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Agroecological assessment of agricultural soils fertility in the Iglinsky region, the Russian Federation

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Abstract: The article provides an assessment of soil fertility indicators of agricultural lands in the northern forest-steppe of the Republic of Bashkortostan within the Iglinsky region (Russian Federation). The content of humus, mobile phosphorus, exchangeable potassium, the thickness of the humus horizon, granulometric composition, morphological properties and soil washout were studied. It was revealed that the soil-forming process occurs on rocks of different ages and genesis, such as diluvial carbonate and carbonate-free clays and heavy loams, limestone eluvium, sandstone eluvium and alluvial deposits, which determine the diversity of the soil cover. In the study area, water erosion processes are developing, influenced by anthropogenic and natural factors such as planar and linear washout on slopes with a steepness of more than 2–3° and high ploughing of agricultural land. In terms of humus content, low-humus and medium-humus soils are widespread, accounting for 45.5 and 40%, respectively. The soil map was corrected and digitised to identify the main types and subtypes of soils, indicating the varieties at a scale of 1: 25,000. Digitised maps, taking into account the current state of soil fertility, are used to develop projects for inter-farm and intra-farm land management of organisations of the agro-industrial complex, state cadastral valuation of agricultural land, determination of land tax and development of measures to improve soil fertility.

Keywords: digital map, humus, morphological properties, particle size distribution, phosphorus, soil fertility

INTRODUCTION

The soil cover is the essential natural formation, and its central role is determined by the fact that it is the primary food source. In conditions of limited geoderm resources, reduction of fertile soils of agricultural land, changing requirements for the quality and quantity of crop production requires the rational use of the remaining soil resources and an increase in their fertility. In this case, the soil acts as a natural indicator of long-term processes, and its condition is the result of the impact of many anthropogenic activity components. In the modern period and the near future, solving the problems facing agricultural production requires a significant strengthening of science in this area. Also, to obtain reliable information on adequate soil fertility and sustainability, agroecological monitoring of lands is required. It should be followed by using the results in agrochemical and reclamation measures [Pathak 2011; Surekha *et al.* 2013]. Agroecological monitoring of soils includes quantitative and qualitative analysis of the territory, geoinformation (GIS) technologies with remote sensing of the Earth, study of the composition, regimes, and properties [Della Chiesa *et al.* 2019; Miller *et al.* 2019]. Carrying out qualitative and quantitative indicators of soil fertility makes it possible to judge the degree of anthropogenic load on a particular site and can be used to develop a scientifically based forecast and identification of "clean" areas [Asylbaev *et al.* 2018]. Agroecological studies are also crucial for studying the ecological functions of soils. It is also essential for researching the biogeochemical cycle of carbon and nitrogen in the context of global climate change [Chen *et al.* 2019]. The main purpose of the agroecological assessment of soils is comprehensive scientific knowledge about the soils and soil cover of the study area, with the aim of rational use of land resources and proper organisation of agricultural use.

One of the most challenging tasks in current conditions is the inventory and systematisation of existing soil-geographical data. It is known that the existing collection materials, reports of various soil expeditions, and other sources are contained in various formats and are often not suitable for scientific analysis. Along with a great variety and volume of initial information, the primary data of soil surveys are in most cases difficult to access [LITVINOV 2018]. Under these conditions, the digitisation and correction of soil data from previous surveys using GIS technologies come to the fore, allowing for the systematisation of soil-geographical data and transfer them into digital form without losing important information. This approach allows you to organise information and make it suitable for the digital processing of large amounts of data for monitoring purposes [KIRILLOVA 2018; SAVIN *et al.* 2019].

The use of digital soil cartography and modelling methods allows solving a wide range of applied problems related to accounting for soil resources, conducting soil monitoring and cadastral valuation of agricultural lands with a high degree of efficiency. Corrected and digitised large-scale soil maps are the basis for forming explications of soil varieties and holdings of agricultural land plots. Such works in Russia are carried out based on maps compiled, as a rule, in the 20th century. Repeated studies make it possible to directly assess the current trends in the development of soils and geosystems in general, using detailed studies carried out several decades ago as a basis for retrospective monitoring [KIRILLOVA 2018; SAVIN *et al.* 2019].

