Ecological Assessment of Disturbances in the Landscape Structure of Alluvial Soils of Floodplains Under Technogenesis Influences

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Abstract. The article considers the problem of disturbances in the landscape structure when extracting constructional sand causes the formation of a technogenic relief. The objective of this study was to determine the change in the main fertility indicators for alluvial turf and meadow soils disturbed by open-pit mining and building communications. The study included tasks stated below. The research tasks included identifying the quantitative changes in the composition and properties of alluvial soils disturbed by construction sand extraction. Determination of the change in the organic matter content of the upper layer in the artificial soil-like formations (technozems) in comparison with undisturbed soils. Specifying the nature of changes in the texture of the humus horizon of donor soils and technozems bulk layers. Determination of the change in the pH of the aqueous extract, and the content of the accessible forms of K₂O and P₂O₅ in the soils disturbed by mining. The objects of the study were: plots of agricultural land with soil samples of alluvial turf and alluvial meadow soils, sampled at a depth of 0-20 cm. In the floodplain zone, the research was conducted on soils with a disturbance within the upper 50 cm thickness on alluvial turf soil. Technozem, an artificial soil-like structure consisting of one bulk layer of technogenic soil, was studied in the central floodplain. The studies found that open-pit mining has an impact on the composition and properties of alluvial soils. Disturbances in the landscape structure at open-pit mining cause significant destruction of a fertile layer as the soil texture changes. There is also a loss of organic matter in the disturbed soils depending on the degree of manifestation of anthropogenesis.
1. Introduction
Under the impact of industrial activity, the landscape structure changes, and all components of the landscape are transformed [2]. At the same time, mining affects practically all components of the landscape, not only soils and soil cover [4].

Thus, during the open-pit extraction of minerals (construction sand) following types of disturbances in the landscape are observed: the destruction of agricultural lands and soils, emerging of the hydro imbalance [3], [5], surface and groundwater pollution, geochemical contamination of the surrounding soils [12]. Disturbances in the landscape structure during the extraction of construction sand causes the emergence of technogenic relief, namely: dumping, quarry, erosion development, dust pollution of the soil cover, the formation of depression craters, and, as a result, the alienation of agricultural land [6]. The fertile cover is influential in the water balance and the formation of the composition of soils, lakes, and rivers [8]. The reason is that precipitation that falls on the soil surface penetrates deeply into the soil, and enters in chemical reactions with mineral and organic components of the soil, soil-forming animals, microorganisms, and the root system of plants [7], [9].

The quarry method of construction sand mining affecting almost the entire soil profile. Mechanical actions during sand extraction directly changing the solid phase of the soil profile, and creating new soils. Disturbances of the soil profile are observed within the upper fifty centimeters layer of the soil due to mixing of technogenic material with the original genetic horizons, accumulation of aero-technogenic and de-alluvial technogenic loads, deposition of bulk technogenic substrates on the cut soil [5].

Soils and soil-like bodies, differing in the level of technogenic disturbance, are not the only compositions found in the areas changed by mining. "Nonsoils" or ground other than from a surface (technogenic, natural, displaced surface deposits in areas of open-pit mining), can also be exposed in open-pit excavations. Technogenic grounds include natural displaced loose and dense surface sediments, alluvial and bulk rock dumps, and embankments, hidden in quarry excavations. Quaternary aged-alluvial sediments represent technogenic grounds with different resistance to erosion. Thus, disturbances of the soil occur at all stages of mining - exploration, surface mining, creation of embankments, and access roads.

The studied technogenic soils are formed by mechanical disturbances of alluvial turf and alluvial meadow soil profiles [11].

**The objective of this study** is to determine the change in the main fertility indicators for alluvial turf and meadow soils disturbed by open-pit mining (construction sand) and building communications (embankments, dams, access roads).

The following tasks are to be solved:
1. Identify the quantitative changes in the composition and properties of alluvial soils disturbed by construction sand extraction
2. Determine the change in the organic matter content of the 2-20 cm layer in the artificial soil-like formations (technozems) in comparison with undisturbed soils.
3. Show the nature of changes in the texture of the humus horizon of donor soils and technozems bulk layers.
4. Determination of the change in the pH of the aqueous extract, and the content of the accessible forms of K₂O and P₂O₅ in the soils disturbed by mining.

