Features of soils in the floodplain landscapes of Siberian Rivers

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Abstract. This paper examines the role of soils in floodplain landscapes of Siberian Rivers. Floodplain landscapes are very specific objects in terms of variability and stability. Their structure is constantly changing under the influence of external factors. The processes of formation of floodplain soils are described. The deposition of alluvium plays an important role in the development of soil-forming process of the floodplain. Formed by alluvial sediments, the floodplain soils are periodically replenished with elements of plant nutrients that cause an increased and sustainable fertility of floodplain soils. The main role in the formation of soils in the floodplain landscapes of Siberian Rivers belongs to the sod soil-forming process. It takes place when there is a strong grass, sod forming, and relatively deep groundwater. It is confined mainly to the riverside floodplain and high hills of the central floodplain. The structure of the soil cover of the floodplain of rivers is analysed and mapped. The following types of alluvial soils have become widespread: sod stratified, sod, sod-gley (meadow soils), silty-gley, peatgley and peat. The characteristics of these types of soils are given.

1. Introduction

The soil is “a mirror of the landscape” because it is “the result, the function of total mutual activity of these agents - soil-formers: the climate of the area, its plants and animals, the relief and the age of the country or its absolute height, finally, the substrate (i.e., ground parent rocks). Like any natural body, the soil has its past, its life and genesis” [1, p. 16].

The soil cover of floodplain has an extremely high level of dynamism. It manifests itself in a significant seasonal and annual variability of water-physical, physical-chemical and chemical properties of floodplain soils, as well as diversity of floodplain soil [2]. The soil is a non-equilibrium, highly dynamic bio-inert system, rich in free energy [3].

The special conditions of the development are inherent for the floodplain soil, relating with the periodicity of the flood of the floodplain and, therefore, with the break in the forming of soil, as well as with the annual deposition on the floodplain of the alluvial deposit that are contribute to the constant rejuvenation of the soils. The most powerful influence of the long river spill and of annual deposition of alluvial sediments has an inhibiting influence on the soil-forming process. For the floodplain soils are typical next processes: intense waterlogging in spring and summer and by more or less significant drying in the summer-autumn period. The seasonal dynamics of redox processes in floodplain soils occurs under the influence of periodic excess of moisture with a predominance of the oxidation in the period of the autumn low water, and with reduction of the oxidation during spring and summer [4].

2. Formation of soils in the floodplain landscapes of Siberian Rivers

The main role in the formation of soils in the floodplain landscapes of Siberian Rivers belongs to the sod soil-forming process. It takes place when there is a strong grass, sod forming, and relatively deep groundwater. It is confined mainly to the riverside floodplain and high hills of the central floodplain. The intensity of the sod soil formation depends on the amount of annually dying off organic matter and on the rate of its mineralization. Soils of high levels of floodplain are filled with the flood waters not every year, and their period of flood is shorter than those of the soils of low levels of floodplain. Therefore, high level floodplain soils are under the impact of zonal conditions more than soils of low floodplain. It leads to that, on the sod process on high elements of the topography of a floodplain is imposed the zonal podzol process.

In the case the level of groundwater is shallow, along with the sod process a gley soil-forming process also occurs. Finally, in the case of standing water on the surface at a consistently high level of groundwater the peat-bog soil-forming process occurs, which is typical for the lowlands of central and near-terrace floodplains (figure 1).