The study aimed to analyse soil fertility and agroecological assessment with the correction and digitisation of soil maps of agricultural land on the territory of the Iglinsky district of the Republic of Bashkortostan.

MATERIALS AND METHODS

MATERIALS

The research objects were the soils of the agro landscapes of the northern forest-steppe zone within the Iglinsky district of the Republic of Bashkortostan (Russian Federation), located 54°49 N latitude, 56°24 E longitude and covers the area of 113,460 ha (Fig. 1).

The northern forest-steppe occupies 32.4 thous. km^2, accounting for 23.1% of the Republic's area. The boundaries of the zone are in the south-west and south – the Belaya River, in the north-west – the Kama River, in the north – the administrative border of the Republic with Udmurtia and the Perm region, in the east – the denudation scarp of the Ufa Plateau eastern edge. The territory of the Iglinsky district belongs to the gently undulating and hilly-ridged plain – Pribelskaya. The genetic type of relief in the western part of the territory (up to the Sim River) is erosional-accumulative. The relief form is hilly and ridged. The genetic type of relief in the eastern part of the territory (after the Sim River) is denudation-litomorphic.

Fig. 1. Location of the study area; source: own elaboration

Pribelskaya hilly-ridged upland is located in the west, south-west, and north of the territory. Its eastern border is drawn along the Sim River to a large extent. The total marks of the watersheds are 89–274 m. The foothills of the Urals' western slope are located in the eastern part of the Sim River region, while the watersheds' total marks are 100–512 m. The karst rocks are widespread in the region. According to the conditions of occurrence of karst rocks, karst located on the region's territory belongs to the karst country of the East European Plain. By the nature of the relief, the karst in the region belongs to the flat karst in horizontally and gently spreading weakly dislocated rocks of the Cis-Urals (the western part of the region, the territory is affected by karst 5–25%). And then it goes to the bare and foothill karst of the Cis-Urals in the gently lying and weakly stratified rocks (in the eastern part of the region, karst infestation of the territory is less than 1%). The border between these types of karst runs along the Sim River. The intensity of distribution (damage) of manifestations of gully erosion of the territory is less than 1%, the intensity of distribution (damage) of manifestations of erosional slope processes is 1–5%. The objected area's total marks vary from 89 m to 512 m [ABDRAKHMANOV *et al.* 2005; KHAZIEV *et al.* 1995].

The climate of the territory varies. Average annual air temperature is in the range of 1.2–1.7°C, the amount of precipitation per year reaches 608 mm, the sum of active temperatures (T > 10°C) – 2000, and the duration of the frost-free period is 90–110 days [ABDRAKHMANOV *et al.* 2005; KHAZIEV *et al.* 1995].

The territory of the region is composed of diluvial, eluvial-diluvial parent rocks. The northern part consists of formations of the Permian period (gypsum, marl, clay, limestone, etc.), and the southern part consists of neogenic stones, clay, pebbles, and sands.

RESEARCH METHODS

The experimental work was carried out by expeditionary field and laboratory analytical methods. An expeditionary field soil survey was carried out in 2017 on agricultural lands of the Iglinsky District of the Republic of Bashkortostan. The work has been completed, including cameral processing of field survey materials, the formation of explications of land with a breakdown into groups, determination of the areas of soil varieties. It also includes determination of agricultural land groups, a compilation of electronic soil maps, preparation of a draft list of precious productive agricultural land, the use of which is not allowed for purposes not related to agricultural production.