2. Objects and methods
The studies were conducted on agricultural lands with soil samples of alluvial turf and alluvial meadow soils at a depth of 0-20 cm. Within the levee floodplain zone, studies were conducted on alluvial turf soil with a disturbance within the upper 50 cm thickness [10]. In the central floodplain zone, we studied technozem - an artificial soil-like body consisting of a single bulk layer of technogenic soil.

- The amount of organic matter was measured by the method of its determination.
- The pH of the aqueous extract was measured by determining the specific electric conductivity, pH, and dense residue of the aqueous extract.
- Soil texture and microstructure were analyzed by laboratory method of determining the soil composition.
- The content of mobile compounds of exchangeable potassium and mobile phosphorus was calculated by Kirsanov's method in the CiNAO version.
- Soil samples were taken according to GOST 58595-2019; GOST 17.4.3.01-2017 "Nature Protection. Soils. General requirements for sampling". Soil sampling was carried out with a sharp-edged digging shovel.

3. Results and discussion

The areas of land disturbed by quarries of various purposes amount to 0.01-0.02% in the Russian Federation. Quarries for the extraction of mineral soil and non-ore materials cause significant damage. Types of anthropogenic impacts on the soil are classified into 3 groups [1]. By the nature of the human activity - specialization of activity, relation to natural processes and phenomena, duration and intensity of the impact. By relation to the soil - direct and indirect impacts, reversibility and sustainability, compatibility, the natural response of the body. By the impact results - depending on the quality of the result obtained. Thus, the type of agricultural activity determines the main directions of the soil changes.

Technogenic soils include soils formed by industrial activities with partial or complete mechanical disturbance of the profile [7]. In the studied territory influenced by open-pit mines, there are two groups of technogenic-transformed soils combined with "non-soil" formations. One is the natural soils with surface mechanical transformations, appearing within the upper 50 cm thickness. The other is soils with a partial dilution of the upper horizons with technogenic material. The choice depends on the degree of addition of technogenic material during the functioning of the middle and lower soil horizons.

Studies established that the disturbance of alluvial turf near the floodplain by quarrying construction sand caused changes in the composition and properties of the fertility horizon at 0-20 cm depth. Thus, differences in the quantitative content of fractions of mechanical elements, characterizing the texture of soils, are proved. A sharp decrease in the amount of particles of a size less than 0.1 mm by 2.2 times compared with the undisturbed control sample was found. Also, the increase of the number of particles of a size 0.25-0.1 mm to 81.37 % or 2.9 times in the soils disturbed by open-pit mining works were revealed. That causes deterioration of soil density; the decrease of water permeability and, as consequence, degradation of the water-air regime. These processes are of utmost importance for the elementary soil processes taking place in alluvial flood plain soils of the near river floodplain (figure 1).
Figure 1. Changes in the texture of the alluvial turf.

The identified changes in the soil texture cause differences in the intensity of humus accumulation and the content of nutrients (Table 1).

Thus, the rate of organic matter loss from the 0-20 cm soil layer of the disturbed land area compared to its level in the control sample of undisturbed soils is 2.71%. That is 58.3% of the initial humus level in undisturbed soils. Therefore, the amount of lost humus was 81.3 t/ha.

A change in the nutrient regime in alluvial turf disturbed by excavations has been shown. In particular, 1.5 times (to 23.1 mg/kg) decrease for exchangeable potassium in the soils of disturbed land. There was also found a slight increase in mobile phosphorus from 22.13 mg/kg in undisturbed soils to 33.11 mg/kg in the soils of disturbed land.

Table 1. The anthropogenic impact on changes in the main indicators of the alluvial turf fertility.

| Soil Sample № | pH H₂O | Organic matter, % | K₂O mg/kg | P₂O₅ mg/kg | Soil texture, % |
|---------------|--------|-------------------|-----------|------------|----------------|
|               |        |                   | >10 mm    | 10-5 mm    | 5-2 mm        | 2-1 mm        | 1-0.5 mm      | 0.5-0.25 mm  | 0.25-0.1 mm | <0.1 mm |
| 1             | 7.47   | 1.94              | 42.88     | 33.11      | 0             | 0             | 0.13          | 0.25        | 4.25        | 81.37    | 13.99    |
| 2 (K)         | 7.71   | 4.65              | 65.98     | 22.13      | 0             | 0             | 0.44          | 19.01       | 22.05       | 27.75    | 30.75    |

The pH value of the aqueous extract changed from "slightly alkaline" (pH 7.71) in undisturbed control soil samples to "neutral" (pH 7.47) in alluvial soils of the alluvial floodplain disturbed by land works.

