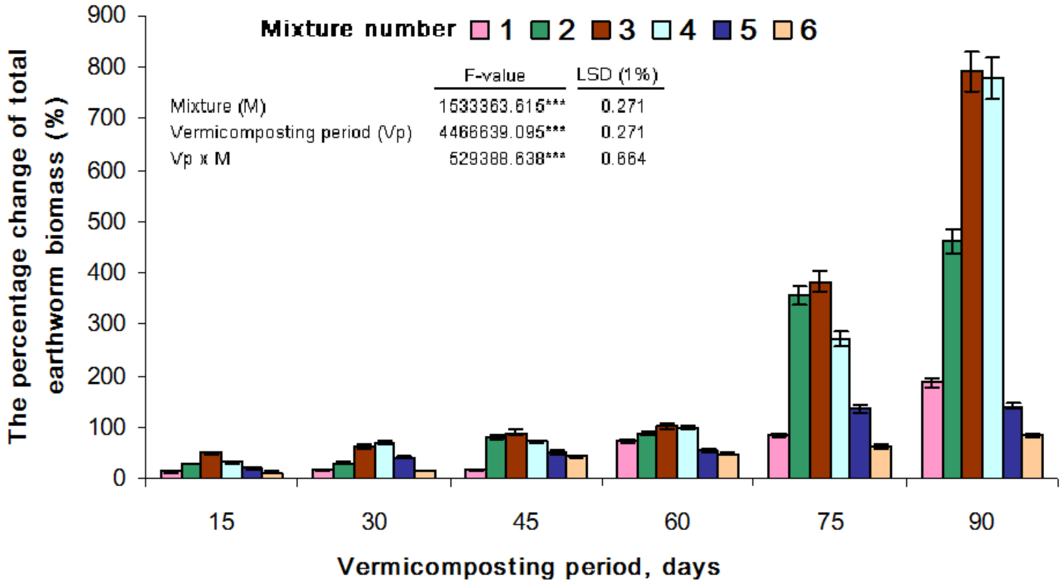

Figure 1. The percentage change of total earthworm biomass in experimental units obtaining in different feed mixtures (n=5)

In all feed mixtures, significant differences in the total earthworm biomass were recorded. The percentage change of total earthworm biomass was similar in all vermicomposting periods. Feed mixtures no.3 (20% SS + 40% CM + 40% HH) had the highest worm masses while the lowest was observed in the 50% SS + 25% CM + 25 HH feed mixture (no.6) at $P<0.001$. Increasing percentage of SS in the feed mixtures led to decrease in the number of earthworm *E.feotida*. The net number gain by *E.foetida* was higher in feed mixtures no. 3 and 4 compared to other feed mixtures. The maximum earthworm biomass and number were observed in the 75th or 90th day in all the feed mixtures.

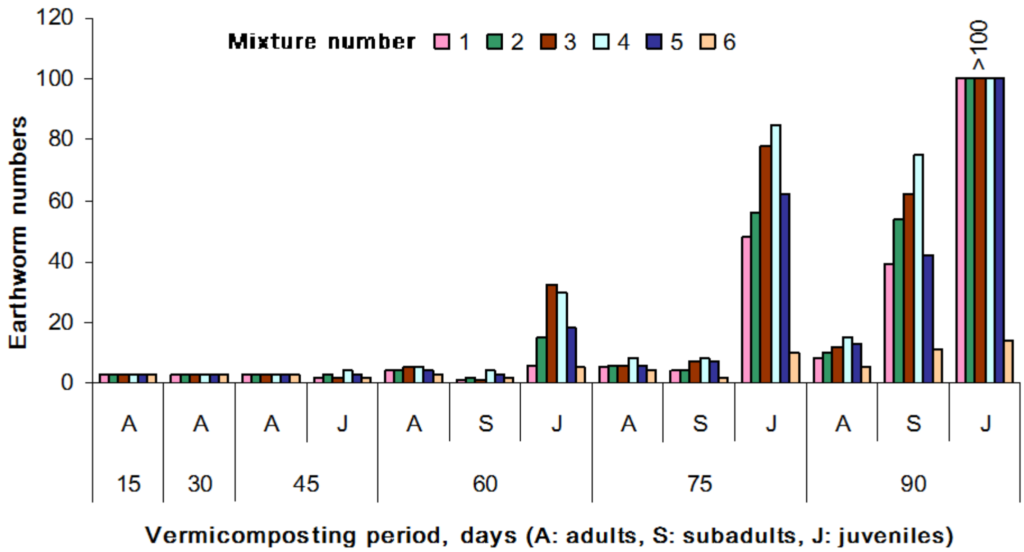

Figure 2. Population dynamics of earthworm *E.feotida* in experimental units in different feed mixtures (n=5)

Total Zn contents in vermicompost

Table 2 presents the heavy metal status in different mixtures of SS, HH and CM before vermicomposting.

Table 2. Zinc concentrations (mg.g^{-1}) in feed mixture before vermicomposting

	Mixture number					
	1	2	3	4	5	6
Zn	339,89	1902,07	3464,26	5026,44	6588,62	8150,81

The results of comparisons revealed that Zn concentrations in final vermicompost in the feed mixtures no. 1–6 were lower than that of the initial feed mixtures (Figure 3) and this Zn concentrations increased from the feed mixtures no 1 to 6. Feed mixtures no 4–6 contained more SS than that of feed mixtures no 1–3. Zinc concentrations in the vermicompost decreased associated with time increasing (Figure 3).

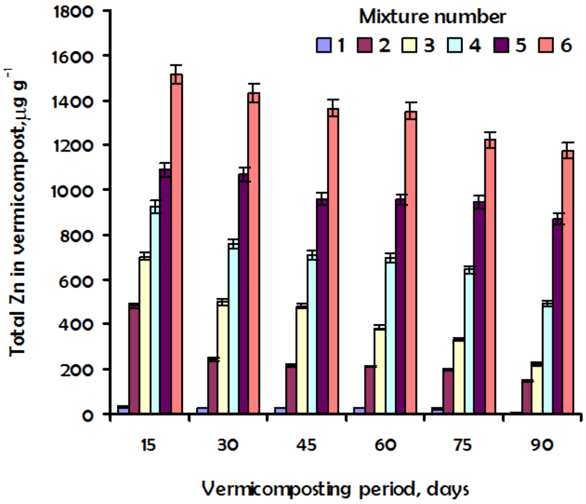

Figure 3. Changes in Zn concentrations (mg.g^{-1}) from different feed mixtures associated during vermicomposting process. Vertical bars indicate standard error of mean of three replicates at 95% confidence level

Based on the chemical analysis of vermicomposted samples, considerable reduction in Zn concentrations was observed for all feed mixtures (Figure 4). Vermicomposted material had reduced Zn content at the end of the experiment. The reductions ranged between 74.6 and 98.3% for Zn (Figure 4).

The Zn reduction increased associated with vermicomposting period depending upon earthworm growth activities. Therefore, it was attributed to the earthworm activity and/or vermicomposting time in the waste decomposition system. Zn were accumulated in body tissues. Similarly, previous studies have revealed that earthworms can accumulate heavy metals in their tissues during the process of vermicomposting (Hartenstein and Hartenstein 1981; Garg and Kaushik 2005; Gupta et al. 2005). Gupta et al. (2005) studied the vermicomposting of fly ash by mixing it with cow dung in different ratios and reported 30–50% loss in heavy metal content in different combination, at the end. They reported that heavy metals bioaccumulated in earthworm tissues. This study confirmed that earthworms could efficiently reduce the metal content in substrate.

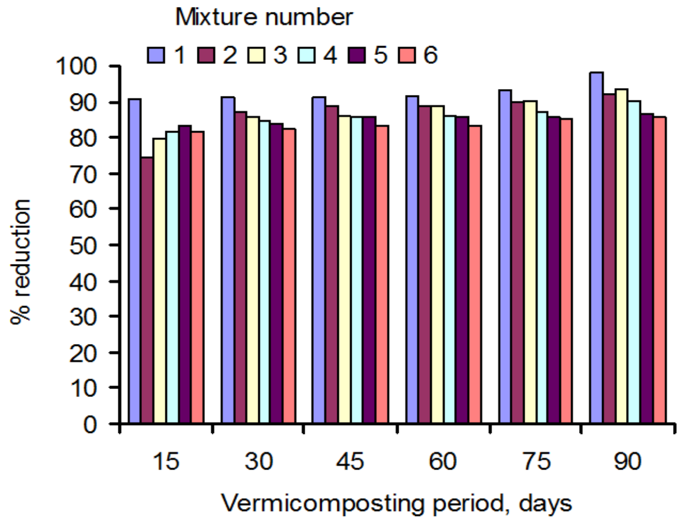

Figure 4. % reduction of Zn of different feed mixtures with time during vermicomposting process

Zn contents in Earthworm body

The earthworm *E.feotida* collected at the end from different feed mixtures showed considerable concentrations of Zn in their bodies (Figure 5). The difference among feed mixtures in terms of contents of Zn in earthworms was statistically significant.

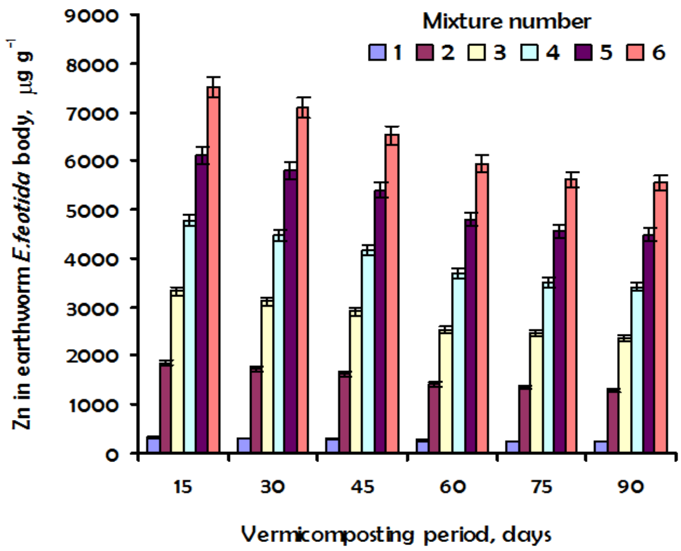

Figure 5. Changes in Zn contents in earthworm *E.feotida* body during vermicomposting process. Vertical bars indicate standard error of mean of three replicates at 95% confidence level

The Zn concentrations in earthworm body tissues decreased associated with time, and at all vermicomposting period of the experiment. Zinc content of earthworm body in the feed mixture no. 6 (50% SS + 25% HH + 25% CM) was significantly higher ($P<0.01$) than that of other feed mixtures. The observed difference in Zn contents in vermicomposted material for different feed mixtures may be related to the different rates of SS for Zn. It meant that the Zn

level in earthworm was directly related to the contents of Zn in feed mixtures.
This study confirmed and extended the earlier studies that earthworms can accumulate a considerable amount of metals in their tissues when inoculated in SS. In general, the content of metals in earthworms depends on inhabiting substrate metal contents (Lukkari et al., 2006).

Bioaccumulation factor
The BAF for the Zn in the earthworm *E.feotida* body tissues during the 90 day vermicomposting period are depicted in Figure 5. BAF varied associated with the different feed mixtures in this study.

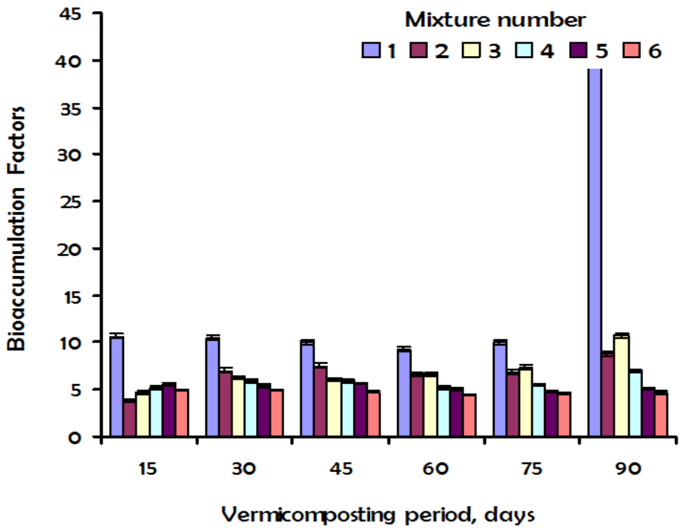

Figure 6. Bioaccumulation factors of Zn accumulated in earthworm *Eisenia feotida* body in feed with different mixtures. Vertical bars indicate standard error of mean of three replicates at 95% confidence level

Recent studies have revealed that accumulation of metals, especially Cd, Cu and Zn, in earthworms is mainly due to the binding of metals by metallothioneins (Kagi and Kojima, 1987). The BAF ranges calculated in this study, however, were higher than those of reported by earlier researchers (Dia et al.,2004; Hsu et al., 2006; Suthar and Singh 2008; Kizilkaya 2004,205). The observed difference for BAF in present and past studies could be related with the level of metals contamination and exposure duration or earthworm species type (Suthar and Singh 2008).