The binding of soil sections to the coordinates was carried out with the GPS navigator "Garmin Montana 680" (Fig. 1). Soil samples were taken from the main genetic horizons of the soil profile after laying the soil section, including the humusaccumulative horizon (A), illuvial (B), and parent rock (C). When selecting soil samples, the patterns of soil cover formation in landscapes were taken into account. Genetic horizons were identified visually. The soil samples were taken with a mass of 300 g, and their laboratory analysis was carried out for the content of humus, acidity, mobile forms of phosphorus and potassium, particle size distribution after drying and sifting through sieves with a diameter of 0.25 mm. The selection of soil samples was carried out in three replicates. Conventional methods in soil science carried out the determination of the agrochemical and morphological properties of soils. Determination of organic matter in soils was carried out by the Tyurin method [GOST 26213-91], mobile phosphorus and potassium compounds were determined by the Chirikov method in the modification of CINAO [GOST 26204-91], pH – salt extract – by the potentiometric method [GOST 26483-85]. Laboratory work was carried out by the laboratory of the FSBI "Station of the agrochemical service "Ishimbayskaya". This organisation has a "Certificate of accreditation of testing laboratory 43 (centre) in the accreditation system of analytical laboratories (centres)" No. ROSS RU.0001.514154.

A topographic survey of the surveyed area was carried out on a scale of 1: 25000. The study area was mapped using ArcGIS 10.4.1, MapInfo and Adobe Illustrator CS5. The data obtained from the research were processed by statistical methods [Dmitriev 1995; Dospekhov 1985] using Microsoft Office Excel 2003 and Statistica 10.0.

RESULTS AND DISCUSSION

The soil survey was carried out on agricultural land, except for land under water bodies (ponds, canals, streams, small rivers, lakes). A total of 321 full-profile soil sections were laid (Fig. 2). To determine agrochemical parameters 1163 soil samples were used. The survey revealed a complex structure of the soil cover with numerous varieties of soils, characterised by a great variety and distinctive features of the properties that determine their fertility. According to the agrochemical and morphological survey, gray forest soils prevail in the study area, subdivided into gray forest soils – 49,018 ha (43.2%), dark gray forest soils – 22,856 ha (20.1%), light gray forest soils – 11,551 ha. (10.2%), podzolised and leached chernozems – 7,794 ha (6.3%), alluvial – 12,690 ha (11.2%), soddy-carbonate – 2119 ha (1.9%), meadow – 1,290 ha (1.7%) (Fig. 3). The gradation did not include the soils of the gully-ravine complex, sand and gravel deposits, active ravines, and disturbed lands and quarries that occupy an area of 6,119 ha (5.4%).

It is necessary to determine the fertility to assess the agroecological state of soils. The humus indicator expresses it as to the most significant component and the content of mobile compounds of phosphorus, exchangeable potassium, the environment's reaction, and granulometric composition. Almost all soil fertility components are in direct proportion to the content of humus [Abdrakhmanov *et al.* 2005; Asylbaev, Khabirov 2016]. It determines the number of essential soil properties: structure,

