Ecological Assessment of Alluvial Soil Resistance to Anthropogenic Impact

L P Stepanova¹, N A Yelizarov¹, A V Pisareva²a

¹Parakhin Orel State Agrarian University, Doctor of Agricultural Sciences, Professor, Department of Agriculture, Agrochemistry and Agrology, 302019, 69 Generala Rodina Street, Orel, Russia
²Bauman Moscow State Technical University (National Research University), Associate Professor, Candidate of Biological Sciences, Department of Medical and Technical Management, 105005, Building 1, 5 Vtoraya Baumanskaya Street, Moscow, Russia

E-mail: pavpav.06@mail.ru, pavpav@bmstu.ru

Abstract. The article presents studies aimed at establishing the influence of anthropogenic impact on composition and properties of the alluvial soddy soil. Assessment is demonstrated of the degree of damage caused to soils as a result of fertile layer removal and closure. Degree of the alluvial soil fertility indicator alteration is established by the water extract pH value, content of organic matter, level of provision with available forms of phosphorus in connection to violating the stripping and quarrying technology in extraction of construction sand and reclamation of damaged lands. Our studies were conducted on a land plot with soil samples of alluvial soddy soil taken at the depth of 0-20 cm. Rate of decrease was established in the organic matter content in soil layer of 0-20 cm as a result of stripping and quarrying. Studies demonstrated significant alteration in the soil granulometric (grain) composition in the damaged land confirmed by a sharp decrease in the soil aggregate fractions number. Destruction of the alluvial soil fertile layer, and damage to the soil cover during extraction of minerals by the open-pit quarrying method, and, as a consequence, deterioration in its environmental and water protection role, both for natural soils and for soils of river valleys, was proved. Thus, degradation of soil, as a means of agricultural production, is a loss of soil fertility and land productivity; soil degradation, as a historically formed body, is a decrease in its reliability, elasticity and durability. Negative processes are manifested to a varying degree on agricultural lands, which requires the need to assess the levels of impact of factors causing degradation, degree of soil alteration and possibility of their rehabilitation, elaboration of ways to optimize and create an ecologically sustainable land use system.

1. Introduction
Under conditions of increasing anthropogenic contamination of soils and landscapes, the function of soil resistance to pollution and the ability to self-purify are becoming of great importance [2], [5]. Soil cover plays a significant role in water balance and formation of composition of ground, lake, river and even sea water composition. This happens because precipitation falling on the soil surface seeps deep into the soil, enters into chemical reactions with the soil mineral and organic components, with soil-forming animals, microorganisms and plant root systems [1], [6]. As a result of these reactions,
atmospheric moisture entering the soil forms soil solution and groundwater enriched with mineral and organic substances [7], [8], [9], [10], [11]. Globally, there exists a problem that current land use practices are characterized by an adverse impact on soil cover [12]. Russia is experiencing significant changes in land use in the recent decades due to increased demand for the agricultural products [13]. This causes multiple alterations, which could be manifested by a decrease in the soil chemical and physical properties leading to deteriorating soil quality and continuing decline in productivity [14]. Soil organic matter transformation in cultivated soils leads to soil degradation and, ultimately, to impossibility of ensuring sustainable agricultural production, if rehabilitation measures are not carried out [15]. Data on the soil particles density are of great importance in conducting soil research, since they are required to assess the damaging effect on soil cover, rate of particles deposition, relative saturation, thermal conductivity, thermal capacity and volumetric ratios of water and air [16], [22]. Specific studies include simulating the processes of water, air and heat flows, as well as chemical substances transfer in soil samples [17], [21]. Alluvial soils are formed in fluvial plains and river deltas under conditions of impounding with flood waters and formation of the alluvium fresh layers with different granulometric and chemical composition [3], [18], [20]. Soil cover in fluvial plains differs in composition and properties depending not only on their geographic location, but also on location of the fluvial plain different parts in relation to the river bed [1], [2], [5], [6].

In this regard, three groups of alluvial soils are distinguished, i.e. alluvial soddy soils on sabulous loamy alluvium in the fluvial plain river bed part and along ridges of the central fluvial plain, alluvial meadow soils formed in central areas of the river fluvial plains on loamy and clayey alluvia and alluvial meadow bog soils and bog soils occupying low and swampy terraced parts of the river fluvial plains [3], [4], [19].