Conclusion

Disposal of SS by environmentally acceptable means is a serious problem. Our trials demonstrated that vermicomposting could be an alternate technology for the management of primary SS mixed with HH and CM. Vermicomposting of SS, after mixing it with a HH and CM reduced in the concentration of heavy metals. However, in both feed mixture no. 3 (20% SS + 40% HH + 40% CM) and feed mixture no. 4 (30% SS + 35% HH + 35% CM) maximum increase in numbers and biomass production rates of earthworms as well as decrease in heavy metal concentrations was recorded during the vermicomposting period. The decrease in metal concentrations in the vermicompost indicated the capability of *E. feotida* in accumulating heavy metals in their body tissues. Although, earthworm *E.feotida* could efficiently reduce the contents of heavy metals in sludge, which could be further used for sustainable land restoration practices, but greater level of bioconcentrated metals in earthworm tissues could not be ignored due to high level of mortality was recorded in ³ 60% SS feed mixtures. The results indicated that after the addition of primary SS in appropriate quantities (20–30%) to the HH and CM, it may be used as a raw material in the vermicomposting.

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Direct and residual effects of boron and zinc on growth and nutrition status of rice and subsequent wheat crop

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Abstract

The micronutrient deficiencies are wide spread in the areas of two major stable food rice wheat cropping system. So nutrition status of rice and wheat has direct effect on the health of human population. A field study was conducted to observe the direct and residual effects of boron (B) and zinc (Zn) fertilizers on crop growth and its grain nutrition status. Each plot received either B or Zn at the rates, 0, 1, 2, 3 and 4 kg B ha^{-1}, 5, 10, 15 and 20 kg Zn ha^{-1}, combined B and Zn application at 1 kg B and 5 kg Zn ha^{-1}, 2 kg B and 10 kg Zn ha^{-1}. Boron and Zn application significantly enhanced the growth and yield of rice at all levels as compared to control. The highest yield was recorded at 3 kg B, 15 & 20 kg Zn and 2 Kg B, 10 Kg Zn ha^{-1} rates. Boron also improved the nutrition status of rice as B, protein and total carbohydrates content of spikelet augmented. The residual B and Zn were also effectual for the second season wheat crop as all yield components of the plant significantly improved. The highest grain yield was recorded at the residual rates of 3 and 4 kg B, 15 and 20 kg Zn ha^{-1} than the other treatments. This study showed that one application of B and Zn can increase crop yields for at least two consecutive seasons.

Key words: Residual Boron, Zinc, Rice, Wheat.

Introduction

Cereal crops rice and wheat are the largest cropping system in the world because it is the major staple food of the global population. Despite the prime position of this cropping system in food security and the economy of the many countries, the productivity of these both crops is not uptomark. *FAO* (2015) forecasts recommend that by 2050 global crop yields should be increased upto 70 percent, to meet the food demand of world populace. Rice and wheat are nutrient exhaustive crops so the nutrient removal from the soil is high. Zinc and B deficiencies are most common in world soils, which are causing low-grade crop quality and production (*Alloway*, 2008; *Rashid and Ryan* 2004; *Rafique* et al., 2008). One of the major reasons of low per hectare yield of these crops is due to limited use of micronutrients (B and Zn). Although micronutrients are required in minute quantity but due to nutrient mining plant available B and Zn had become deficient in soils. Keeping in view the significance of micronutrients in sustainable crop production and the importance of cereal crops rice and wheat, a long term field trial was conducted to observe the direct and residual effects of B and Zn on growth of rice and wheat crops. This experiment was designed to discover the proper levels of Zn and B for not only rice but also residual effects of these levels on subsequent wheat crop.

Materials and Methods

Field experiments on rice and wheat crops were conducted at B and Zn deficient farmer's field in the main rice growing area of Sindh-Pakistan (GPS location: 28^{0}13'03.28 N, 68^{0}47'36.09 E). The experimental site was silty clay, slightly saline and alkaline (EC 4 dS/m and pH 8.0 in 1:2 soil-water extract), low in organic matter (0.80%), phosphorus (4 ppm), Zn (0.38 µg g^{-1}), B (0.3 ppm), total N (0.05%) content and adequate in K content (130 ppm). The size of plots was 16 m^{2}. Each plot received either B as sodium pentaborate or Zn as zinc sulfate, the rates were T1= control, T2= 1 kg B ha^{-1}, T3= 2 kg B ha^{-1} and T4= 3 kg B ha^{-1}, T5= 4 kg B ha^{-1}, T6= Zn 5 kg Zn ha^{-1}, T7= 10 kg Zn ha^{-1} T8=15 kg Zn ha^{-1}. T9= 20 kg Zn ha^{-1}, T10= 1 kg B and 5 kg Zn ha^{-1}, T11= 2 kg B and 10 kg Zn ha^{-1}. The plots were alienated from each other by 30 cm high ridges and one meter wide path. Hybrid coarse rice variety was sown by transplanting.

Residual effects of B and Zn on wheat

Experimental layout was kept undisturbed for observing the residual effect of B and Zn on subsequent wheat crop. After harvesting of rice and before plantation of wheat physico-chemical properties of soil were again analyzed which showed that B and Zn levels were high in the B and Zn applied plots compared to control. The second season wheat crop (variety TD1) was planted after the interval period of 30 days. All agronomic observations and laboratory analysis were conducted of wheat crop by following standard methods. Statistical Analysis System (SAS) software package version 8.2 were used for the statistical analysis of data. The treatments were compared by using analysis of variance (ANOVA) procedure and Tukeys' honestly significant difference at 95% level of confidence.

Results and Discussion

The application of B and Zn has shown positive effect on all the agronomic parameters of the rice crop (Table 1). Although number of tillers increased at all the levels of B and Zn but significantly higher number was counted at 3 kg B ha^{-1}, 15 & 20 kg Zn ha^{-1} and 2 Kg B, 10 Kg Zn ha^{-1}. The plants received B and Zn was taller in height in compare to control. The plots applied with 20 kg Zn ha^{-1} had tallest plants in compare to other levels of B and Zn. The number of grains per panicle increased higher number of grains were counted in the plants which received 3 kg B ha^{-1}, 15 & 20 kg Zn ha^{-1} and combined application of 2 Kg B,10 Kg Zn ha^{-1}. All the levels of these micronutrients significantly increased the grains weight in compare to 0 Kg ha^{-1} B and Zn. The plants treated with 3 & 4 kg B ha^{-1}, 20 kg Zn ha^{-1} and combined 2 Kg B, 10 Kg Zn ha^{-1} had significantly heaviest 1000 grains weight in compare to plants treated with lower levels of B and Zn. Boron and Zn content of the rice grain significantly increased with the increasing levels of these micronutrients in compare to control. The maximum grain B content was recorded at 3 & 4 kg B ha^{-1} and the highest Zn content was analyzed in the rice grain samples from the plots applied with 20 kg Zn ha^{-1}. According to *Gupta* (1993) B is actively involved in the seed formation. Our results are consistent with the findings of *Ashraf* et al. (2004), *Rahmatullah* et al. (2011), they reported that B application significantly increased the number of tillers and spikelets, size and weight of panicle, leaf and grain B concentration. Rice is a rich source of dietary energy so it plays vital role in achieving better nutritional balance. Boron application increased nutrition status of rice. Boron concentration in spikelet increased with its application. More than 50% B concentration increase was recorded at 3 kg B ha^{-1} over the control. The protein content of rice spikelet was also augmented. The improvement in the yield parameters of plants over control could be attributed to the enhanced enzymatic activity and auxin metabolism in plants due to Zn application. *Alloway* (2008) explained that more than 300 enzymatic activities are related to Zn. Our results are in agreement with the findings of *Gao* (2007). They reported that Zn application improved all yield parameters of rice crop. As the application of B and Zn improved the agronomic growth of rice plant so ultimately per hectare yield of the crop also increased at all B and Zn levels in compare to control. The highest yield was recorded at 3 kg B ha^{-1}, 15 & 20 kg Zn ha^{-1} and combined application of 2 Kg B, 10 Kg Zn ha^{-1}. The yield increase was about 23% over the control at these B and Zn levels. These findings are consistent with those of *Saleem* et al (2011), Ehsan-Ul-Haq et al. (2009). They reported that rice crop with B fertilizer harvested higher yields over the control.

Table 1. Effect of B and Zn application on growth yield of rice crop

B and Zn levels (ha^{-1})	No. of Tillers $Plant^{-1}$	Plant height (cm)	Grains $panicle^{-1}$	Weight 1000 grains (g)	Grain B (mg kg^{-1})	Grain Zn (mg kg^{-1})	Protein	Grain Yield Tons/ha
0 Kg B & Zn	11.0 D	108.0 B	171.6 F	23.6 E	6.3 D	10.3 B	5.8 C	8.13 F
1 kg B	11.2 CD	109.3AB	177.4 EF	24.6 DE	6.4 CD	11.0 B	5.8 C	8.33 F
2 kg B	12.6 CD	110.2AB	188.0 CD	25.6 BC	8.0 BC	11.0 B	6.2 B	8.93 E
3 kg B	15.0 A	111.0AB	200.0 A	27.2 AB	10.6 A	11.2 B	6.9 A	9.76 A
4 kg B	14.4 AB	109.6AB	196.3 AB	27.4 AB	11.0 A	11.3 B	7.10 A	9.0 B
5 kg Zn	12.0 CD	110.4AB	182.3 DE	23.3 E	6.2 D	12.6 B	6.0 C	8.40 F
10 kg Zn	13.3 BC	111.6AB	190.3BCD	25.2 CD	6.6 CD	14.6 AB	6.4 B	9.10 DE
15 kg Zn	15.6 A	112.0AB	201.0 A	26.06AB	6.33 D	17.0 AB	6.8 A	9.68 AB
20 kg Zn	15.5 A	113.3 A	202.6 A	27.6 A	6.4 CD	21.2A	7.9 A	9.73 AB
1 kg B, 5 kg Zn	12.5 CD	111.6AB	197.67 AB	26.2 AB	8.4 B	11.0 B	6.5 B	9.20CDE
2 kg B,10 kg Zn	15.0 A	111.6AB	202.00 A	27.6 A	10.3 A	13.0 B	7.0 A	10.00 A

The values with same letter within columns are not significantly different at p=0.05.

Residual effects of B and Zn on wheat

There was positive residual effectiveness of B and Zn on subsequent wheat crop sown in the same field after the harvesting of rice (Table 2). Residual effect of 3 & 4 kg B ha^{-1} and 20 kg Zn ha^{-1} recorded taller plants, followed by 15 kg Zn ha^{-1} and 2 kg B. The same trend was observed in tillers per plant of wheat. The results indicated that the residual 4 kg B ha^{-1} and 20 kg Zn ha^{-1} produced the higher number of tillers compared to the control and other B and Zn levels. The maximum number of spikelets was obtained from the residual effectiveness of 4 kg B ha^{-1} and 20 kg Zn ha^{-1} followed by other levels. The results of 1000 grain weight revealed the significant differences among various residual B and Zn rates. The residual effects of B at 3 and 4 kg ha^{-1} and Zn at 15 and 20 kg ha^{-1} resulted in significantly higher grain weight than the other levels. This increase in grain weight is due to the role of Zn on the reproductive development rather than on the vegetative part of the plant (*Kovacevic* et al. 2007). Laboratory analysis of grain samples showed that the highest B concentration was found in the residual effect of 3 and 4 kg B ha^{-1} plots compared to the other treatments. This same trend was observed when wheat grains were analyzed for Zn content. The highest Zn concentration was observed in wheat grains harvested from 15 and 20 kg Zn ha^{-1} applied plots. The residual B and Zn remained fully effective in correcting their deficiency for the second season wheat crop as all yield components of the plant significantly enhanced. Crop harvested from last season fertilizer applied plots, produced significantly higher wheat yields at the rates of 3 and 4 kg B ha^{-1}, 20 kg Zn ha^{-1} and 2 Kg B, 10 Kg Zn ha^{-1} than the other treatments. At these rates the yield was 13% higher than the control. This field study showed that one B and Zn fertilizer application can improve crop yields for at least two consecutive seasons because very small quantities of these nutrients are consumed by first season crop and remaining amount was present in soil which were used by second season wheat crop for healthy growth. The findings of this experiment are consistent with other researchers who reported that the yield of wheat crop significantly increased due to B residual effect they observed that residual B and Zn have positive effect on agronomic parameters and yield of wheat and there is no need to apply Zn in each season (*S.M. Alam* 2004; *Singh* 2008).