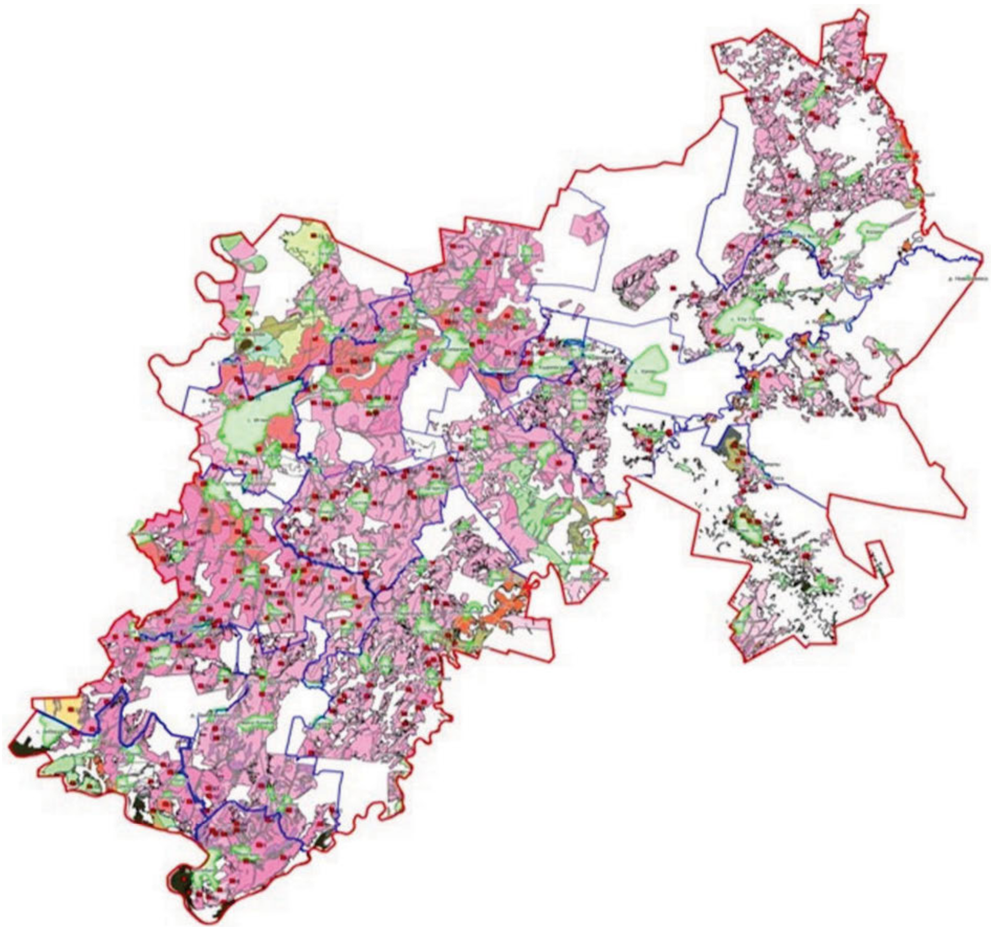

Fig. 2. Soil map of 2021 and location of the sections; source: own study

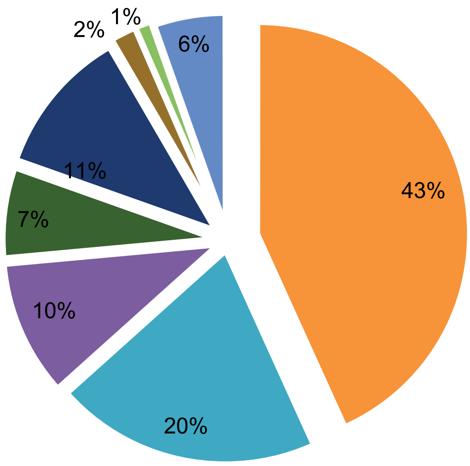

Fig. 3. Distribution of soils in 2021 (% of the area); source: own study

density, accumulation of mineral substances, etc. In turn, agricultural soils' fertility is an artificially maintained property that ensures the flow of air and nutrients into cultivated plants [CHEKMAREV *et al.* 2017; DE ORO *et al.* 2019; KIANI-HARCHEGANI *et al.* 2019].

The soil-forming process in the northern forest-steppe zone goes on under the forest and herbaceous vegetation under periodically flushed water regimes. Rich vegetation allows leaving behind a significant amount of root residues in the soil, contributing to the accumulation of a large amount of humus and pre-humus components in it. Despite the favourable properties and regimes that determine the region's soil fertility's high potential, the latter has several disadvantages. The region's soils have been ploughed up due to intensive use, the farming system has been disturbed, and crop rotation is disturbed due to the annual cultivation of "marginal" crops on the same fertile soils.

It is necessary to determine the fertility, expressed by the indicator of humus, the content of mobile compounds of phosphorus, exchangeable potassium, the reaction of the medium and the granulometric composition. Almost all components of soil fertility are directly dependent on the content of humus, which determines the number of essential properties of the soil: structure, density, accumulation of mineral substances, etc. The research results showed that on agricultural lands, the most widespread in terms of humus content were low-humus soils – 51,590 ha (45.5%), medium-humus soils occupy 45,313 ha (40%), low-humus – 5,190 ha (4.6%), micro-humus – 1,517 ha (1.3%), obese – 3,776 ha (3.3%). All arable soils to one degree or another were subject to erosion processes, in which, first of all, the most minor fractions are lost [KIANI-HARCHEGANI *et al.* 2019; SOBOL *et al.* 2017]. The humus also decreases with the silty fraction. Earlier studies on the Bashkir State Agrarian University's experimental fields established the regularities of changes in the content and composition of humus in soils when used in agrocenoses. When it is involved in arable land, the content of total humus decreases by 15–30% [IVANOVA *et al.* 2015].