Results of the soil samples analysis taken from 0-20 cm depth on both the disturbed and undisturbed floodplain land territory proved that the disturbance of the soil profile integrity caused a sharp deterioration of composition and properties of alluvial turf of the disturbed territory. It was confirmed by high rates of loss of organic matter as the main indicator of the soil fertile strength.

Laboratory study of the samples of technozem soil of 0-20 cm depth in the central floodplain and comparison of the results with the indicators of the control undisturbed soil sample revealed a
complete loss of organic matter in the given layer of the disturbed land area. The amount of organic matter was 0.72% and decreased by 8.9 times compared with its amount in undisturbed soil (6.43%). The amount of organic matter decreased to 171.3 t/ha against the initial stock of organic matter in the disturbed soil (6.43%). Therefore the reserve of organic matter in the disturbed soil was 21.6 t/ha, and further restoration of the initial quantity of the organic matter is impossible in such soils with unstable indices of composition and properties (table 2).

**Table 2.** Anthropogenic influences on the change in the main indicators of alluvial meadow soil fertility.

| Soil Sample № | pH H2O | Organic matter, % | K2O, mg/kg | P2O5, % | Soil texture, % |
|---------------|--------|-------------------|------------|---------|----------------|
|               |        |                   |            |         | >10 mm | 10-5 mm | 5-2 mm | 2-1 mm | 1-0.5 mm | 0.5-0.25 mm | 0.25-0.1 mm | <0.1 mm |
| 1             | 6.90   | 0.72              | 48.09      | 13.38   | 0       | 0       | 0.02   | 2.83   | 13.05     | 77.39     | 6.71     |
| 2 (K)         | 7.72   | 6.43              | 50.97      | 22.13   | 0       | 0       | 0.89   | 18.05  | 19.72     | 34.73     | 26.61    |

Open-pit mining caused the deterioration of the nutrient regime indicators, namely a decrease in the amount of exchangeable potassium and mobile phosphorus to a "very low" level. A slight decrease of disturbed soil alkalinity, from pH 7.72 in the control sample to pH 6.90, was revealed.

A significant deterioration of the soil texture in the disturbed territory has been proved. Specifically, a sharp decrease in the amount of particles less than 0.1 mm in the disturbed soils (6.71%), which is 4 times lower than in the control soil (26.61%). Simultaneously, the amount of particles 0.25-0.1 mm increased by 2.2 times compared with their content in undisturbed soils. Changes in the fractional composition of mechanical elements have a significant effect on the absorption capacity of the soil and its water-air regime (Fig. 2).

![Figure 2. Changes in the texture of alluvial meadow soil.](image-url)
The loss of organic matter in soils causes the loss of fertility, buffer stability, low productive capacity, and a sharp deterioration of the ecological situation of the surrounding territories.

Excavation activities on alluvial (flood plain) soils lead not only to loss of their natural fertility but is the main reason for a change in the soils water regime of the river valleys and surrounding territories. Alongside, it leads to gley-formation and changes in the oxidation and regeneration state of soils, reduction in the level of groundwater, loss of water in wells, forest drying, increase in fire danger of forestland.

4. Conclusions
1. Open-pit mining of minerals (construction sand) causes changes in the composition and properties of alluvial soils of agricultural floodplain lands.
2. Landscape structure disturbance during open-pit mining destroys the fertile layer of alluvial floodplain soils, and the appearance of technogenic relief (dumps, quarries).
3. The nature of changes in the texture of the disturbed soil is established. It directed to the sharp decrease of fraction less than 0.1 mm, with the significant increase of fractions in the size of 0.1-0.25 mm.
4. High rates of organic matter loss, reaching 58.3% in the disturbed alluvial turf and 88.8% in the alluvial meadow soil of the disturbed land area depending on the degree of technogenesis were confirmed.

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