**Purpose of research** is to establish the anthropogenic impact influence on composition and properties of agricultural land alluvial soddy soils.

In this case, the following **tasks** are subject to solution:

1. Assessing the degree of damage to the agricultural land soils caused by removal and closure of the fertile soil layer.
2. Establishing alteration degree in fertility indicators of the agricultural land alluvial soils by the water extract pH value; organic matter content; degree of provision with available forms of P2O5 in connection to violation of the stripping and quarrying technology in extraction of construction sand and reclamtion of the damaged lands.
3. Demonstrating the nature of alterations in granulometric (grain) and microaggregate composition of the alluvial soddy soil.

**Objects and methods of research.** Research was carried out on an agricultural land plot with soil samples of alluvial soddy soil taken at the depth of 0-20 cm. Water extract pH value was determined in accordance with GOST 26423-85-Soils. “Methods for determination of electrical conductivity, pH and solid residue in water extract”. Organic matter amount was measured according to GOST 26213-91-Soil. “Method for determination of organic matter”. 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 the mobile phosphorus mobile compounds was carried out in accordance with GOST R 54650-2011-Soils. “Determination of mobile phosphorus compounds by the Kirsanov method in modification by TsINAO”. Selection of soil samples was carried out in accordance with GOST 17.4.3.01-2017 “Nature protection. Soils. General requirements for sampling”. To take soil samples, a pointed digging shovel “GOST 19596-87” was used.

2. Results and discussion

Alluvial soddy soils are formed in conditions of having a deep groundwater level under the rich in herbs cereal and sparse vegetation. Alluvial soil provision with moisture and plant nutrient elements as a result of regular flood waters and alluvium deposition create favorable conditions for cultivation of
crops demanding fertility, as well as for cultivation of forage crops and using these soils in grassland and pastures.

Landscape transformation in human economic activity enforced by the influence of industry and cities provides a significant impact on the existing natural flows of matter and energy. Moreover, along with positive changes, technogenesis negative consequences are being increasingly manifested, and they often exceed ecologically acceptable limits and ecosystem ability to self-regulation causing their destruction (Table 1).

Table 1. Indicators of alterations in alluvial soil fertility of the agricultural land plot damaged by sand quarrying.

| Soil sample No. | Sampling depth, cm | pH H₂O | Organic matter, % | P₂O₅, mg/kg | Granulometric (grain) composition, % |
|-----------------|-------------------|--------|-------------------|-------------|-------------------------------------|
|                 |                   |        |                   |             | ≥0.5 mm | 10.5-0.5 mm | 5-2 mm | 2-1 mm | 1.05-0.5 mm | 0.5-0.25 mm | 0.25-0.1 mm | <0.1 mm |
| 1               | 0-20              | 9.35±0.0 | 0.33±0.0         | 10.50±3.6  | 0   | 0   | 0.0         | 3.8      | 19.2     | 29.1   | 43.9   | 3.77   |
|                 |                   |        |                   |             | 7    | 7   | 0   | 9   | 1    | 7     |
| 2               | 0-20              | 9.42±0.0 | 0.28±0.0         | 23.70±8.3  | 0   | 0   | 0.2         | 6.6      | 19.1     | 32.7   | 39.0   | 2.20   |
|                 |                   |        |                   |             | 6    | 6   | 5   | 5   | 0    | 4     |
| 3               | 0-20              | 6.70±0.0 | 9.06±1.8         | 471.97±94  | 0   | 0   | 0   | 3.0   | 15.7    | 38.9  | 29.5   | 12.8   |
| (K)             |                   |        |                   |             | 1    | .39 | 1   | 1   | 4    | 5     | 0     |