Table 2. Residual Effect of B and Zn application on growth parameters of wheat crop

B and Zn levels ha^{-1}	Plant height (cm)	Tiller $plant^{-1}$	Grains $spikelets^{-1}$	Weight 1000 grains (g)	Zn in grain ($mg\ kg^{-1}$)	B content of grain ($mg\ kg^{-1}$)	Yield Tons ha^{-1}
0 Kg B, 0 Kg Zn	65.33 B	4.25 C	40.0 C	41.0 C	11.0 B	3.0 B	3.8 B
1 kg B	67.31 B	4.32 C	41.0 C	41.30 C	11.0 B	3.96 B	3.86 B
2 kg B	69.00 AB	5.35 BC	41.30 BC	42.0 B	11.0 B	4.66 AB	3.93 B
3 kg B	72.66 A	6.0 B	43.0 B	44.66 A	11.30 B	5.66 A	4.23 A
4 kg B	73.0 A	6.7 A	45.0 A	44.1 A	12.28 B	5.0 A	4.26 A
5 kg Zn	65.29 B	4.28 C	40.0 C	41.36 C	11.66 B	3.96 B	3.80 B
10 kg Zn	67.25 B	4.38 C	41.0 C	42.66 B	14.20 A	3.60 B	3.86 B
15 kg Zn	70.20 AB	5.66 B	42.60 B	44.40 A	16.0 A	4.0 B	4.13 AB
20 kg Zn	73.0 A	6.66 A	45.22 A	45.42 A	17.0 A	3.7 B	4.43 A
1 kg B, 5 kg Zn	71.42 AB	5.66 B	43.28 B	42.60 B	11.66 B	3.67 B	4.1 AB
2 Kg B,10 Kg Zn	71.66 AB	5.70 B	44.6 A	43.0 AB	13.50 AB	4.56 AB	4.23 A

The values with same letter within columns are not significantly different at p=0.05.

Conclusion

Strong evidence of the positive direct and residual effects of B and Zn on rice and wheat crop yields was observed. The applications of up to 3 kg B and 20 kg Zn ha^{-1} in the first season rice crop gave highest yield and encouraging residual effects on the growth and yield performance of the subsequent wheat crop. One application of these micronutrients can increase yields for at least two consecutive cropping seasons.

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Utilization of biomass ash after combustion in an electric power plant: effect on soil and plant quality

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Abstract

The research studied possibilities of biomass ash utilization and its effect on soil and plant quality after combustion of soybean straw for energy purposes. *Permanent collecting of crop residues from fields may deteriorate soil fertility.* Considering the content of valuable nutrients, physical properties and alkaline nature of the ash obtained after combustion of most agricultural crops the ash utilization in agriculture may have a fertilizing effect thus contributing to the sustainable soil fertility management and at the same time solving the problem of ash deposits. A pot experiment was set up with low and high doses of ash alone and in combination with mineral fertilizer on growing barley in 2015. The ash, soil and plants samples were tested for: main soil agrochemical properties (N, C, S, $CaCO_3$, P_2O_5 and K_2O) and the content of potentially toxic and hazardous microelements (As, Cd, Co, Cr, Cu, Ni, Pb, Zn, Fe and Mn). Ash amendment significantly reduced soil acidity, increased content of available P for 83-91%, and K for 64 – 81%, increase yield of barley biomass for 46-54% compared to the control treatment. The higher dose of added ash (20 g/kg soil) didn't show better effects on soil and plant than the lower dose (10 g/kg soil). Content of potentially toxic microelements in soil and plant were below the maximum allowed concentrations. Application of biomass ash was effective in terms of soil nutritional and physical properties resulting in yield increase, suggesting that the analyzed ash can be used as a fertilizer on acid soils with low nutrients content.

Key words: biomass ash, soil, plant, nutrient, trace elements.

Introduction

Recently in Europe a biomass from agricultural field are widely used for energy purposes an alternative source of fuel. However, an important concern is a potential depletion of soil organic carbon, that may partially offset the environmental suitability and convenience of a large-scale bioenergy production policy (Don et al., 2012; Herrmann, 2013) involving agricultural residues. Also, a large part of biomass ashes are disposed as landfills. Finding the pathes to utilize the ash after combustion in an environmentally and economically efficient manner is an important goal. The main objective of this research was studying the possibilities of biomass ash utilization and its effect on soil and plant quality aimed for maintaining the soil fertility and ecological problems arose due to the ash deposits.

Materials and Methods

The ash sampled after combustion of soybean biomass for energy purposes of the Agricultural Corporation PKB Belgrade were analysed for the content of potentially toxic and hazardous microelements (As, Cd, Co, Cr, Cu, Ni, Pb, Zn, Fe and Mn), as well as for the content of nutritive elements (N, C, S, $CaCO_3$, P_2O_5 and K_2O). The experimental soil was *Cambisol*, acidic (pH_{H2O} 4.68), poor with organic carbon and nitrogen. The experiment was designed in five treatments, including low and high doses of ash (10 and 20 g per kg soil) with and without mineral fertilizer (Tab. 1) (CAN, calcium ammonium nitrate, with 27% of N) is in a dose of 0.1 g/kg soil. To study the impact of added ash on growth and quality of crop the barley was seeded. Each of 5 treatments was replicated 3 times in a pot with 2 kg soil. Each pot was weighed every second day and was watered if necessary to keep the 50% field moist capacity. At the end of the experiment the soil was analysed for the content of microelements (As, Cd, Cr, Cu, Mo, Ni, Pb and Zn), mechnical composition and main agrochemical properties. After harvest, the aboveground biomass of barley was analyzed for the content of the same microelements and nutrients.

Table 1. Experimental scheme with addition of biomass ash and fertilizer

No.	Treatments	Weigh, g
1	Control	Without ash and fertilizer
2	Ash 10	10g ash per kg soil
3	Ash 10+CAN	10 gash + 0,1g CAN
4	Ash 20	20 g ash
5	Ash 20+ CAN	20g ash+0,1g CAN

Results and Discussion

Ash characteristics

Both phases of ash characterized with alkaline soil pH, high content of K_2O, total sulphur, calcium carbonate and content of Ca (Table 2). Content of total carbon was nearly twice higher in fly ash than in bottom ash, while content of P_2O_5 was almost 10 times higher in the bottom ash than in the fly ash. Content of nitrogen in the ash was high (0.2415 and 0.013 mg/kg in the fly ash and bottom ash, respectively). Content of potentially toxic micro-elements (PTE) in the ash were below of allowed limits and were comparable to the reported in Austria for most of the cases (Obernberger and Supancic, 2009).

Table 2. Chemical characteristics of the biomass ash after combustion of straw

			mg/100 g				total, %		
	H.V., %	pH	P_2O_5	K_2O	N	C	S	$CaCO_3$	Ca
Fly ash	0.84	13.6	0.92	>40	0.2415	6.595	0.232	26.6	10.64
Bottom ash	1.16	13.5	10.04	>40	0.013	3.887	0.272	37.25	14.9

Soil characteristics after the experiment

At the end of the experiment, expectedly, soil pH significantly increased due to the addition of biomass ash at both doses (Table 3). Content of total N significantly decreased in ash amendment treatments compared to the control, while the content of total C was positively influenced by addition of higher dose of ash. Concentrations of P in soil at lower dose of ash (Ash10) increased for about 6 times and for more than 10 times at higher dose of ash (Ash20). Concentration of K_2O in soil at end of the experiment was significantly higher in ash amended treatments in accordance with the applied doses comparing to the control.
The aboveground yield of barley significantly increased accordingly to the added doses of ash (Table 4), where effect of CAN fertilizer was not observed. Content of the PTE in soil showed no changes after addition of biomass ash, except copper (Cu) that has positive linear correlation with increasing the doses of ash and fertilizer (Table 5).

Table 3. Agrochemical characteristics of the soil after the experiment (end of the experiment)

Treatment	pHin water	Total N	Total C	Total S	P_2O_5	K_2O	$CaCO_3$
			%		mg/100g		%
Control	4.68a	0.111a	1.062a	0.053a	5.50a	17.58a	0.000a
Ash 10	7.17b	0.107b	1.062a	0.043a	33.01b	49.27b	0.821b
Ash 10+CAN	7.25b	0.106b	1.051a	0.049a	34.47b	54.49b	0.835b
Ash 20	7.40bc	0.107b	1.145b	0.044a	62.32c	95.07c	1.044c
Ash 20+ CAN	7.57cd	0.108b	1.179b	0.050a	55.66c	91.93c	1.030c

§ The different letters indicate statistically significant difference at the 0.05 level of significance

Table 4. Content of main nutrients in aboveground biomass of barley after harvest

Treatment	Total N	Total C	P_2O_5	K_2O	Aboveground biomass yield
	%		mg/100g		g
Control	1.40a	43.07a	0.220a	0.913a	2.17a
Ash 10	1.67ab	42.97a	0.613b	1.390b	4.05b
Ash 10+CAN	1.90b	42.77a	0.583bc	1.497b	4.07b
Ash 20	1.97b	42.50a	0.367ac	1.693b	4.74c
Ash 20+ CAN	1.82b	42.22a	0.280a	1.640b	4.60c

§ The different letters indicate statistically significant difference at the 0.05 level of significance

Plant characteristics at the end of the experiment

Content of N in the plants increased in ash amended treatments, where the greatest accumulation of N was observed in the treatment with high dose of ash. Content of carbon was not changed (Tab. 4). Concentration of P_2O_5 in plants increased in lower dose and was not changed in the higher dose of ash. Content of K_2O in plants increased proportionally to the dose of added ash.

Addition of higher dose of ash resulted in slightly alkaline soil pH that was expected because of the alkaline nature of added ash (pH 13.5) and high content of $CaCO_3$ in the ash (Piekarczyk et al., 2011).The values of soil pH at the end of the experiment positively correlated with other soil characteristics and barley yield, except with soil nitrogen.

High $CaCO_3$ content in the ash increased the content of $CaCO_3$ in the soil at the end of the experiment accordingly to the applied doses of ash. In the acid soil with no calcium carbonate the calcium added with ash was spent for substitution of H ions thus increasing the substrate pH as well as was accumulating in soil.

Table 5. Content of microelements in the experimental soil and plant after the harvest

Treatment	As	Cd	Co	Cr	Cu	Ni	Pb	Zn	Fe	Mn
					mg/kg d.w. soil					
Control	6.10a§	0.30a	15.51a	37.22a	20.72a	37.19a	17.24a	56.39a	23826.16a	795.02a
Ash 10	6.18a	0.31a	15.74a	36.71a	21.50b	36.99a	17.11a	56.28a	23582.83a	831.36a
Ash 10+CAN	6.25a	0.29a	16.39a	36.49a	22.05b	37.17a	17.88a	57.28a	23869.50a	845.86a
Ash 20	6.17a	0.30a	15.36a	39.43a	22.93c	38.46a	16.85a	59.34a	24592.83a	801.86a
Ash 20+ CAN	6.25a	0.29a	15.29a	37.39a	22.84c	36.76a	17.05a	57.98a	23316.16a	800.86a
Treatment					mg/kg d.w. plant biomass					
Control	0.38a	0.18a	0.41a	6.07a	7.58a	4.00a	1.39a	33.31a	896.49a	86.11a
Ash 10	0.42a	0.15a	0.44a	7.86a	7.71a	4.25a	1.67a	29.97a	904.95a	86.11a
Ash 10+CAN	0.54a	0.19a	0.54a	8.22a	8.29a	4.56a	2.22a	31.80a	1,147.07b	98.18a
Ash 20	0.39a	0.15a	0.49a	10.10a	10.97b	5.14a	2.74b	30.67a	1,135.24b	93.75a
Ash 20+ CAN	0.32a	0.18a	0.39a	9.66a	10.34b	4.69a	1.84a	32.05a	738.72a	96.13a

§ The different letters indicate statistically significant difference at the 0.05 level of significance

Potentially toxic elements

Since the straw contains the same amount of heavy metals than in the ashes, the heavy metal loading on the soil did not change significantly. At the same time the solubility of most of PTE is lowered in near neutral and alkaline substrate (Sherene, 2010).

Effect of ash addition on copper changes in soil and plant was due to the changes in pH, because at higher pH the Cu might transform into more plant available form (Cuske et al., 2013). The added ash contained high amount of iron what was the reason of higher assimilation of Fe by plants in 10Ash+CAN and 20Ash treatments. While in the treatment Ash20+CAN the alkaline soil pH resulted in immobilization of plant available iron. Changes in the content of Fe in plant observed in ash added treatments were due to its solubility that is controlled by pH and redox (Shuman, 2005).

Addition of the ash in the doses of 10 g and 20 g per kg soil increased the dry matter of barley for 1.87 and 2.2 times, respectively. The primary factors that influenced the yield increase were increased soil pH and addition of plant available P and K with ash, what is confirmed by positive correlations between these indicators.

Conclusions

Application of ash was effective in terms of soil nutritional and physical properties resulting in yield increase, suggesting that the analyzed ash could allow the use of ash as fertilizer on acid soils. The higher dose of 20 g/kg soil of ash didn't show stronger effect on soil and plant qualities than the lower dose of 10 g/kg soil, suggesting that the dose of 10g of biomass ash per kg soil may be successfully used in acidic soil with low nutrients content.

Our preliminary results suggest that the ash after combustion of the agricultural crop biomass can be effectively used in the soil, which are initially low in the content of carbon and nitrogen, phosphorus and potassium and has acidic pH, considering that the applied ash meets the regulations on the maximum allowed concentrations of potentially toxic and hazardous elements.

