Changes in floodplain soils of the Nizhny Don under the influence of flow regulation and anthropogenic load

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Abstract. Formation of hydromorphic floodplain soils of the valley of the Nizhny Don occurs mainly under the influence of anthropogenic erosion and due to lowering the water content of the floodplains below the dams as the result of the construction of the Tsimlyansk reservoir. Road transport and overgrazing contribute to the degradation of natural meadow vegetation until its complete destruction. As a result, the properties of soils, as well as the content and composition of humus, significantly change, the water-physical properties of soils deteriorate and the processes of secondary salinization develop with the nearby proximity of mineralized groundwater.

1. Introduction

Analysis of historical data shows that for a long time this territory was mainly a nomadic animal husbandry area. It was only from the 18th — 19th centuries that the development of agriculture began. At the same time, up to the beginning of the 20th century, the fallow farming system was dominant. The construction of the Tsimlyansk reservoir had a significant impact on the functioning of floodplain landscapes. The volume of spring runoff decreased to 30-40%, and in some cases — even to 20%. But significantly increased runoff in other seasons of the year suggests a further decrease in the value of spring runoff.

The waterfall of the floodplain below the reservoir dam decreased, which led to profound changes in floodplain landscapes. Currently, there is a further decrease in the flow of the Don under the influence of anthropogenic (due to the increase of irrecoverable water losses in agriculture, industry, municipal water supply) and climatic factors. As a result, we can expect a decrease in the water content of floodplain landscapes and their further transformation under the influence of anthropogenic factors [1].

The decrease in the spring part of the runoff in the present and future leads to a decrease in the role of flood elements in the formation of floodplain landscapes: surface flooding and sediments of the solid phase by water spills.

In the lower reaches, the valley of the Don is represented by five terraced levels: modern Holocene and four floodplain terraces composed of quaternary loess sediments. Floodplain terrace within the study area also has a step structure. There are four floodplain levels: three, four, five and six-meter marks at the absolute height. Floodplain vegetation is represented at low levels by cereal and forb-grass associations with dominance of bluegrass (Poa) and awnless campfire (Brōmus inèrмis)
At the highest flood level there is a wormwood association with a mixture of steppe species, which indicate the process of vegetation steppe formation. Currently, after rare floods, the vegetation increases area hygrophilous associations. Bonfire and bluegrass are supplanted by wheat grass. In relief depressions, in former channels and oxbows, wetland plants (reeds and cane) are developing. As a result of the regulation, the productivity of the meadow hayfields has decreased greatly (from 15-20 to 5-8 kg/ha).

2. Methods and materials
The objects of study are hydromorphic soils and wetlands of the Nizhny Don valley. The main methods of research are comparative-geographical, comparative-analytical, soil-archaeological, as well as mapping wetlands with the involvement of remote sensing. To characterize the composition and properties of soils, a complex of conventional agrophysical, chemical, physico-chemical, granulometric, structural, mineralogical analyses was used.

3. Results and discussion
The study of the soils of the floodplain of the Nizhny Don was carried out by B.P. Polynov, V.N. Budko, G.V. Dobrovolsky, et al. Soil formation in the studied area of the floodplain develops in two main directions, determining the formation of soils of meadow and meadow-steppe series. The meadow series include alluvial meadow-dark-colored and wet-meadow dark-colored soils. Also, silt is widespread in marsh soils.

These soils develop at low floodplain levels, on clay sediments under cover of cereal and grass-cereal vegetation with a ground water level of no more than 3.0-3.5 m [2, 3].

These types of soils are characterized by low or medium humus content, high absorption capacity, with a wide variety of soil absorbing complex. The most common saline to the difference in area is divided into the fall. Salinization of soils makes them sulphatic with the content of salts to 1.0-2.058.

The soils of the meadow-steppe series are represented by meadow-chernozem and meadow-chernozem solonetzic soils in a complex with solonetzic-saline soils, formed in microdepressions 5-15 cm deep. This type of soil develops based on sediments of the lightweight granulometric composition with the groundwater level above 3.0-3.5 m.

Studies have shown that meadow-chernozem solonetzes in their properties are largely similar to saline solonetzes. The main differences between them are the absence of the upper part of the humus horizon and their higher salinity. Soils are characterized by a low content of organic matter, low absorption capacity. The composition of the soil absorbing complex of meadow-chernozem solonetzes and salt marshes is often by more than 50% saturated with sodium (Na). These soils, especially saline soils, are characterized by a high salt content, reaching 1.0-1.5% [2, 3].

Excessive grazing pressure on some parts of the floodplain has led to the destruction of vegetation and soil erosion. The area of eroded areas, such as cattle tracks on some saline and waterlogged soils, reaches 10-16 %.

In eroded soils there is a decrease in the humus content, accumulation in some cases of easily soluble salts and the entry of sodium into the soil absorbing complex.

Similar soil changes occur in the course of haphazard passage of vehicles. As a result of the development of secondary processes, meadow-black soil solonetzes under the trails and roads transform into salt marshes. As studies have shown, natural salt marshes are similar in their properties to salt marshes-salt marshes under paths and roads.

Based on studies of the biological cycle of salinization of meadow soils, a number of assumptions can be made. Formation of natural salt marshes-salt marshes of the studied territory proceeded in a way similar to salt marshes-salt marshes located under paths and roads. The process of formation of salt marshes is associated with changes in their surface, especially with the destruction of vegetation of floodplain soils [4].
At the same time, on some other soils, such as meadow and chernozem, etc., violation of the surface, in particular laying of tracks and roads, does not lead to the significant changes in properties of soils.