Our research established the impact quarrying and stripping in sand extraction on composition and properties of riverbed fluvial plain alluvial soil (Table). So, result of the analysis of soil samples characterizing soil cover fertility level of the land territory damaged by stripping in extraction of construction sand in the territory of the riverbed fluvial plain, i.e. near the river bed, and their comparison with indicators of the alluvial soil composition and properties undisturbed by land open-cut mining (control), confirms the fact of the soil profile integrity destruction, damage to soil cover on the entire area of the 86 330 m² land plot and, as a consequence, annihilation of the alluvial soil fertile layer was established and proved. Thus, soil samples taken from the damaged territory testified to complete absence of organic matter, which amount was 0.28-0.33%, i.e. by 27.5 times lower than the organic matter control amount in the damaged alluvial soil of 9.06%. and the reduction degree reached 8.73-8.78% or 97% of the organic matter amount in the original undamaged soil. It is practically impossible to restore such a high rate of losing the organic matter given the uneven-age nature of the soil-forming process in river fluvial plains and would require not only high, but also long-term investment in material and technical means.

Nature of alteration in the alluvial soddy soil reaction during land stripping was revealed. Thus, an increase in soil medium alkalinity of the water extract pH from pH H₂O 6.60 to pH H₂O 9.35-9.42 was proved, which characterizes the strongly alkaline reaction of the medium.

High level of loss was established in the mobile phosphorus nutrient amount reaching 95-98% of the control content of mobile phosphorus in the undamaged alluvial soil of 471.97 mg/kg; level of mobile phosphorus content in anthropogenically altered soils was 10.5-23.7 mg/kg and was estimated as the “very low” phosphorus. Restoration of the lost levels of the mobile phosphorus content would require not only significant material and financial investment, but also high time expenses.

Alterations in granulometric (grain) composition of the alluvial soil damaged by stripping and quarrying due to significant decrease in soil particles less than 0.1 mm in size ranging from 12.8%
the undamaged control soil sample to 2.2-3.77% in the destroyed alluvial soil was proved. And that is the reason for significant decrease in the soil retentivity or absorption capacity, which determines its fertile strength and ecological resistance to adverse environmental factors.

At the same time, it should be noted that alluvial soils are characterized by high environmentally friendly role (especially, in water protection) played in natural soils and biocenoses of river valleys. This fact primarily requires special attention and responsibility, when involving alluvial soils in any type of production.

3. Conclusions

1. Alteration in main indicators of the alluvial soil fertility indicators was established on the agricultural land plot, and the fact of destruction (damage) of the fertile soil layer as a result of anthropogenic impacts was proved.

2. Rates of decrease of organic matter content in the soil layer of 0-20 cm as a result of stripping and quarrying from 9.06% of humus in the control undamaged soil to 0.28-0.33% of organic matter in the damaged soil was proved. At the same time, degree of humus decrease in the anthropogenically modified soil reached 8.73-8.78%, or 97% of the organic matter amount in the original undamaged soil. The amount of lost humus stock from the arable 0-20 cm layer of alluvial soddy soil was 263.4 tons per hectare.

3. Degree of decrease in the amount of available phosphorus in soils damaged by the construction sand extraction was determined. Thus, the amount of phosphorus mobile forms in the damaged land soil decreased on average by 28 times in comparison with its average content level in the 0-20 cm layer of 17.1 mg/kg and mobile phosphorus amount of 471.97 mg/kg in the control soil samples with undisturbed lands.

4. Research proved significant alteration in the damaged land soil granulometric (grain) composition confirmed by a sharp decrease in the number of soil aggregates fractions less than 0.1 mm from 12.8% in the undamaged control soil sample to 2.2-3.77% in the alluvial soil damaged by quarrying; i.e. the number of aggregates less than 0.1 mm in size decreased by 4 times. The number of aggregate particles ranging in size from 0.5 mm to 0.25 mm increased by almost 1.4 times, on average to 41.5% compared to the number of particles of the indicated size in the background control soil of 29.55%.

5. The pH value varied in the range of 9.35-9.42 units in the soil layer of 0-20 cm of anthropogenically altered soil in comparison with the water extract pH values in control soil samples, where the water extract pH value was 6.70 units.

6. Destruction of the alluvial soil fertile layer and damage to soil cover during mineral extraction by open pit quarrying and, as a consequence, deterioration of their nature protection and water protection roles were proved, both for natural soils and for soils in river valleys.

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