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The influence of organic fertilizers on the properties of sward-podzolic soil

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Abstract

The purpose of research is to study the influence of chicken manure and cattle manure on the physical, physical-chemical and microbiological properties of sward-podzolic soil, depending on its granulometric composition and biological characteristics of crops.
The results of research: on sward-podzolic fixed-sandy loamy soil, with application of cattle manure for winter wheat, hydrolytic acidity increased by 0.08 in comparison with chicken manure per 0.12 meq / 100 g of soil, the degree of saturation with bases decreased by 5%, soil density decreased by 0.20, the density of solid phase decreased by 0.15 g / cm^3, porosity and the porosity of soil aeration was 31 and 33%.
On fixed-sandy loamy soil, with application of cattle manure for corn, hydrolytic acidity decreased by 0.02 and increased with application of chicken manure by 0.03 meq / 100 g of soil. On average loamy soil it increased by 0.04 and 0.14 meq / 100 g respectively. On fixed-sandy loamy soil, with application of cattle manure, the degree of saturation with bases increased by 3%, with application of chicken litter – by 9%. The density of solid phase increased by 0.15 g / cm^3 and 0.17 g / cm^3; on average loamy soil – by 0.10 and 0.17 g / cm^3, respectively, the total porosity decreased from 51 to 32 (cattle manure) and 35% (chicken litter) on fixed-sandy loamy soils and from 46 to 30 and 31%, respectively, on medium loamy soil. The microbiological activity of the soil during the cultivation of winter wheat was medium on fixed-sandy loamy soil with application of chicken litter and cattle manure – 45 and 42%, and amounted to 38 and 34%, respectively, on medium loamy soil; it was strong in corn with application of chicken litter and cattle manure cattle on fixed-sandy loamy soil – 51 and 54%, and amounted to 42 and 50%, respectively, on medium loamy soil.
Key words: soil, properties, organic fertilizers, winter wheat, corn.

Introduction

In the structure of meat production in the Republic of Belarus, poultry meat accounts for more than 36%; of which 93% is the production of broiler meat [5]. However, increased capacity of poultry farming and increased production volumes inevitably lead to an increase in the production of large-tonnage production waste, in particular bird droppings. With the existing structure, number and technology of bird feeding, the poultry industry of the country provides an annual volume of excrement at the level of 12% of the entire livestock sector [2]. Organic fertilizers are less concentrated in the content of toxicants and more environmentally friendly in comparison with mineral fertilizers. However, one should take into account the fact that organic fertilizers are used in much higher doses, especially in the zones of influence of industrial poultry enterprises [3].
Chicken litter is a valuable organic fertilizer with a high content of basic nutrients (nitrogen, phosphorus and potassium) and trace elements, with nutrients in compounds easily accessible for plant nutrition. According to the content of nutrients, it exceeds any organic fertilizer, and according to accessibility it is not inferior to mineral fertilizers. The value of 1 ton of broiler litter is equivalent to 180 kg of full mineral fertilizer [4].

Materials and Methods

In order to study the influence of chicken droppings on straw underlay and litter manure of cattle on physical, physical-chemical and microbiological properties of sward-podzolic cohesive-sandy loam and medium loam soil in 2016 and 2017, field experiments were laid. The research was carried out in OAO "Vitebsk broiler poultry farm 'Ganna'"and at the Department of Soil Science of Belarusian State Agricultural Academy. OAO "Vitebsk broiler poultry factory 'Ganna'", one of the largest in the Republic of Belarus, has a herd of 2 million 889 heads including 2 million 784 thousand broilers, adult hens – 105 thousand, laying hens – 94 thousand. The yield of bird droppings per month varies from 10 to 11 thousand tons, per year – more than 120,000 tons. The cattle headcount is 4,440 heads, the yield of litter manure is 47,000 tons. It is located in the north-eastern part of Belarus. This region is characterized by a temperate continental climate.

As organic fertilizers for winter wheat and maize, we used bird droppings and cattle manure on straw litter at a dose of 40 and 80 tons / ha, respectively. The chemical composition of organic fertilizers was determined by conventional methods. The technology of crop cultivation is common for the conditions of Belarus [8]. Before sowing and before the harvesting of winter wheat and maize in the arable horizon, soil samples were selected to determine physical and physical-chemical properties of the soil. Before sowing, a flax bed was laid to determine the microbiological activity of the soil. The hydrolytic acidity (Hr) of the soil was determined by the Kappen method, the sum of exchange bases (S) – by the Kappen-Gilkowitz method, the degree of saturation of soil with bases, the addition density, the density of solid phase, and the porosity of the soil – according to conventional methods.

Results and Discussion

According to the results of conducted agrochemical analyzes, the content of nutrients in chicken litter and cattle manure obtained in OAO "Vitebsk broiler poultry farm 'Ganna'" is, respectively: total nitrogen – 18.60 and 9.00; phosphorus (P_2O_5) – 10.20 and 11.90; potassium (K_2O) – 19.60 and 6.50; calcium (CaO) – 6.80 and 4.30; magnesium (MgO) – 7.60 and 1.70 kg / t. Chicken manure has a high content of Zn – 596.45 mg / kg of dry matter (at the norm of 39) and copper – 99.1 mg / kg of dry matter (at the norm of 25), in cattle manure the amount of Zn is 16.4 mg / kg and copper – 1.33 mg / kg.

The physical-chemical properties of the soil are the properties of the soil associated with its absorbing complex. As a result of the studies [1, 3, 7, 9] it was established that the prolonged use of litter reduced metabolic and hydrolytic acidity, increased the amount of absorbed bases and the degree of saturation with bases. On average, the density of solid phase in most mineral soils is 2.50-2.65 g / cm^3. Due to their biological characteristics, each crop requires the optimal density of root layer for its development: for grain and tilled crops, the optimal bulk density is 1.20-1.35 g / cm^3 [6]. According to the results of our studies, there have been significant changes in the physical-chemical and physical properties of the soil: before the harvest of winter wheat, the hydrolytic acidity of sward-podzolic cohesive sandy loam soil increased with the introduction of cattle manure from 0.76 to 0.84 Meq / 100 g of soil, and with chicken litter – to 1.12 Meq / 100 g of soil, the degree of saturation with bases decreased from 94 to 89%, the bulk density of soil decreased from 1.82 to 1.62 g / cm^3, the density of solid phase of soil decreased from 2.67 to 2.52 g / cm^3, general porosity and the porosity of soil aeration remained below the normative index (31-33%). Before the harvesting of corn, the hydrolytic acidity on cohesive sandy loam soil decreased from 1.84 to 1.82 Meq / 100 g of soil when cattle manure was applied and increased from 1.84 to 1.87 Meq / 100 g of soil when chicken litter was introduced. On medium loamy soil, it increased from 1.41 to 1.55 with the introduction of chicken litter and from 1.41 to 1.45 with the introduction of cattle manure. The degree of saturation with bases on cohesive sandy loamy soil increased from 77 to 80 (cattle manure) and 86% (chicken litter), while on average loamy soil it remained unchanged. The density of solid phase of soil at the time of harvest increased from 2.46 g / cm^3 to 2.61 g / cm^3 with the introduction of cattle manure and up to 2.77 g / cm^3 with the introduction of chicken litter on sward-podzolic cohesive sandy loam, from 2.61 to 2.71 g / cm^3

with the introduction of cattle manure and up to 2.77 g / cm^3 with the introduction of chicken litter on sward-podzolic medium loamy soil. The bulk density of soil increased at harvest time from 1.21 to 1.78 g / cm^3 when cattle manure was applied, and up to 1.81 g / cm^3 when chicken litter was applied on cohesive sandy loam soil; from 1.42 to 1.97 g / cm^3 with the introduction of chicken litter, and up to 1.92 g / cm^3 with the introduction of cattle manure on medium-loam soil. At the norm of 45-50% [6], the total porosity decreased from 51 to 32 (cattle manure) and 35% (chicken litter) on cohesive sandy loam soils and from 46 to 30 and 31%, respectively, on medium loamy soil. Since chicken litter contains a large number of organic substances, it is a favorable environment for the development of microorganisms. In the conditions of natural aeration and at the appropriate humidity and temperature of the environment, the content of microorganisms in the litter can reach colossal amounts, which is reflected, subsequently, in its fertility. The microbiological activity of soil in winter wheat crops was medium on cohesive sandy loam soil with the introduction of bird litter and cattle manure – 45 and 42%, and on medium loamy soil it was 38 and 34%, respectively; in corn with the introduction of chicken litter and cattle manure on cohesive sandy loam soil, it was high – 51 and 54%, on medium loamy soil it was medium – 42 and 50%, respectively.

Conclusion

The type of organic fertilizer, the biological characteristics of the crop, and the granulometric composition of sward-podzolic soil affect its physical, physical-chemical, and microbiological properties.

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Investments of the MERS micro-fertilizer in crop farming of the republics of Kazakhstan and Uzbekistan, and the state of Turkmenistan

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Abstract

One of the main challenges of farming is the timely and full financing of expenditures for the agricultural crops cultivation, which is solved by receipt and timely implementation of high-quality yields of plant production. The issue of the state subsidization is resolved partially.
Aim of the project: The staged investment of the MERS innovative microbiological fertilizer to the crop farming of the Republic of Kazakhstan and Uzbekistan and the State of Turkmenistan, in order to participate in implementation of the roadmap priority areas within the "Action strategy for 2019-2023".
Methodology. Income accounting processing through implementation of additional crop within the domestic market by application of the MERS micro-fertilizer on agricultural crop farming of the Republic of Kazakhstan and Uzbekistan, and the State of Turkmenistan.
Results. The staged investment of the MERS fertilizer in the crop farming in 2019-2023, within the full -scale introduction of the development product, out of implementation of additional yields, will ensure the following domestic market income (**USD million**):
- in the Republic of Kazakhstan - under irrigation conditions of 1.3 million hectares and dryland of 12 million hectares - 3,278.5;
- in the Republic of Uzbekistan - under irrigation conditions of the area of 3,000 thousand hectares - 2,735.04;
- in the State of Turkmenistan - under irrigation conditions of the area of 1,531 thousand hectares - 524,504.

In case the sale of products on a domestic market would provide the income of 15-40 USD per 1 USD expenses, then in a foreign market the value-added additional harvest processing would provide the income raise up to 100-1,000 USD per 1 USD expenses.
Conclusion. The economic analysis results serve as the basis for rapid development of the economic power of the Republics of Kazakhstan and Uzbekistan, and the State of Turkmenistan.
Key words: MERS micro-fertilizer, yield gain, investment, action strategy.

Introduction

Provision of ever-increasing global population with adequate food products in the 21st century is a very relevant issue. In this respect, the innovative development of farming sector, in particular, the crop farming production, is of great importance [4], which in turn depends on timely and full financing of the expenditures coverage. The chemicals use in crop production, in particular, the application of mineral fertilizers, led to a threat of loss of the state food security, the main cause of which were the following factors: land degradation; humus substance decrease; deterioration of soil ecology [3]. In order to solve the aforesaid shortcomings of food products and plant protection and obtain a high-quality agricultural crops, "Ana Zher" Research and Production Association LLP of the Republic of Kazakhstan developed the new generation of biological products – MERS micro-fertilizer. Its effect is based on the use of inexhaustible free energy of soil micro - and macro- organisms, which is a new direction in food provision of the global population in the 21st century [1, 2].
The staged investment of the MERS fertilizer to the crop farming of the Republic of Kazakhstan and Uzbekistan and the State of Turkmenistan could be the basis for implementation of directions on the development and liberalization of economies, development of social sphere

"Action strategy for further development of the Republics of Kazakhstan and Uzbekistan and the State of Turkmenistan" for the years of 2019-2023.

Methods and Materials

The state registration tests, pilot and production activities, as well as the results of application of the MERS micro-fertilizer in the Republic of Kazakhstan in the area of over 3 million hectares (2003-2017), the State of Turkmenistan - 90 thousand hectares (2015-2017), the Republic of Uzbekistan in 9 oblasts (2013, 2014, 2017, 2018), in 4 regions of the Russian Federation (2013-2014), served as the main basis for determination of funding source for implementation of the "Action strategy for 2019-2023" by priority areas of development and liberalization of the economy and social sector improvement.

The methodology innovation for execution of activities lies in selection of funding sources. It includes: invested MERS micro-fertilizer; funds available from realization of an additional agricultural crops and products of their advanced processing, obtained within the use of the MERS micro-fertilizer.

Results and Discussion

1. The funding sources and income by years for implementation of priority directions of the "Action strategy" for the years 2019-2023.

The funding sources will be:

1. The invested MERS micro-fertilizer;
2. Resources from sale of a minimum additional quality crop on a domestic market with use of MERS

•on dryland condition: a spring soft wheat, etc. - 3 centner/ha;
•on irrigation condition: a raw cotton - 8 centner/ha; winter soft wheat - 10 centner/ha; potatoes, vegetables and melons/gourds - 150 centner/ha; fruit and vineland crops - 150 centner/ha, which in terms of money (USD/ha) composes:

- on dryland of spring soft wheat – 35;
- on irrigation of raw cotton – 200;
- winter soft wheat – 80;
- vegetables and melons/gourds – 1 800;
- fruit crops (apples, etc.) – 4 500;
- vineland crops – 7 500.

