Influence of Anthropogenic Impact on Alteration in the Alluvial Soil Fertility Indicators

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Abstract. The article presents studies on establishing the influence of anthropogenic impacts on alluvial soils of agricultural lands. To solve the problem set, tasks were determined to estimate the degree of damage caused to soils of agricultural lands as a result of the soil humus layer loss or closure. These tasks included establishing the degree of alteration in soil fertility indicators for agricultural lands in regard to pH volume; organic matter content; degree of provision with K₂O and P₂O₅ accessible forms as a result of violating technology of the damaged land stripping and reclamation. Nature of changes in granulometric (grain) and micro-aggregate soil composition is demonstrated. Study objects included agricultural land territories with soil samples of alluvial granular soil taken at the depth of 0-5 cm and 5-20 cm. Necessity is demonstrated to study in detail the agroecological assessment of land use systems and the development of differentiated measures ensuring reproduction of soil fertility, crop growth and territory ecological sustainability. Negative processes are manifested to a varying degree on agricultural land in most administrative regions of Russia including agricultural land in the Orel Region, which requires creation of the ecologically sustainable land use system. Since transformation of compounds entering the ecological system primarily occurs in the soil, which acts as a filter and as the factor of transformation and accumulation of the entering substances, agrobiological features of soil composition and properties make it extremely sensitive to anthropogenic impact. As a result of scientific research, it was revealed that the studied area experienced a decrease in soil fertility main indicators of the alluvial soils and destruction (deterioration) of the fertile soil layer as a result of exposure to anthropogenic influence. Rates of decrease in the organic matter content in soil layer as a result of the soil humus layer damage are shown. Significant fluctuations in the amount of exchangeable potassium in the soils of anthropogenically damaged agricultural lands are established. Degree of decrease in the amount of available phosphorus in soils without humus layer is revealed. Significant alteration in the granulometric (grain) composition of the damaged land soil is proved.
1. Introduction

Russia is the country with the largest territory in the world and enormous land resources [9]. Land and land resources are the source of wealth for any society, since they are the spatial basis of all types of social production, people accommodation, human life and means of production for a number of sectors of the national economy [10]. More than 90% of food products human race obtains from soil as a result of agricultural activities [11]. Variety of climatic and soil conditions in Russia against the background of large territories of separate regions cause the problem of rational use of land resources taking into account specific features of the soil cover both at the regional and federal levels of administrative management [1], [2], [3].

Soil performs a variety of agroecological functions providing sustainability of both separate biogeoecoses and the biosphere in general [5]. Using agronomic and ecological functions of soil ensures human well-being and its existence [12]. It follows that both ecological and agronomic roles of soil in biosphere and human life are irreplaceable; even soil fertility, as the most important function of soil, is only part of that irreplaceable ecological role of soil, which it plays in biosphere and human life. And its preservation and reasonable use is a prerequisite for biosphere established functioning and further development of human civilization [5], [6], [7].

At present, exposure to anthropogenic influence on soil led to destruction of soil cover in large areas, soil contamination and deterioration of its properties. About 1.5-2 billion hectares of fertile soils were lost, and agricultural land reduction is continuing as a result of alienation and degradation processes, thus creating a dangerous ecological situation [4], [8], [10].

Main processes in agricultural land plots degradation include such processes as long-term non-use of land; land colonization with weeds, shrubs and low forests; water and wind erosion; flooding and swamping; salinization, desertification, contamination with hazardous chemicals; mineral extraction; construction work [13], [22]. Negative processes are manifested to varying degrees on agricultural land in most administrative regions of Russia, including agricultural land in the Orel Region [2], [3], [9].

One of the priorities in improving the current situation is creation of the ecologically sustainable land use system [21]. Since transformation of compounds entering the ecological system occurs primarily in soil, which is both the filter for incoming toxicants and the most important factor in their transformation, as well as a place accumulation thereof [14], [20]. Agrobiological features of soil composition and properties of soils make this substance being important for biosphere processes extremely sensitive to anthropogenic impact [15], [19]. This raises the need for detailed study of agroecological estimation of the land use systems and elaboration of differentiated measures to ensure reproduction of soil fertility, crop growth and ecological sustainability of the territory [16], [18].

In this regard, establishing the degree of degradation alterations and anthropogenic transformation of the agricultural lands soil is relevant and appears to be of theoretical significance for assessing features of manifestation and development of elementary soil processes on agricultural lands and determines the practical need for agroecological and hygienic estimation of soils in zones of the developing negative processes that worsen the qualitative state of land, in order to elaborate recommendations aimed at preventing and reducing the negative anthropogenic impact on ecosystems, which determined the purpose and objectives of our research [17].

Purpose of research: establishing the influence of anthropogenic impact on the agricultural lands alluvial soil.