The humus horizon's thickness is dominated by medium-thick soils – 64,594 ha, powerful – 33,189 ha. A smaller area is occupied by low-power – 9,580 ha (8%) (Tab. 1).

Previous studies on the experimental fields of the Bashkir State Agrarian University established the regularities of changes

Table 1. Distribution of soils in 2021 by the thickness of the humus horizon

Characteristics of the thickness	Area (ha)
Powerful	33,189
Medium power	64,594
Low-power	9,580
Very low power	22
Soils not included in the gradation	6,075
Total	**113,460**

Source: own study.

in the content and composition of humus in soils when used in agrocenoses. The content of total humus decreased by 15–30% when it was involved in arable land. A complex of agrotechnical, agrochemical, and reclamation measures is necessary to preserve and increase soil fertility. The use of various organic fertilisers, mineral fertilisers, and ameliorants is required [GABBASOVA 2004].

The granulometric composition of the soil is of great agronomic importance [AKHTYRTSEV, YABLONSKIKH 1986]. It affects physical, physicochemical, physicomechanical properties, and such soil regimes as water, air, and nutrient conditions [GABBASOVA *et al.* 2016].

According to the granulometric composition, the soils were distributed as follows: heavy loamy soils are predominant – 50,950 ha (45%), light loamy soils occupy 46,221 ha (41%), medium loamy soils – 6,832 ha (6%), medium loamy soils – 2,465 ha (2%). The share of heavy clay – 496 ha (0.4%), sandy loam – 363 ha (0.3%) and light loamy – 59 ha (0.1%), respectively (Tab. 2).

Table 2. Distribution of soils in 2021 by the granulometric composition

Characteristics of soils	Area (ha)
Heavy clay	496
Medium clay	6,832
Light clay	46,221
Heavy loamy	50,950
Medium loamy	2,465
Light loamy	59
Sandy loam	363
Soils not included in the gradation	6,075
Total	**113,460**

Source: own study.

All arable soils of the study area were, to one degree or another, subject to erosion processes in which, first of all, the minor fractions are lost, and with it the humus content. It is confirmed by a significant decrease in the humus content of all soils. It should be noted that among the non-eroded subtypes of chernozems, the highest humus content is characteristic of leached chernozems (≤8%) and dark gray forest soils (≤7.2%). On the district's territory, the processes of water and, to a lesser extent, wind erosion have developed significantly. Water erosion affects 50% of the agricultural land area, of which 44,675 ha (39%) are weakly washed out, 10,970 ha (10%) are moderately washed out, and 1,377 ha (1.2%) are heavily washed away. Soils not prone to erosion – 50,364 ha, which is 44% (Fig. 4).

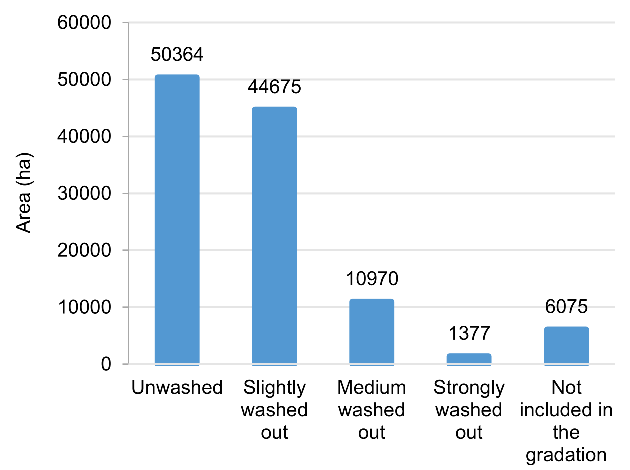

Fig. 4. Distribution of soils in 2021 by categories of erosion; source: own study

As a result of degradation processes, depending on the type of soil and the depth of ploughing, the annual loss of organic matter in arable soils, according to various expert estimates, ranges from 0.33 to 1.0 $Mg \cdot ha^{-1}$ [Eremin, Gruzdeva 2018; Kotchenko *et al.* 2018].