The staged investment of the MERS fertilizer in the crop farming in 2019-2023, within the full-scale introduction of the development product in 2022, out of implementation of additional yields, will ensure the following domestic market income (million US dollars):

- in the Republic of Kazakhstan - under irrigation conditions of 1.3 million hectares and dryland of 12 million hectares - 3,278.5;
- in the Republic of Uzbekistan - under irrigation conditions of the area of 3,000 thousand hectares - 2,735.04;
- in the State of Turkmenistan - under irrigation conditions of the area of 1,531 thousand hectares - 524,504.

2. Articles of income distribution in 2023, obtained after implementation of additional agricultural crops in 2022

In the Republic of Kazakhstan, it is proposed to distribute the additional income received under irrigation conditions of 1.3 million hectares and under dryland conditions of 12 million hectares - 3,278.5 million USD, to the following articles:

- agricultural producers – 1,639.25 million USD (50%);
-state reserve fund (construction of a completely new class of food and plant protection products, creation of additional jobs, assistance to the poor and retired persons) – 1, 311.4 million USD (40%);
- financing of science – 163,9 million USD (5%);
- budget of the company overseeing the project – 163.9 million USD (5%).

In the Republic of Uzbekistan, it is proposed to distribute the additional income received under irrigation conditions of 3,000 thousand hectares - US $ 2,735.04 million, to the following articles:

- agricultural producers – 1187.52 million USD (50%);
- state reserve fund (construction of a completely new class of food and plant protection products, creation of additional jobs, assistance to the poor and retired persons) – 949.98 million USD (40%);
- financing of science – 118.77 million USD (5%);
- budget of the company overseeing the project – 118.77 million USD (5%).

In the State of Turkmenistan, it is proposed to distribute the additional income received under irrigation conditions of 1 531 thousand hectares – 524.504 million USD, to the following articles:

- agricultural producers – 262.25 million USD (50%);
- state reserve fund (construction of a completely new class of food and plant protection products, creation of additional jobs, assistance to the poor and retired persons) –209.8 million USD (40%);
- financing of science – 26.2 million USD (5%);
- budget of the company overseeing the project – 26.2 million USD (5%).

Conclusion

1. Based on *performed* complex of agrochemical and economic studies on crops of the Republic of Kazakhstan and Uzbekistan and the State of Turkmenistan, as well as taking into account the results of application of the MERS micro-fertilizer in the Republic of Kazakhstan in the area of over 3 million hectares (2003-2017), the State of Turkmenistan - 90 thousand hectares (2015-2017), the Republic of Uzbekistan in 9 oblasts (2013, 2014, 2017, 2018), in 4 regions of the Russian Federation (2013-2014), the main framework and source of financing have been *identified* for implementation of the "Action strategy for 2019-2023" by priority areas of development and liberalization of the economy and social sector improvement.
2. The MERS micro-fertilizer at the background of mineral nutrition by increasing the yield of agricultural crops on dryland soil by 20-40% and under irrigation conditions up to 40-100% ensures the income of 15-40 USD per 1 USD expenses. Moreover, an advanced processing of additional crops contributes to receipt of the profit of 200-1000 USD. Hence, it is the basis for rapid development of the economic power of the Republics of Kazakhstan and Uzbekistan, and the State of Turkmenistan.

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Synthesis, physicochemical and toxicological characteristics, agrochemical and economic efficiency of new complex active substances for cotton seeds dressing on the methylol urea and zinc phyto-compound basis

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Abstract

Seed disinfectants, in particular cotton dressers, used in crop farming, with their high biological efficiency, at the same time negatively affect the land productivity and do not contribute to receipt of high and quality yields.
Aim of the study: Synthesis, study of physicochemical and toxicological characteristics, determination of agrochemical and economic efficiency of new complex active substances for cotton seeds dressing on the methylol urea and zinc phytocompound basis.
Methods: Chemical, visually-polythermal, isothermal, X-ray phase, differential thermal, IR spectroscopic, toxicological methods of analysis; determination of cotton plant diseases on root rot, gummosis, raw cotton yield, yield and fiber length parameters, soil analysis for easily hydrolyzable nitrogen content, mobile forms of phosphorus pentoxide and potassium dioxide, organic substances and humus.
Results: The areas of crystallization of new double compounds based on monomethylol urea (MMU), dimethylol urea (DMU) and zinc phytocompounds (ZPC) - MMU • ZPC, 4DMU • ZPC – an active substances of a preparative form of multifunctional action dressing composition were determined. The active substances have a high melting point, an individual crystalline grid. They are coordinated through the oxygen of carboxyl group and classified as a low toxicity compounds (Class IV toxicity).
The preparative form of the composition, with its high biological efficiency against root rot and gummosis of the cotton plants, provides, in comparison with the standard, the yield gain of 4-5.5 c/ha, increase in fiber yield by 1.5-2% and its length up to 0.5-0.7 mm, and decrease of micronaire by 0.7-0.9 units, as well as accumulation in the soil of organic substances of 6.8-7.6 t/ha, 4,5-14,5% NPK nutrients.
Conclusion: Double connections of MMU•ZPC, 4DMU•ZPC and complex double connection [MMU•ZPC + 4DMU•ZPC] – are an active substances of dressing composition of multifunctional action in comparison with the standard due to the yield gain provide the economic benefit of 69 700-95 950 tenge/ha, accumulation in the soil of additional 10-15% of nutrients and 3.6-7.6 t/ha of organic substances.
Key words: double compounds, active substances, crop, root rot, gummosis.

Introduction

At the end of last century the cotton seed dresser P-4 [1] has been developed in the Republic of Uzbekistan, and Sunkar-3 - in the Republic of Kazakhstan (20% aqueous suspension) [2]. The active substance of both dressers was a low-toxic mono and dimethylol urea. Based on performed studies it was established that Sunkar-3 ensured the efficacy against a root rot – up to 98.4%, against a gummosis – up to 98.2%, and the yield gain of raw cotton by 2 centner/ha. Along with positive effect of the cotton seed dresser Sunkar-3 to the land productivity with high biological efficiency and additional yield of 2 c/ha, as of today, it does not meet the requirements of practice. With the aim to overcome the challenges, the new innovative compositions of active multifunctional action substances have been synthesized that simultaneously provide the effect against diseases of root rot, gummosis, as well as a preservation of soil productivity and obtaining of high and quality cotton harvests, especially under conditions of saline land [3-7].

The initial data for the theme development were the active substances (AS) of the cotton seed dresser Sunkar-3 – monomethylol urea (MMU), dimethylol urea (DMU) and zinc phytocompound (ZPC).
The synthesis of new active substances has been made by studying the triple water-salt systems of MMU-ZPC-water, DMU-ZPC-water by classical visually-polythermic and isothermal methods of analysis.
On the basis of performed studies, new double compounds of MMU • ZPC, 4DMU • ZPC were synthesized, which were identified by chemical, X-ray diffraction, differential thermal and IR spectroscopic methods of analysis. It was found that the double compounds have a melting point of 80-100°C, an individual crystalline grid, and are coordinated through the oxygen of the carboxyl groups.
The field tests were carried out in the period of 2015-2017 in the free market farm "Aman" of Maktaaralsky district of SKO with the aim to determine the agrochemical and economic efficiency of the formulation of multifunctional action compositions based on active substances of: MMU • ZPC; 4DMU • ZPC; [MMU • ZPC + 4DMU • ZPC] on the cotton crop fields.
The field tests have been carried out with triplicate repetition and placement in one layer, with size of field 0.1 ha and the test area 1.5 ha.
The test agrotechnics were common for the Muktaaralsky district cotton-growing zone. The cotton seeds of Mactaaral-4005 were used on the first reproduction. The irrigation was - 2 times. Prior the cotton seeds treatment, the formulations were diluted with water at the rate of 15 liters of spray material per 1 ton of seeds. An ammonium nitrate was introduced into the soil at the beginning of the bud-formation stage in an amount of 200 (N-68) kg/ha. The degree of soil salinity was 0.075% on Cl-ion (high degree of salinity).
Sunkar-3 was used in the reference version in an amount of 0.5 l/ha, in test versions, l/ha: MMU • ZPC - 0.5; 4DMU • ZPC - 0.5; [MMU • ZPC + 4DMU • ZPC] - 0.5.
The output parameters for determination of the formulations efficiency were:
- degree of affection of cotton plants by root rot and gummosis at the end of May;
- preservation of plants for harvesting (beginning of September);
- the cotton crop;
- economic benefit of the composition in comparison with the reference as a result of increase of the yield gain minus the formulations cost;
- output and length of fiber;
- accumulation in the soil of mobile forms of nitrogen, phosphorus pentoxide and potassium dioxide after harvesting.

Based on three-years experience it was established that cotton plants in the control version have been affected by root rot in 17% and gummosis in 21%, the preservation of plants for harvesting composed 90 thousand pieces/ha. In the Sunkar-3 seed dressing version, only 1.8% of plants were affected by root rot and 2.0% by gummosis, and the preservation of plants for harvesting composed 96 thousand pieces/ha.
Apparently, the multifunctional action compositions obtained by application of one active substance, in comparison with Sunkar-3, reduce the damage of plants by root rot and gummosis by 13-17%, and the composition on the basis of complex double compounds made in total 22-25%. If the compositions with single active substance ensure a greater preservation of plants for harvesting in comparison with Sunkar-3 - 7-11 thousand pieces/ha, then the composition based on the complex active substance ensures 16 thousand pieces/ha. The positive effect of a preparative form of the multifunctional action composition on the plants growth and development has been demonstrated, when compared with Sunkar-3 seed dressing agent, led to provision of the cotton yield gain.
If the preparations on the basis of one active ingredient, in comparison with Sunkar-3, provide an additional yield of 4-4.5 c/ha and income (with deduction of all expenditures) of 69.700 –

78.450 tenge/ha, then the composition based on the complex active substance provides an additional yield of 5.4-5.5 c/ha and income of 94.200 – 95.950 tenge/ha. Moreover, the fiber yield was increased by 1.5-2%, fiber length by 0.5-0.7 mm, and micronaire by 0.7-0.9 units.
The fact of accumulation of additional mobile forms of nutritive elements after harvesting was established. For instance, if in case of Sunkar-3 application, at the end of the vegetation an easily hydrolysable nitrogen composed 19.5 mg/kg of soil, a mobile forms of phosphorus pentoxide - 11.9 mg/kg, soil and an exchangeable potassium dioxide - 205 mg/kg of soil, humus – 1.1%, then in options with use of multifunctional action compositions based on single active substances, an easily hydrolyzable nitrogen made in total 21.6-22.9 mg/kg of soil, a mobile forms of phosphorus pentoxide - 12.5-13.7 mg/kg of soil, an exchangeable potassium dioxide - 209-215 mg/kg of soil, and humus – 1.17-1.22%. The best indicator was observed in case of complex active substances application with accumulation of organic substances in soil at the level of 6.8-7.6 t/ha.

Conclusion

The application of the multifunctional action compositions with single active substance as a material for pre-sowing cotton seed treatment, in comparison with Sunkar-3 seed disinfectant, ensures:
- reduction of plant damage by root rot and gummosis by 13-17%, and consequently, the preservation of plants for harvesting for over 7-11 thousand pieces/ha;
- receipt of additional raw cotton yield at the level of 4-4.5 c/ha;
- economic benefit as a result of additional yield at the level of 69 700-78 450 tenge/ha;
- accumulation in the soil of an additional 10-15% of nutrients and 3.6-4.8 t/ha of organic substances;
- improvement of the cotton fiber quality by 7-9%.

The application of the multifunctional action compositions with use of complex active substances as a material for pre-sowing cotton seed treatment, in comparison with Sunkar-3 seed disinfectant, ensures:
reduction of plant damage by root rot and gummosis by 22-25%, and consequently, the preservation of plants for harvesting for over 14-16 thousand pieces/ha;
receipt of additional raw cotton yield at the level of 5.4-5.5 c/ha;
economic benefit as a result of additional yield at the level of 94 200-95 950 tenge/ha;
accumulation in the soil of an additional 20-22% of nutrients and 6.8-7.6 t/ha of organic substances;
improvement of the cotton fiber quality by 12-14%.

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Urease enzyme activity in a sandy clay loam soil outflow solution influenced by organic waste addition

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Abstract

The effect of hazelnut husk (HH) application on urease enzyme activities in outflow solution of a sandy clay loam soil column was investigated. Hazelnut husk was incorporated with four different rates (0, 2, 4 and 6%) into the soil. Changes in soil properties were determined at the end of 1, 2, 4 and 8 weeks. Addition of HH into the soil increased organic carbon content, basal soil respiration, aggregate stability, total porosity, and decreased soil bulk density. Urease enzyme activities in a pore volume (PV) of outflow solution increased from 0.93 μg N/PV in control treatment to 11.37 μg N/PV in 6% HH application doses at the end of 8th week. Urease enzyme activities in outflow solution had significant positive correlations with aggregate stability, saturated hydraulic conductivity and a significant negative correlation with EC of outflow. Urease enzyme activity in outflow solution had also a positive relationship with basal soil respiration. It can be concluded that urease enzyme activity is higher in outflow soil solution obtained from the organic waste applied soil system.
Key words: Urease, enzyme, hazelnut husk, outflow, soil properties.