In this case, the following problems are subject to solution:

1. Assessing the degree of damage caused to agricultural lands soil as a result of the fertile soil layer removal and closure.
2. Establishing the degree of alteration in agricultural lands soil fertility indicators by pH value; organic matter content; degree of provision with accessible forms of K₂O and P₂O₅ due to violations in stripping and reclamation technology of the damaged lands.
3. Demonstrating the nature of changes in granulometric (grain) and microaggregate soil composition.
Objects and methods of research: research was carried out on the agricultural land with soil samples of alluvial granular soil taken at the depth of 0-5 cm and 5-20 cm.

Water extract pH determination was performed according to GOST 26423-85-Soils. “Methods for determination of relative electrical conductivity, pH and solid residue of aqueous extract”.

Granulometric and microaggregate composition was determined according to GOST 12536-2014-Soils. “Methods for laboratory determination of granulometric (grain) and microaggregate composition of soil”.

Content of mobile compounds of exchangeable potassium and mobile phosphorus was determined according to GOST R 54650-2017 Nature protection. “Soils. General requirements for sampling”. To take soil samples, a pointed digging shovel GOST 19596-87 was used.

2. Results and discussion
As could be seen from data in Table 1, the amount of organic matter in the studied soil samples decreased at the depth of 0-5 cm to 1.71-2.76% or by 3.5 times and at the depth of 5-20 to 1.92-3.32% or by 3.3 times, compared to the organic matter amount in the control (background) soil, where the amount of humus at the depth of 0-5 cm was 7.8%, and at a depth of 5-20 cm - 8.54%. The amount of lost organic matter in the soil humus layer was on average 5.46% in the 0-5 cm soil layer and 6.16% in the 5-20 cm soil layer. Thus, lost humus amount in the 0-20 cm arable soil layer increased to 172.2 tons per hectare, while it is practically impossible to restore the lost supply of organic matter. It should be noted that soil humus is an integral soil property and its resistance to unfavorable climatic conditions and to anthropogenic influences.

Table 1. Indicators of alteration in the fertility of agricultural land plot alluvial soil as a result of anthropogenic impacts.

| Soil sample No. | Sampling depth, cm | pH H₂O | Organic matter, % | K₂O | P₂O₅ | Granulometric (grain) composition, % |
|-----------------|-------------------|--------|------------------|-----|------|-----------------------------------|
|                 |                   |        |                  |     |      | >10 | 1-5 | 0.25-1 | 0.1-0.25 | <0.1 |
| 1 0-5           | 8.21±0, 8.05, 8.05| 2.34± | 50.81±1 | 90.55±18, 0      | 0   | 2.5 | 6.98 | 35.1 | 51.0 | 4.3 |
| 2 5-2           | 8.05, 0.66        | 54.87±1| 113.87±22 | 0    | 3.4 | 8.41 | 38.7 | 45.5 | 3.83 |
| 3 5-0           | 8.11, 0.55        | 56.77±1| 95.18±19 | 0    | 3.0 | 10.0 | 39.4 | 44.4 | 3.13 |
| 4 2-0           | 8.2, 0.42         | 44.88±8| 94.49±18, 0 | 0    | 2.6 | 6.04 | 41.7 | 46.6 | 2.89 |
| 5 0-5           | 8.09, 0.51        | 46.60±9| 87.12±17, 0 | 0    | 2.0 | 7.06 | 39.9 | 45.9 | 5.03 |
Significant alterations were found in the amount of nutrient available forms, both in relation to the amount of exchangeable potassium and to mobile forms of phosphorus. Decrease in the exchangeable potassium (K\textsubscript{2}O) amount in damaged soil averaged 50.6% of the exchangeable potassium control content in the undamaged soil samples, or 58.76 mg/kg with content fluctuations from 44.88 mg/kg to 56.77 mg/kg in soil samples from the damaged lands. More significant deviations from the mobile phosphorus control content in the undamaged land soil samples were found in the mobile phosphorus (P\textsubscript{2}O\textsubscript{5}) amount alteration. If in undamaged samples the amount of mobile phosphorus was 119 mg/kg in the 0-5 cm soil layer and 117.98 mg/kg in the 5-20 cm soil layer, with the average content level in the 0-20 cm layer of 118.5 mg/kg, in soil samples from the damaged territory the mobile phosphorus amount fluctuated within the limits of 88.79 mg/kg in the 0-5 cm layer and of 90.93 mg/kg in the 5-20 cm layer, with the average content level in the damaged land plot soil of 89.86 mg/kg, i.e. the amount of available phosphorus in soils devoid of humus layer decreased by 1.3-1.5 times. Proven changes in the nutrient regime of the agricultural land soil would require significant long-term economic investment to restore productive capacity of the soil nutrient regime.