Anthropogenic and endogenous factors influence the development of eroded processes. Among the endogenous factors that determine the danger of erosion processes, a unique role belongs to terrain relief [Gabbasova *et al.* 2016].

The main factors of the relief causing danger of water and wind erosion on the territory of the region are the presence of slopes with a steepness of more than 2–3° and a healthy dissection of the territory by a gully-girder network.

Water erosion affects 50% of the agricultural land area, of which 44,675 ha (39%) are weakly washed out, 10,970 ha (10%) are moderately washed out, and 1,377 ha (1.2%) are heavily washed away – soils not prone to erosion – 50,364 ha, which is 44% (Tab. 3).

Table 3. Distribution of soils in 2021 by categories of erosion

Characteristics of soils	Area (ha)
Unwashed	50,364
Slightly washed out	44,675
Medium washed out	10,970
Strongly washed out	1,377
Soils not included in the gradation	6,075
Total	**113,460**

Source: own study.

In many studies of Russian and foreign scientists, it is noted that the soil cover has changed dramatically over the past decades, and water and wind erosion have sharply increased. The dehumification of soils and spraying of the arable layer associated with the soils' technogenic impact is intensified. On large tracts of soil cover, the differences of strongly-, medium- and weakly eroded soils with a decrease in fertility level have become isolated [Coxhead, Øygard 2007; Gabbasova *et al.* 2016].

Based on the materials obtained from the field survey and the results of laboratory studies, the areas of agricultural land were clarified, and the soil maps were corrected and digitised. The survey area within the boundaries of the Iglinsky district was 113,460 ha. Digitisation of soil contours was carried out based on soil maps produced in the period from 1961 to 1983 and a detailed digital soil map was compiled for the entire territory of the Iglinsky district to identify the main types and subtypes of soils with an indication of varieties at a scale of 1: 25000 in the MapInfo program (Fig. 2). Simultaneously with the map of agricultural land, the soil map obtained as a result of the correction is digitised. The results of this work are presented in the form of a complex of electronic layers: 1 layer – the name of the soil variety, mechanical composition, parent and underlying rocks; 2 layers, the content of humus in the soil, the provision of mobile forms of nutrients, the pH value, the thickness of the humus horizon.

As a planning basis, on which you can open the created layers and receive information on soils, a raster basis, coordinated to the local coordinate system (MSK 02 zone 1), serves.

CONCLUSIONS

A comprehensive survey of the territory on agricultural land showed that the area of the district is 113,460 ha, of which 66,397 ha of arable land. The diversity of the soil cover is heterogeneous and includes 13 types and 33 subtypes of soils, including gray forest soils (75.3% of the area), podzolised and leached chernozems (6.3%), alluvial (11.2%), soddy-calcareous (1.9%), meadow (1.7%). It was revealed that half of the area of agricultural soils is subject to erosion processes, which are caused by the steepness of slopes of more than 2–3° and a highly dissected ravine-gully network of relief, which harms soil fertility. In terms of humus content, the main distribution is low-humus – 45.5% and medium-humus soils – 40%. In terms of the thickness of the humus horizon, they are medium-thick – 57% in texture, heavy loamy – 45%, light clay – 41%. Digitised maps, considering the current state of soil fertility, make it possible to develop projects for inter-farm and intra-farm land management of organisations of the agro-industrial complex, conduct a state cadastral assessment of agricultural land, determine a land tax and develop measures to improve soil fertility.

REFERENCES

Abdrakhmanov R.F., Abzalov R.M., Asphandiyarov A.Z., Baimbetova L. R., Balkov V.A., Bayanov M.G., ..., Yaparov I.M. 2005. Atlas Respubliki Bashkortostan [Atlas of the Republic of Bashkortostan]. Omsk. Izdatel'stvo Omskaya kartograficheskaya fabrika.

Akhtyrtsev B.P., Yablonskikh L.A. 1986. Zavisimost' sostava gumusa ot granulometricheskogo sostava v pochvakh lesostepi [Dependence of humus composition on particle size distribution in forest-steppe soils]. Pochvovedenie. No. 7 p. 114–121.