Introduction

Enzymes in soil are important for participating the cycling of elements and affecting their availability to plants. Microorganisms, active roots and dead cells are the basic sources of soil enzymes. A major proportion of the extracellular enzymes found in soil is adsorbed on to clay and humic colloids. The enzyme fraction that remains in the soil solution is labile and exposed to degradative processes and therefore, only a very small fraction of the total soil enzyme content is found in solution (Burns, 1982). Kiss et al, (1975) reported that abiotic enzymes are; i) Function extra-cellularly either free in the soil solutions or bound to inorganic and organic soil constituents, ii) That are present in particulate cell debris and iii) That is present in dead cells or in viable but non-proliferating cells which may be animal, plant or microbial in origin. Urease activity in soil may originate from plant residues, animal waste or soil microbes containing urease (Dharmakeerthi and Thenabadu, 1996).

It is known that soil enzymes are very persistent and are unaffected by adverse soil environmental conditions like high temperature, low moisture and active microbial attack. For example, Skujins and Mc Laren (1969) reported that urease activities have been detected in stored, geologically preserved soils, carbon dated to about nine thousand years old. However, Gülser and Erdoğan (2008) found that urease enzyme activity of roadside soils negatively affected with heavy metals such as; Cr, Mn and Pb contents of soils.

Baldrian (2009) reported that a significant fraction of the enzyme is often not extractable from soils due to binding to soil components like microbial biomass or abiotic soil material. The extractable fraction of total activity in soil having high clay content may account for less than a few percent of the total. Review by Burns (1978) indicated that enzymes are physically and chemically immobilized within the discontinuous organic colloidal material, which itself is associated with soil clay particles, an immobilization that occurs during humic matter genesis when exoenzymes and endoenzymes from lysed cells becomes trapped. Tiwari et al. (1988) reported that the enzymes present in soil solution account for only a very small fraction of total enzyme activity.

Urease (urea amidohydolase, EC 3.5.1.5) is the enzyme that catalyses the hydrolysis of urea to CO_2 and NH_3: ($NH_2CONH_2 + H_2O = CO_2 + 2NH_3$). Incorporating of organic matterials into soil promotes microbial activity and also urease activity (Kızılkaya and Ekberli, 2008), reduces bulk density, increases total pore space, mineralization, available nutrient elements and electrical conductivity of soils (Candemir and Gülser, 2010). Hazelnut is one of the most important agricultural products with a yield of around 630.000 tons per year in the Black Sea Region of Turkey. Large quantity of hazelnut husk as an agricultural waste material is available in the region. The objective of this study was to investigate the effects of hazelnut husk (HH) application on some soil physicochemical properties and urease enzyme activities in outflow of sandy clay loam soil column.

Materials and Methods

A sandy clay loam textured soil was air-dried in a laboratory and sieved through 2 mm screens. Some soil properties given in Table 1 can be summarized as; the textural class is sandy clay loam, slightly alkaline in pH, low in organic matter content, non saline according to EC value (Soil Survey Staff., 1993).

Table 1. Some physical and chemical properties of the soil

Sand, %	52.1±0.15	Organic matter, %	0.5±0.04
Silt, %	26.1±0.27	Ca, me /100 g	37.7±0.78
Clay, %	21.8±0.12	Mg, me /100 g	17.9±0.09
$EC_{25°C}$, µS cm^{-1}	740±15	K, me /100 g	0.5±0.06
pH (1:1)	7.6±0.04	Na, me /100 g	0.6±0.05

Hazelnut husk (HH) was obtained from a hazelnut orchard in Samsun, Turkey. Some properties of HH were determined according to the Kacar (1984). Hazelnut husk had 49.49% organic C, 0.96% total N, 51.31 C:N ratio, 5.00 pH and 6.05 dS/m EC in saturation extract. After HH was ground and sieved into less than 4 mm fractions, it was incorporated to the soil sample at 0, 2, 4 and 6 % by weight. The experiment was carried out in a completely randomized plot design with three replicates. Mixtures of HH with soil were moistened near the field capacity and incubated for 1, 2, 4, 8 and 16 weeks at 25±5°C under the laboratory conditions for hydraulic conductivity, aggregate stability (AS), basal soil respiration (BSR) and electrical conductivity (ECs) measurements. Soil respiration rate was determined according to Isermayer (1952) by measuring CO_2 produced without adding glucose at 22°C. CO_2 production was explained as mg CO_2 100g–1 oven dry soil at the end of the 24 hours incubation period after each soil sampling. Undisturbed soil samples from the pots were taken using the cylinders having 4.5 cm inside diameter and 5 cm length for measurements of saturated hydraulic conductivity (Ks). At the end of the each incubation period, aggregate stability according to Kemper and Rosenau (1986), saturated hydraulic conductivity by constant head method (US Salinity Lab. Sta., 1954) were determined. Urease (EC 3.5.1.5) enzyme activity (UA) in one pore volume of outflow collected from each soil column was measured by the method of Hoffmann and Teicher (1961).
The correlations among the data were done using the SPSS programme.

Results and Discussion

Organic C content of sandy clay loam soil increased with application of hazelnut husk (HH) compared with the control treatment. During the decomposition of HH in soil by microorganisms, OC contents of soil samples in all treatments decreased from 1^{st} week to 8^{th} week of incubation period (Figure 1).

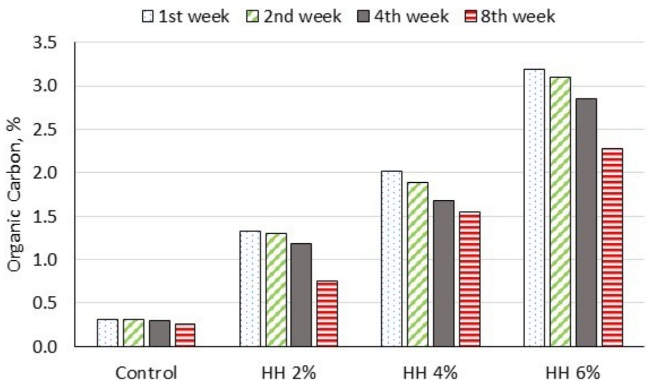

Figure 1. Changes in organic C content of soil with hazelnut husk (HH) application

Basal soil respiration (BSR) in all HH treatments generally increased from 1st week to 8th week of incubation period over the control (Figure 2). Decreasing in OC content with increasing BSR of the soils may be attributed to the increasing population of microorganisms which utilize decomposable hazelnut husk both as a source of food and energy (Chefetzet al., 1998).

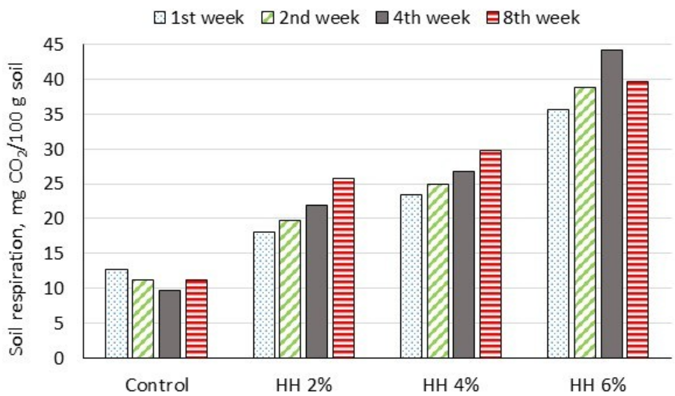

Figure 2. Changes in soil respiration with hazelnut husk (HH) application.

Changes in bulk density and total porosity in soil by the application of hazelnut husk are given in Figure 3. Hazelnut husk application decreased the soil bulk density over the control. The lowest bulk density was determined with 6% dose of HH in all incubation periods. Decreases in bulk density also caused increases in total porosity values.

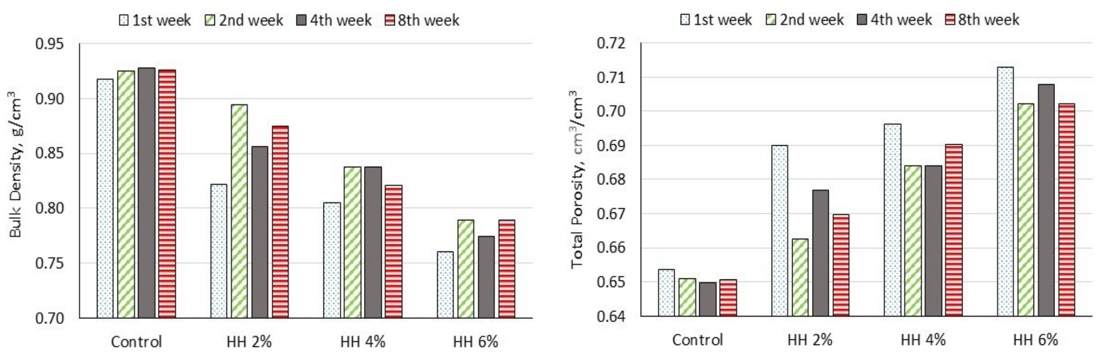

Figure 3. Changes in bulk density and total porosity with hazelnut husk (HH) application

Effect of HH application on EC values in soil and EC values of outflow are given in Figure 4. HH application increased soil electrical conductivity (EC_soil) values. EC is an important parameter for monitoring organic matter mineralization (Candemir and Gülser, 2010) and reflecting dissolved nutrient elements in anion and cation forms in soil (Smith and Doran, 1996). While EC_outfl values for HH applications decreased during the incubation period, EC_outfl values for the control increased.

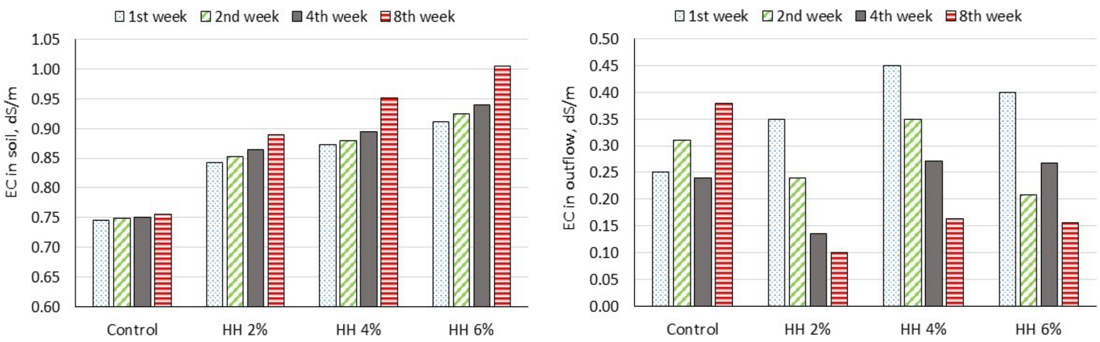

Figure 4. Changes in EC values in soil and outflow solution with hazelnut husk (HH) application

Effect of HH application on aggregate stability (AS) and saturated hydraulic conductivity values (Ks) are given in Figure 5. HH increased aggregate stability values over the control. Organic matter increases aggregate stability (Gülser et al., 2015). AS is influenced by the microorganisms with the mechanical binding of soil particles together, and the production of effective binding agents either by synthesis or through the decomposition of organic materials (Oades, 1984). HH application at the beginning of the incubation decreased Ks values over the control. Organic matter increases the water retention capacity of soils by direct absorption and by enhancing the formation and stabilization of aggregates (Weil and Magdoff 2004). The soil having a larger pore size distribution generally has higher Ks (Hillel, 1982, Gülser 2006).

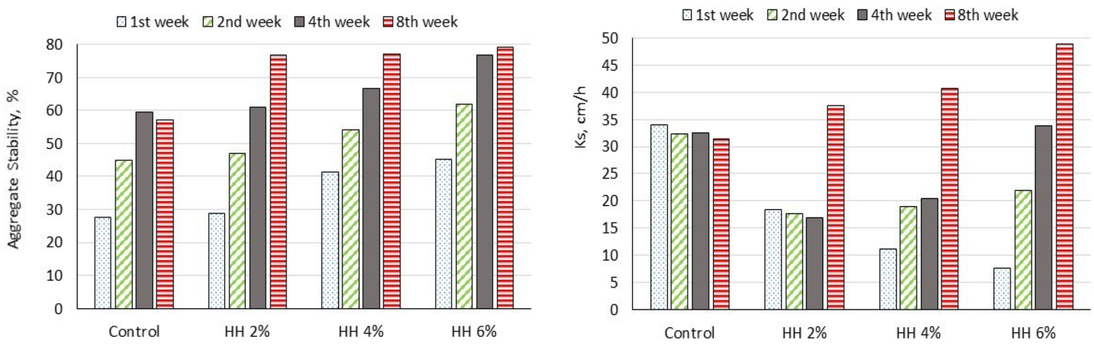

Figure 5. Changes in aggregate stability and hydraulic conductivity (Ks) values in soil with hazelnut husk (HH) application

Urease enzyme activity in a pore volume of outflow increased from 1st to 8th week. HH applications generally had higher urease activity over the control. Incorporation of organic material into soil promotes microbial activity and also soil urease activity. Most of enzyme activity may be localized in the “active” or “biological” space that is the space resulting summation of the microhabitats where microorganisms can survive or grow. Therefore, total enzyme activity may be related with this space rather than total physical space (Dharmakeerthi and Thenabadu, 1996).