Our research proved significant alteration in the granulometric (grain) composition of the damaged land soil. This is caused by removal to the surface of deep and heavy in granulometric composition layers of soil-forming rock and illuvial horizons characterizing this type of soil and confirmed by a significant decrease in the number of fractions of soil aggregates less than 0.1 mm from 20.91-23.58% in the control soil samples to 3.8%, i.e. the number of aggregates less than 0.1 mm in size decreased by 6 times. The number of aggregate particles ranging in size from 0.5 mm to 0.25 mm increased on average to 37.34% in comparison with the number of particles of the indicated size in the background control soil - 13.78%, i.e. almost by 3 times. Such alteration in the soil granulometric (grain) composition causes abrupt changes in water, air, thermal and soil regimes, in the soil physical and physical-mechanical properties, which directly effects deterioration in soil fertility and productivity.

Results of our research of soil anthropogenic changes showed insignificant deviations in the pH value of water extract both in the 0-5 cm layer and in the 5-20 cm soil layer compared to pH indicators with the undamaged land control soil samples. The pH value varied in the range of 8.09-8.21 units in the soil layer of 0-5 cm and pH H\textsubscript{2}O 8.05-8.20 units in the 5-20 cm layer of anthropogenically modified soil compared to pH values of water extract in control soil samples, where the pH value of water extract varied within the limits of pH 8.32 in the 0-5 cm layer and pH 8.25 in 5-20 cm soil layer, which characterizes the degree of alkalinity of the soil medium reaction as alkaline or medium alkaline soil. At the same time, it should be noted that an increase in the degree of soil alkalinity has an effect on the increase in the soil humus components mobility, their solubility and decreasing soil aggregation.

| Layer | pH Value (0-5 cm) | pH Value (5-20 cm) |
|-------|------------------|--------------------|
| 0-5 cm | 8.09-8.21 units  | 8.05-8.20 units    |
| 5-20 cm | 8.32 units       | 8.25 units         |

| Layer | K\textsubscript{2}O (mg/kg) | P\textsubscript{2}O\textsubscript{5} (mg/kg) |
|-------|-----------------------------|---------------------------------|
| 0-5 cm | 119 mg/kg                   | 117.98 mg/kg                    |
| 5-20 cm | 90.93 mg/kg                 | 89.86 mg/kg                     |

| Layer | K\textsubscript{2}O (mg/kg) | P\textsubscript{2}O\textsubscript{5} (mg/kg) |
|-------|-----------------------------|---------------------------------|
| 0-5 cm | 119 mg/kg                   | 117.98 mg/kg                    |
| 5-20 cm | 90.93 mg/kg                 | 89.86 mg/kg                     |
3. Conclusions

1. Main indicators decrease in the alluvial soil fertility was registered, and destruction (damage) of the fertile soil layer as a result of anthropogenic influences was established on the land plot with cadastral number 72:17:1705001:59.

2. Rates of decrease were established in organic matter content in the soil layer of 0-5 cm and 5-20 cm as a result of damaging the soil humus layer. Thus, the rate of humus decline in anthropogenically altered soil reached 1.71-2.76% (0-5 cm) and 1.92-3.32% (5-20 cm). The amount of humus lost stock in the arable 0-20 cm soil layer was 172.2 tons per hectare.

3. Significant fluctuations were proved in the amount of exchangeable potassium in the soils of anthropogenically degraded agricultural land. Decrease in the amount of exchangeable potassium (K\textsubscript{2}O) in damaged soil averaged 50.6% of the control (58.76 mg/kg) content of exchangeable potassium in soil samples of undamaged land with fluctuations in content from 44.88 mg/kg to 56, 77 mg/kg in soil samples from the damaged land.

4. Degree of decrease in the available phosphorus amount was established in soils devoid of humus layer. Thus, in soils of damaged land the amount of phosphorus mobile forms decreased by 1.3-1.5 times compared to the amount of mobile phosphorus 119 mg/kg in the soil layer of 0-5 cm and 117.98 mg/kg in the soil layer of 5-20 cm from undamaged lands with the 118.5 mg/kg average level of its content in the 0-20 cm layer.

5. Research proved significant alteration in the granulometric (grain) composition of the damaged land soil confirmed by a sharp decrease in the number of soil aggregate fractions less than 0.1 mm from 20.91-23.58% in control soil samples to 3.8% in soils of damaged land, i.e. the number of aggregates less than 0.1 mm in size decreased by 6 times. The number of aggregate particles ranging in size from 0.5 mm to 0.25 mm increased almost by 3 times, on average to 37.34%, compared to the number of particles of the indicated size in the background control soil - 13.78%.

6. The pH value varied in the range of 8.09-8.21 units in the soil layer of 0-5 cm and pH H\textsubscript{2}O 8.05-8.20 units in the 5-20 cm layer of anthropogenically altered soil in comparison with the pH values of the water extract in control soil samples, where the pH value of the water extract varied within the limits of pH 8.32 in the 0-5 cm layer and pH 8.25 in the 5-20 cm soil layer.

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