To study the effect of erosion on the properties and regimes of floodplain soils in the field, an experiment was conducted. During the experiment on experimental plots, herbicides were introduced to the undisturbed soil surface according to the main soil differences of the floodplain. The result was the destruction of natural vegetation [5]

As shown by the results of observations, the lack of vegetation shading the surface of the soil increases their warming on summer days by 10-20°C. In the meadow, the dark-colored saline soils and meadow-chernozem solodized solonetzes wave capture additional heat in the capillary fringe. There is an increase in evaporation of groundwater, resulting in an increase in the amount of water-soluble salts in these soils. As a result of secondary salinization, strongly saline meadow-chernozem solonetzes soils turned into saline solonetzes soils, and meadow-dark-colored soils; medium-saline turned to strongly saline [5, 6].

In meadow-chernozem and meadow-dark-colored fused soils, additional heat does not reach the capillary rim, so secondary salinization did not occur.

In the first years of the experiment, the number of salts in the secondary salted solonetzic soils without vegetation had considerable hesitations, and in the damp years they approached sizes which are characteristic of control specimens of soils. Further flushing of salts has become more difficult, which was determined by the development of other secondary soil processes.

Due to the mineralization of organic matter and the impact of deflation in dry years, the destruction of soil aggregates of the upper horizons occurred. The surface of the plots without vegetation deepened by 11 cm. The products of destruction were partially carried by wind processes outside the experimental sites. A part of the silt fraction with amorphous iron oxides and humus substances in wet years was washed out together with salts down the profile, and they deposited in the illuvial horizon, filling the pores. The predominance of soda in the composition of secondary accumulating salts, as well as the increase in the content of mobile organic matter, contributed to the increase in the mobility of the silt fraction.

Thus, the strengthening of the saline process occurs in wet periods. The illuvial horizon is enriched with silt particles. As the amount of illuminated matter in the horizon "B" increases, voids, especially pores, become more and more clogged, which worsens the possibility of soil washing from water-soluble salts.

In the horizon "B" the pores of the natural solonetz-saline are almost completely filled with illuminated clay, which determines its negative water-physical properties. However, strengthening of solonetzic process happens against the background of a rather stable high level of ground waters. This factor defines the evaporative water mode and accumulation of salts in a soil profile. And deterioration in conditions of the descending substance migration happens in stabilization of secondary salinization. Thus, the solonetzic process leads to strengthening of the saline process and to formation of difficult reclaimed soil differences in a flood plain of the Nizhny Don.

 Destruction of vegetation on meadow-dark-colored merged and meadow-black-earth soils did not cause secondary salinization. On the contrary, salt reserves in meadow-chernozem soils without vegetation decreased slightly. There were no significant changes in the structure of soils and their properties. On lightweight meadow-chernozem soils, the particle size and the absence of sodium in the soil absorption complex consisting of soluble salts have not led to the displacement of the clay fraction and the formation of the relevant secondary properties of soils. On meadow-dark-colored fused soils, the clay granulometric composition and deep occurrence of the groundwater level proved to be an obstacle to changing the properties [5, 6].

The absence of significant adverse properties of vegetation-deprived meadow-chernozem and meadow-dark-colored merged soils affected the possibility of rapid vegetation renewal on them (after 4-5 years). The emergence of higher vegetation led to a rapid recovery of humus reserves and humus composition. On the contrary, on meadow-chernozem solonetzes and meadow-dark-colored saline soils,
due to a number of unfavorable initial properties and the acquisition of new ones, the overgrowth of plots did not occur, and the soils remained not overgrown for 8 years.

The results of the study of soil properties under the trails and dirt roads, as well as field experiment data, allow us to identify two main groups of floodplain soils. The impact of erosion on the first group of soils, which includes meadow-chernozem solonetzes and meadow-dark-colored saline soils, leads to the development of irreversible changes in their properties, so that they move to other classification units.

In the second group of soils, which include meadow-dark-colored fused and meadow-black soils, anthropogenic erosion causes reversible changes, which quickly, within 2-3 years, leveled to the original state after the resumption of vegetation, although the composition of the emerging phytocenosis is actually different from the indigenous one.

4. Conclusion
Allocation of groups of floodplain soils by their resistance to anthropogenic erosion allows developing measures for their rational use. In the area of distribution of the group of soils resistant to anthropogenic erosion, which includes meadow-dark-colored fused and other soils, it is possible to carry out grazing, mowing and construction of irrigation systems. In order to increase the productivity of floodplain lands for animal husbandry, the establishment of cultural pastures should be recommended. The construction of rice irrigation systems requires a well-developed drainage network, which will eliminate the rise of groundwater levels above the critical one.

For a group of soils unstable to anthropogenic erosion and sensitive to vegetation destruction, grazing should be strictly regulated. Given that there is a high probability of adverse changes in the soil, it is advisable to mow and organize cultural pastures, where by means of irrigation, fertilization and using other measures one can achieve dense vegetation and strong turf. When creating cultural pastures on the soils of this group, it is necessary to carry out a set of measures to reduce the level of groundwater, as well as its chemical melioration. For this purpose, a number of meliorants can be used: sulfuric acid, sulfuric acid waste, phosphogypsum, gypsum, organic waste, etc.

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