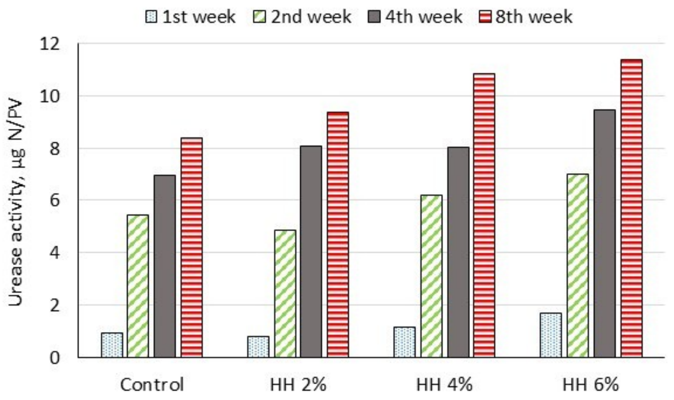

Figure 6. Changes in urease activity in one pore volume outflow with hazelnut husk (HH) application

Relationships between urease activity in outflow volume and some soil physicochemical properties are given in Table 2. Urease activity in outflow volume had significant positive correlations with AS (0.947**), Ks (0.654**) and a significant negative correlation with EC of outflow volume (-0.586*). Even though, they were not significant statistically, urease activity values had positive relationships with BSR and EC of soil samples. AS values gave significant positive correlations with BSR (0.563*) and EC (0.616*) of soil samples.

Table 2. Correlation matrix among the urease activity and some soil physicochemical properties

	OM	BSR	DB	F	EC_soil	EC_outfl	AS	Ks
UREASE	0.035	0.366	-0.044	0.038	0.441	-0.586*	0.947**	0.654**
OM		0.906**	-0.945**	0.924**	0.800**	0.445	0.253	-0.316
BSR			-0.896**	0.882**	0.919**	0.076	0.563*	0.051
DB				-0.994**	-0.860**	-0.355	-0.269	0.235
F					0.841**	0.329	0.266	-0.230
EC_soil						0.095	0.616*	0.084
EC_outfl							-0.464	-0.735**
AS								0.546*

** significant at 0.01 level, * significant at 0.05 level.

Conclusion

Application of HH into sandy clay loam soil increased urease activity in outflow, soil OC content, BSR, EC_soil, Ks and AS values during the 8 weeks of incubation. BSR as an indicator for microbial activity in soils had relation wih soil hydraulic properties and EC_outfl. Increasing ECs in bulk soil at the end of the incubation period indicates that decomposition products of HH such as cations might be fixed by micro aggregates. Increasing Ks due to increased soil macroporosity decreased EC_outfl. Urease enzyme activities in outflow had significant positive correlations with AS, Ks, and a significant negative correlation with EC_outfl. Although it was not a significant statistically, urease enzyme activity in outflow had a positive correlation with BSR. Enzymes are physically and chemically immobilized within the discontinuous organic colloidal material, which itself is associated with soil clay particles (the organo-mineral complex), an immobilization that occurs during humic matter genesis when exoenzymes and endoenzymes from lysed cells becomes trapped (Burns, 1978). The enzymes present in soil solution account for only a very small fraction of total enzyme activity (Tiwari et al., 1988). In this study, It was showed that urease enzyme in soil was related with soi physical and chemical properties and extracellular urease enzyme leached from soil column durig the outflow of soil suspension. As a result, it can be concluded that urease enzyme activity is higher in outflow soil solution obtained from the organic waste applied soil system.

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Investigation of morphogenetic properties and reclamation methods of oil polluted soils of Absheron peninsula

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Abstract

The main purpose of the investigation is examination of influence of oil to morphogenetic features, chemical, agrophysical and biological properties and prepearing biological recultivation methods under different plants by investigating of soil pits in different textured soil, oil - polluted and non - polluted soils in Absheron peninsula. According to granulometric texture soils of the investigation area is silty loamy and silty, physical clay (< 0,01 mm) differs between 25,97-37,20% within genetical layers. Amount of dry mass is less (0,25%) in natural non- polluted soils while amount of salts in relation to dry mass is higher 0,36-2,66% in deep layers of oil - polluted soils. Salt composition is sulphuric - chloric - sodium. Bulk density of the soil is 1,27-1,77 g/cm^3 from top layers to deep layers, pH is very high 7,7-9,9. Carbonates, nutrients (N, Ph, P) and humus is less. Saltiness is not observed in non - polluted areas whereas middle and high pollution is observed in oil - polluted areas (16,84-34,18%). Heavy metals and particular microelements are within allowable level in top layers of natural and oil - polluted soils. In the soils of investigation area general amount of hydrocarbons is up to 73,4%. Aromatic hydrocarbons are 52,15%, saturated hydrocarbons 13,20%, paraffin hydrocarbons 26,50%. Vegetation experiments under different plants according to pollution degree and texture of soils in grey - brownish soils in Absheron peninsula have been carried out in order to investigate toxitidy of plants and prepearing the recultivation methods in oil - polluted soils. Soil pits in size of 40x40x60 cm is filled by sandy loam and silty soils as control (clean), 1, 2, 3 və 4% oil polluted soils in the investigation area. In order to carring out vegetation experiments in the open area Olea curopaea, Pinus eldarica L., Morus alba, Trifolium pratense L., are planted in polluted sandy loam but Punica granatum, Cupressus Sempervirens L.Sp, Elacagnus comutata are planted in silty soils and phenological observations have been carried out.
Key words: Oil products, soil morphological, oil-polluted soils, pysica-chemical characters.

Introduction

The reserve soil of Azerbaijan was degraded by anthropogenic factors, erosion, salinization, dehumidification, polluting with oil, and chemical poisons. Thousands of the hectares of fertile soil were polluted during many years by the extraction of oil, gas and construction materials from the Earth layer and got out of used. As a result of these, the growth of plants is weakening, surface and the groundwater resources are running low, the danger of degradation of the ecosystem is rising, the fertility of landscape is decreasing and the desertification process is happening in the areas. After a while desertification causes soil erosion and salinization. In our country such type of lands are found in Absheron peninsula, Siyazanmonoclinal, South-eastern Shirvan and Mughan plain more [1].

More than 160 years of development of the oil industry and other industries related to oil caused polluting of thousands hectares soil with black oil and oil products. In the Azerbaijan Republic, there is 33.3 thousand hectares area which are polluted with oil and 10 thousand hectares of it is considered highly polluted areas. According to preliminary estimates, 24156 hectares, where reclamation will be done, are 24156 hectares. 13805 ha of the area are in Absheron. This is in the Absheron peninsula and 10351 hectares belong to other areas. The depth of the layer which IS polluted with oil and oil products is 2-2.5 meters [2, 3].

The main research Plain (to collect information about the technogenic landscape landed zone, non-polluted with oil(background) and correct packing soil substances (suarfes) in the researched area for getting information about physical-chemistry and agrochemistry properties of the polluted oil, to learn thickness of oil in the soil profile) and Cameral (Determining in the soil oil products and phenols; Organic carbon and carbohydrate; Moisture absorbent; Granulometric composition; Absorbed bases (Ca, Mg), Micro and Macro elements; pH; evaporating soil and ground water, humus, nitrogen, phosphorus) researchers are learning differ-(individual)cleaning technologies on the base of information and making for these areas. During the reclamation of the oil polluted soil using different technologies will be learnt from the level of the polluted soil in the area and the granulometric composition of the soil, being pollution new or old, the level of ground water, relief, and etc.

Materials and Methods

The investigation had been carried out in grey - bownish soils of Absheron peninsula during 2010-2017 and investigation object is area of "Bibiheybatneft" and "Binaqadi" Oil and Gass extraction companies.

Binaqadi oil and gass extraction area for the investigation is in the old oil-mine area and it is situated in the northerin-west part of Baku 8 - 10 km far from it. It had been working from 1896 as oil production area. Area in "Bibiheybatneft" oil and gas extraction area was exposed to antropogenic influences in high degree and it is spesific polluted area with a number of resident points. In the area where it was prodused oil since 1871 played an important role in forming an ecological crisis level. Primitive technology and methods in the first stage of oil usage led to increasing oil polluted areas. The area turned into useless zone with paraffin, salt and oily sands, different tubes, devices, broken equipments, household waste, and oil spills.

The first purpose of the investigation is studing the influence of oil to morphogenetic features, especially thickness of polluted soil profile and prepearing biological recultivation methods under different plants (Olea curopaea, Pinus eldarica L., Morus alba,Trifolium pratense L., Punica granatum, Cupressus Sempervirens L.Sp, Elacagnus comutata) and prepearing the recultivation methods depending on soil texture and pollution degree in grey - brownish soils in Absheron peninsula.

In the investigation area soils pits were created by control (backround), less polluted and high polluted soils in order to learn morphological properties. Depending on backround and pollution level pits were digged in 1,5-2 m depth and being 0-0,25 m, 0,25-0,50 m, 1,0-1,25 m, 1,25-1,50 m both in non - polluted and polluted. Higroscopicity, soil texture, pH, dry mas, HCO_3^{2-}, CO_3, Cl, SO_4, Ca, Mg, So, P, general humus, nitrogen, potasium, heavy metals (chrom, zinc, cuprum, lead, cobalt, molibden, mercury - definition in technogenic soil by atom absorbsion method).

A number of countries consider the allowable level of oil in soil is up to 1%. Allowable level is not defined in our Republic officially. Allowable level of oil and oil products in soil depends on different natural factors such as – soil and ground type, its composition, and usage type of the soil after recultivation. These norms must be determined for different polluted areas based on fundamental researches by taking into account the influence of people and ecosystem. In fact, cleaning soil in natural level is very hard, and requires financial support. Pollution level of soil means higher amount of chemical elements than allowable consentration level of sanitar norms in certain soil [4].

Oil that spills to soil expose to degradation after a long period. Therefore, it should be concidered soil texture and durability of plants (productivity as well). In order to take into account all above mentioned indicators it is important to investigate vegetation experiments under agriculture plants by polluting the different textured soils.

In the middle part of the investigation area there is a microdepression. Soil in the depression is salty because of both natural and oil spiils from oil mines, household waste waters. The soil in the area is wet and dark along a year. In summer is slightly dry. Ground water is near (1,0-0,60 cm) to surface in the area(in the middle). The investigation is carried out in high inclined slopes. There were digged a non- polluted control pit (№1) and 4 pits in different polluted soils. Description of these pits was recorded, water weight of ground water and soil water, soil texture, bulk density, absorbed bases, pH, carbonates, humus, nutrients - N,K, P, heavy metals, radioactive elements were defined. Description of morphological features of the soil is following.

Pit № 1. is digged in grey-bownish oil polluted soil in southern slope of oil mine area (number 2). Vegetation - ephemers, camelthorn, lucerna, wormwood.

$АУ_{\mathbf{VCa}}$ - depth 0-10 cm, texture is silty clay loam, light, grey-bownish, structureless, consistency - loose, roots, dry, high fizzing (10% HCl).

$АУ_{\mathbf{Ca}}$ 10-35 cm silty loam, light grey-bownish, granular, consistence is firm, roots, fine shells, dry, high fizzing.

$B_{\mathbf{Ca}}$ 35-67 cm - texture silty, light grey-bownish, crumps, consistency - firm, roots, weak wet, high fizzing.

$B/C_{\mathbf{Ca}}$ 67-100- cm silty loam, light grey-brownish, crumps, firm, less roots, wet, high fizzing.

C_1 100-124-cm silty clay loam, light grey-brownish, structureless, firm, less roots, high fizzing.

C_2 124-165-cm silty clay loam, light grey, structureless, firm, very weak, rare roots, weak wet, high fizzing.

C_3 165-200-cm silty clay loam, light grey, structureless, firm, very weakhigh fizzing.

Pit № 2. was created in the area of second oil mine in Binaqadi oil and gass department, 80-100 m to west from road, in microdepression, on the right of rain chanal that runs to Boyukshor lake clayey, sandy oil.

X. Depth 0-60 cm, dark color, platy,clay, sandy, very firm, depp layers loose, not fizzing.

X/B. 60-70 cm-sandy clay loam, neft dark color, structureless, loose, oil soaked, wet, not fizzing.

70-100 cm-sandy loam, dark ash color, structureless, platy, firm, not fizzing.