Asylbaev I.G., Gabbasova I.M., Khabirov I.K., Garipov T., Lukmanov N., Rafikov B.V., Kiseleva A., Khuzhakhmetova G., Mukhamedyanova A., Mustafin R.F. 2018. Bioaccumulation of chemical elements by old-aged pine trees in the Southern Urals. Journal of Engineering and Applied Sciences. Vol. 13(11) p. 8746–8751.

Asylbaev I.G., Khabirov I.K. 2016. The contents of alkali and alkaline earth metals in soils of the Southern Cis-Ural region. Eurasian Soil Science. Vol. 49(1) p. 24–32. DOI 10.1134/s1064229316010026.

Chekmarev P.A., Sorokin I.B., Kataev M.Y. 2017. Agroekologicheskoye sostoyaniye pashni Tomskoy oblasti i perspektivy metodov distantsionnogo zondirovaniya zemel' [Agroecological state of arable land in the Tomsk region and the prospects for the use of methods for remote sensing of land]. Rasteniyevodstvo. Vol. 5 p. 7–10.

Chen S., Arrouays D., Angers D.A., Chenu C., Barré P., Martin M.P., Saby N.P.A., Walter C. 2019. National estimation of soil organic carbon storage potential for arable soils: A data-driven approach coupled with carbon-landscape zones. Science of the Total Environment. Vol. 666 p. 355–367. DOI 10.1016/j.scitotenv.2019.02.249.

Coxhead I., Øygard R. 2007. Land degradation. In: Solutions for the world's biggest problems: Costs and benefits. Ed. B. Lomborg. Cambridge. Cambridge University Press p. 146–161.

De Oro L.A., Colazo J.C., Avecilla F., Buschiazzo D.E., Asensio C. 2019. Relative soil water content as a factor for wind erosion soils with different texture and aggregation. Aeolian Research. Vol. 37 p. 25–31. DOI 10.1016/j.aeolia.2019.02.001.

Della Chiesa S., La Cecilia D., Genova G., Balotti A., Thalheimer M., Tappeiner U., Niedrist G. 2019. Farmers as data sources: Cooperative framework for mapping soil properties for permanent crops in South Tyrol (Northern Italy). Geoderma. Vol. 342 p. 93–105. DOI 10.1016/j.geoderma.2019.02.010.

Dmitriev E.A. 1995. Mathematical statistics in soil science. Moscow. Publishing House of Moscow State University. ISBN 5-211-02930-5 pp. 320.

Dospekhov B.A. 1985. Methods of field experience. Moscow. Agropromizdat. ISBN 9785458235402 pp. 315.

Eremin D.I., Gruzdeva N.A. 2018. Agrogennyye izmeneniya plotnosti serykh lesnykh pochv v severnom Zaural'ye [Agrogenic changes in water permeability of light gray forest soils in the Northern Trans-Urals]. Sibirskiy vestnik sel'skokhozyaystvennoy nauki. Vol. 4(76). p. 32–38. DOI 10.26898/0370-8799-2017-5-2.

Gabbasova I.M. 2004. Degradatsiya i rekul'tivatsiya pochv Bashkortostana [Degradation and reclamation of soils in Bashkortostan]. Ufa. Gilem. ISBN 5-7501-0489-3 pp. 283.

Gabbasova I.M., Suleimanov R.R., Khabirov I.K., Komissarov M.A., Fruehauf M., Liebelt P., Garipov T.T., Sidorova L.V., Khaziev F. K. 2016. Temporal changes of eroded soils depending on their agricultural use in the Southern Cis-Ural region. Eurasian Soil Science. Vol. 49(10) p. 1204–1210. DOI 10.1134/s1064229316100070.

GOST 26204-91. Pochvy. Opredeleniye podvizhnykh soyedineniy fosfora i kaliya po metodu Chirikova v modifikatsii TSINAO [Soils. Determination of mobile compounds of phosphorus and potassium by Chiricov method modified by CINAO]. Moskva. Komitet standartizatsii i metrologii SSSR pp. 8.

GOST 26213-91. Pochvy. Metody opredeleniya organicheskogo veshchestva [Soils. Methods for determination of organic matter]. Moskva. Komitet standartizatsii i metrologii SSSR pp. 7.