Vegetation experiments under different plants according to pollution degree and texture of soils in grey - brownish soils in “Bibiheybatneft” oil and gass mine area soil pits in size of 40x40x60 cm is filled by sandy loam and silty soils as control (clean), 1, 2, 3 və 4% oil polluted soil in order to investigate phytotoxitidy of plants and prepearing the recultivation methods in oil - polluted soils. Olea curopaea, Pinus eldarica L., Morus alba, Trifolium pratense L. gillicəli torpaqlarda isə Punica granatum, Cupressus Sempervirens L.Sp, Elacagnus comutata were planted in order to vegetation experiments in the beginning of march 2015 in sandy - sandy loamy soils. Vegetation experiment has been carried out by following scheme: 1.Control clean soil (CCS), 2.CS + RO100 gr (1,0%); 3.CS +RO 200 gr (2,0%); 4. CS +RO 300 gr (3,0%); 5. CS +RO 400 gr (4,0%) (CS - Clean Soil, RO- Raw oil)

As a result of investigation Olea curopaea developed in 4% polluted sandy, sandy-loam grey-brownish soils of Absheron peninsula, while, Pinus eldarica L. and Morus alba developed in 1 və 2% pollution, but in 3 və 4% pollution the plant perished. In silty soils Punica granatum developed within 1-2% pollution, however, perished in 3 və 4% pollution. Cupressus Sempervirens L.Sp and Elacagnus comutata developed in silty soil in 4%.

Results and Discussion

1. Based on carried comparative - geographical investigations morphogenetic indicators were defined in sandy and silty gray-brownish oil - polluted and non - polluted soils in Absheron peninsula.
2. Pollution depth, physical-chemical properties, composition of soil, nutrients (N, Ph, P) color change in layers (deeper in sandy soils), water, physical, and physical - chemical properties

were investigated. The investigation shows heavy metal and radioactive elements do not exceed the allowable level in polluted soils.
3. Olea curopaea develops well in sandy-sandy loam 4% polluted soils. Cupressus Sempervirens L.Sp və Elacagnus comutata develop normally in silty 4% polluted soils.

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Assessment of the salinification of arid territory degraded soils by electrical resistance methods

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Abstract

Water-soluble salts contained in arid regions covering about a third of the earth square to a rather significant extent determine soil quality and their availability for agriculture. In context of global soil degradation express methods of soil evaluation and ecological monitoring are becoming peculiarly important, especially for arid regions with very low level of soil humidity (1-2%). Changing climatic conditions and Caspian Sea regime and intensive farm production held on meliogenic soils of the Astrakhan Region caused increasing degradation of soils of the Volga Delta Region associated with increasing salt content in them. The current work considers the issues of electrical resistance employment for assessment of degraded soil salinification in arid regions characterized by low level of soil humidity. As the objects of the research soils of the eastern Volga Delta suffering humidity shortage due to bunding of the territories and existing under influence of salt accumulation have been chosen. The assessment of soil salinification has been performed under hardware control by the value of electrical resistance of pastes. It has been found out that electrical resistance values vary depending on extent of soil salinification in wide range: from 908 O*m to 0.8 O*m. Salt accumulation and formation of sodium ions in soil adsorption complex determines decreasing electrical current. The use of electrical resistance values makes it possible to simplify the procedure of ecological monitoring and soil regulation in terms of its applicability for agriculture without any laboratory researches. Assessment of soil salinification within the conditions of low soil humidity is also possible.
Key words: soil cover, salinification, electrophysical methods, arid soils.

Introduction

Electrophysical methods are already widely used in soil, ecological, meliorative and agricultural practices. The undoubted advantage of these methods is rapidity. Due to the availability of portable electrical measuring equipment, measurements are performed rapidly, without significant time consumption and labor costs. Applying electrophysical methods in soil science, agriculture and land development began more than a quarter of a century ago with the study of soil salinification in arid regions [1, 4]. The relationship between soil salinification and the electrical parameters of soils [2] such as resistance and electrical conductivity has been thoroughly studied and is being studied by foreign scientists in laboratory conditions on soil pastes and suspensions. Dependences between electric resistance and soil salinification of arid regions are revealed, and the results were published both in Russian and in foreign journals [3, 5, 6]. The greatest closeness of correlation relationships is common for the properties directly (Ca, Mg, Al, Na) and indirectly (humus and clay fraction content) characterizing the qualitative and quantitative composition of the soil absorbing complex.

Materials and Methods

The soils of the eastern Volga Delta suffering humidity shortage due to bunding of the territories and existing under influence of salt accumulation have been chosen.
The assessment of soil salinification has been performed according to the indices associated with the concentration of salts in water-saturated pastes, in particular, by the value of electrical resistance of pastes. The electrical resistance of pastes has been expressed in O*m.
The determination of EC (electrical conductivity) has been carried out in samples with natural soil consistency taken in the sensors. These samples have been moistened to the lowest water

capacity (LWC) or directly in the wall of the moistened section in the field. The determination has been also performed in pastes and capillary-saturated soil sieved through a 1 mm sieve. Reliability of the results has been checked by analyzing the water extract at a water-to-soil ratio of 5:1.
To justify the possibility of application, the methods of horizontal electrical sounding (HES), layered electrical sounding (LES) and vertical electric sounding (VES) have been used in the diagnostics and investigation of saline soils.
The electro-physical device ER-03 Landmapper developed by the scientists of Lomonosov Moscow State University has been used in the work.

Results and Discussion

Electrophysical methods (VES, HES and LES) have been used to study the spatial variability of the soil salinification at the catena-landscape level of soil cover organization, as well as to reveal the areas of soil distribution of different degrees of salinification. A detailed idea of spatial transitions between soil differences of different degrees of salinification at several levels of soil cover organization is possible when using both the results of determining the electrical resistance of soil pastes and applying electric sounding methods at sampling points at the nodes of a uniform grid.
In order to interpret the obtained results, topographic isopleths were used. The Figures 1 and 2 present topographic isopleths of the electrical resistance values of soil pastes shown at the points of sampling over a uniform grid.The results are graphically represented by transects (Figure 1) and in layers (Figure 2).

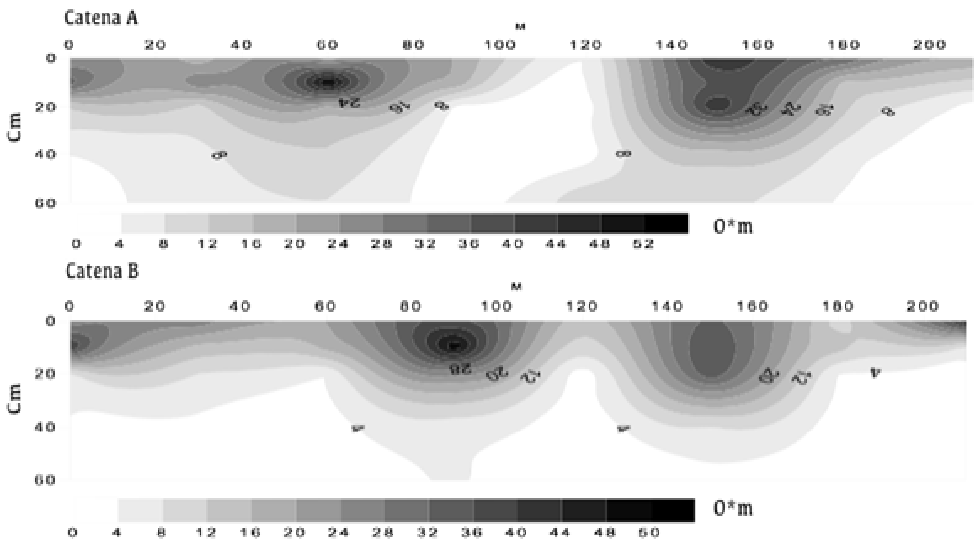

Figure 1. Topographic isopleths of spatial variation of electrical resistance of soils for geomorphic transects in the "near-mound space - the top of Baer's mounds" landscape

Analysis of the topographical isopleths of electrical resistance of soils along the layers have made it possible to establish regularities in the distribution of salts in space. In particular, it is confirmed that a steady increase in the salt content is observed with depth. Some general patterns (Fig.2) have been revealed in the spatial distribution of the salt content according to the elements of the landscape (from the highest point which is the top of Baer's mound to the lowest point by the position in the relief which is the inter mound depression).
The closest deposit of a salic horizon to the surface is confined to the boundary of the area where the area is overflowed with flood waters. It appears that this is the effect of flood wa-

ters that creates a capillary rim in the soil of the mound bottom, which leads to a rise of solutions to the soil surface. The following data speak in favor of this.

The salt content is markedly higher in the lower layers of the soil profile than in the upper ones. Despite this, the Cl/SO_4 ratio increases to the upper layers, which indicates the movement of salts upward. Only capillary waters can be the salt carriers, and these waters are formed during the flood in the lower part of the soil profile of the mound. Precipitations wash away a small upper layer of soil from the salts, which creates a noticeable differentiation of brown soils by the content of salts in their profile. In addition to the above, it is stated that the boundaries of distributional areas of plant associations and soil differences of different degrees of salinity do not always coincide.

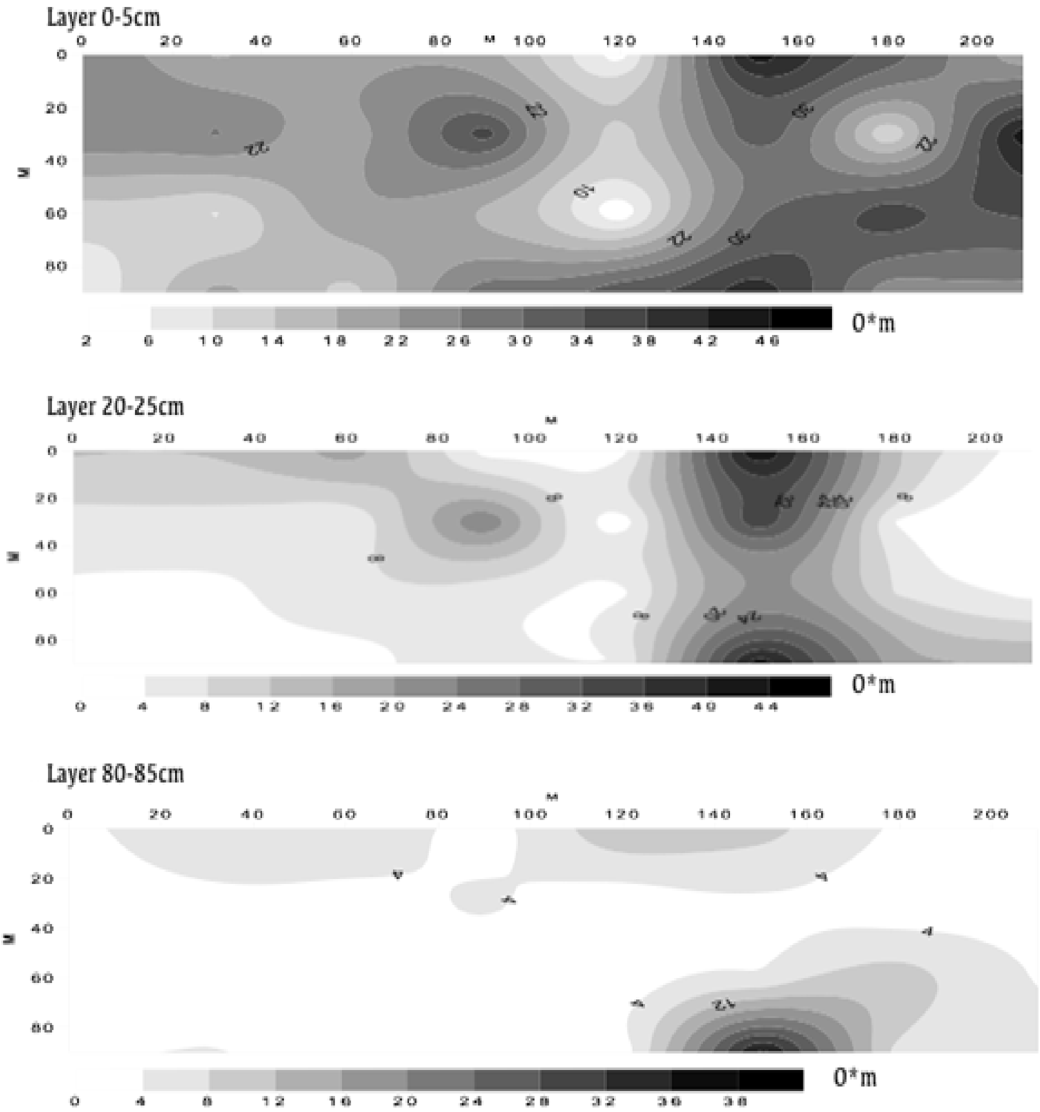

Figure 2. Topographic isopleths of layer-by-layer spatial variation of electrical resistance of soils in the "near-mound space - the top of Baer's mounds" landscape

Conclusions

The joint use and generalization of the results of the determination of the electrical resistance of soil pastes and the research by the HES and VES methods make it possible to obtain a detailed view of the spatial transitions between soil differences of different degrees of salinification at several levels of soil cover organization.

In this case non-contact methods of continuous electromagnetic profiling (CEP) and horizontal electric profiling (HEP) at a constant current should be recognized as the most promising and effective methods which allow to obtain information at any depth without drilling wells and to take measurements only from the soil surface.

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The Proceedings of the 10th International Soil Science Congress on “Environment and Soil Resources Conservation”, Almaty: 2018. - 435 p.

Printed in the printing-office JSC «Poligrafservis i K», Almaty, 050000, Yassaui 66 «a»,

tel: +77272549864, e-mail: polygraph_servis@mail.ru

Electronic layout: Salmukhanbetova Zh.

Pressrun