GOST 26483-85. Pochvy. Prigotovleniye solevoy vytyazhki i opredeleniye yeye pH po metodu TSINAO [Soils. Preparation of salt extract and determination of its pH by CINAO method]. Moskva. Komitet standartizatsii i metrologii SSSR pp. 6.

Ivanova T.N., Bagautdinov F.Y., Asylbaev I.G. 2015. Changes in the content and composition of humus in leached chernozems (Luvic Chernozems) of the Republic of Bashkortostan's Southern forest-steppe during agricultural use. Bulletin of the Bashkir State Agrarian University. Vol. 1(33) p. 19–23.

Khaziev F.K., Mukatanov A.K., Khabirov I.K., Koltsova G.A., Gabbasova I.M., Ramazanov R.Y. 1995. Soils of Bashkortostan. Vol. 1. Ufa. Gilem. ISBN 5-7501-0004-9 pp. 384.

Kiani-Harchegani M., Sadeghi S.H., Singh V.P., Asadi H., Abedi M. 2019. Effect of rainfall intensity and slope on sediment particle size distribution during erosion using partial eta squared. Catena. Vol. 176 p. 65–72. DOI 10.1016/j.catena.2019.01.006.

Kirillova N.P. 2018. Kompleksnyy podkhod k pochvennoy kartografii na osnove tsifrovoy morfometrii i kombinatornogo analiza [An integrated approach to soil cartography based on digital morphometry and combinatorial analysis]. PhD Thesis. Moskva. MGU imeni M.V. Lomonosova pp. 264.

Kotchenko S.G., Eremin D.I., Gruzdeva N.A. 2018. Degumifikatsiya pashni, yeye prichiny i mery predotvrashcheniya v Tyumenskoy oblasti. V: Plodorodiye pochv i otsenka produktivnosti zemledeliya. VIII Sibirskiye Pryanishnikovskiye agrokhimicheskiye chteniya: materialy mezhdunarodnoy nauch.-prakt. konf. [Dehumification of arable land, its causes and prevention measures in the Tyumen region. Soil fertility and assessment of agricultural productivity. VIII Siberian Pryanishnikov agrochemical readings. Materials of international scientific-practical Conference]. 18–20.07.2018 Tyumen. Tyumen. GAU Severnogo Zaural'ya p. 302–306.

Litvinov Y.A. 2018. Inventarizatsiya, garmonizatsiya i analiz raznorodnykh pochvenno-geograficheskikh dannykh dlya tseley agroekologicheskogo monitoringa: na primere Rostovskoy oblasti [Inventory, harmonisation and analysis of heterogeneous soil-geographical data for agroecological monitoring (on the example of the Rostov region)]. PhD Thesis. Moskva. MGU imeni M.V. Lomonosova pp. 147.

Miller G.A., Rees R.M., Griffiths B.S., Ball B.C., Cloy J.M. 2019. The sensitivity of soil organic carbon pools to land management varies depending on former tillage practices. Soil and Tillage Research. Vol. 189 p. 236–242. DOI 10.1016/j.still.2019.104299.

Pathak R.K. 2011. Homa jaivik Krishi: A ray of hope for sustainable horticulture MARDI's initiatives. In: National symposium cum brainstorming workshop on organic agriculture. CSKHPKV 19–20.04.2011. India. Palampur. Souvenir and Abstracts p. 15–16.

Savin I.Y., Zhogolev A.V., Prudnikova E.Y. 2019. Sovremennyye trendy i problemy pochvennoy kartografii [Modern trends and problems of soil cartography]. Pochvovedenie. No. 1 p. 517–528.

Sobol N.V., Gabbasova I.M., Komissarov M.A. 2017. Effect of rainfall intensity and slope steepness on the development of soil erosion in the southern Cis-Ural region (a model experiment). Eurasian Soil Science. Vol. 50(9) p. 1098–1104. DOI 10.1134/S106422931709006X

Surekha K., Rao K.V., Rani N.S., Latha P.C., Kumar R.M. 2013. Evaluation of organic and conventional rice production systems for their productivity, profitability, grain quality and soil health. Agrotechnology. Vol. S11, 6 p. 1–6.