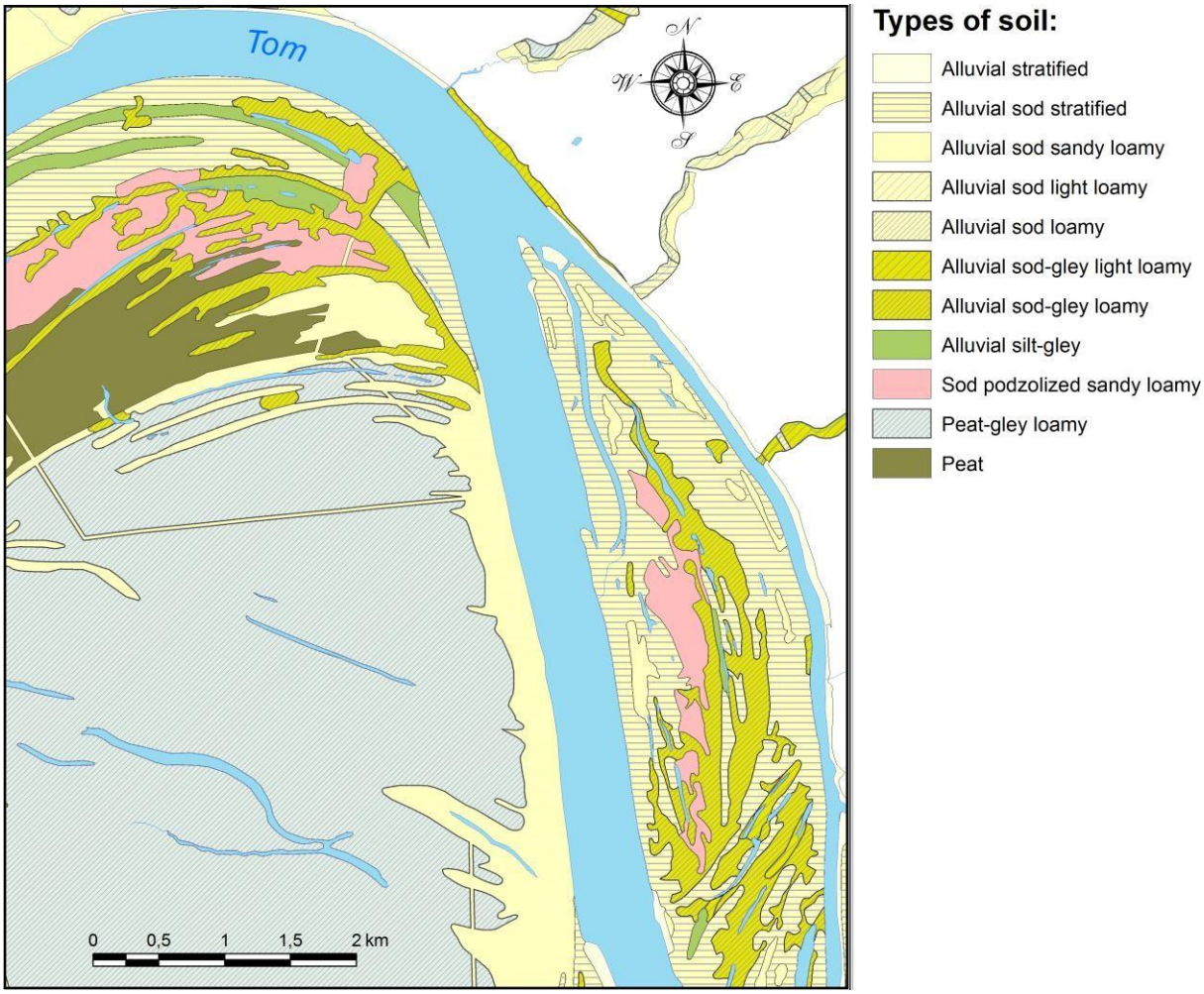

Figure 1. The typical structure of the floodplain soil cover in Western Siberia (fragment of soil map of Tom river valley).

The deposition of alluvium plays an important role in the development of soil-forming process of the floodplain. Formed by alluvial sediments, the floodplain soils are periodically replenished with elements of plant nutrients that cause an increased and sustainable fertility of floodplain soils. During the flood, the surface of the soil is enriched by the silt sediments, which are contributing to soil

nutrients, mainly phosphorus and potassium. The deposition of alluvium has a great influence on the processes of forming of humus, and promotes the formation of soil structure. Due to the long height and duration of inundation of the floodplain and the flood sedimentation, the forming floodplain soils are enriched with calcium carbonate, compounds of phosphorus, potassium, nitrogen, iron, manganese and secondary minerals: kaolinite, hydromicas, montmorillonite, brought from the river basin. During the floods the floodplain is also fed by organic matter, the content of which can be (in terms of humus) from 1 to 5%. There are especially a lot of humus (10-12%) in clay-silty sediments of wetlands, lakes, shallows. All this is the basis for the formation of fertile soils of the floodplain, with high economic value [2].

The process of soil formation begins after the riverside is liberated from the low-water level. It recycles only a thin surface crust of fresh alluvial deposits. A new deposit is forming on the surface of the low shafts that are covered by the flood water annually, so that shafts grow up. Processes of soil formation do not have time to convert the entire thickness of the sediment, so primitive stratified soils are forming. In years of low floods the soil formation can change the entire layer of sediments from previous floods on medium-high and high shafts, which are not flooded annually. So sod-stratified soils are forming.

It should be noted that anthropogenic factors can be imposed on processes of natural dynamics of soils. For example, the Tom River in the last 100 years encountered significant anthropogenic modification of the floodplain ecosystems. The key factors of anthropogenic modification of the ecosystems are industrial and agricultural activities, as well as the expansion of residential areas, construction of transport routes and extensive mining of sand and gravel in riverbed [5]. Now most of all ecosystems within Tomsk neighbourhood are subjected to the anthropogenic modification in some degree or other. Here the vector of the soil formation is directed to the strong draining in consequence of decrease of the underground water level because of overlaid anthropogenic factors [6].

3. The structure of the soil cover of the floodplain

The soil cover of the floodplain is dynamic in time and is complex in structure. In the floodplains of Siberian rivers, the following types of alluvial soils have become widespread: sod stratified, sod, sodgley (meadow soils), silty-gley, peat-gley and peat (figure 1).

Alluvial sod stratified soils are divided into two subtypes: alluvial primitive stratified and sod stratified. Alluvial primitive stratified soils are distributed in the riverside floodplain (figure 2). These are the youngest soils developing under the conditions of an intensive manifestation of the alluvial process. As a rule, in primitive stratified soils, sand layers alternate with low-power loamy and clayey deposits. At the distance from the riverbed, their thickness increases. These soils are found under willow forests, in the absence of grass cover. Alluvial sod stratified soils are distributed under willow forests, shrubs and under the cover of meadows in the riverside floodplain, and also in the transitional part from the river bed to the central floodplain, where the alluvial process is weakened and the initial stage of sod process begins. The thickness of the sod horizon is 5-13 cm, and the humus content in it does not exceed 3-4% [7].

Alluvial sod soils are formed on elevated and flat areas of the central floodplain. This soils are characterized by a significant weakening of the alluvial process and active development of the sod. Sod soils develop under the cover of grassy meadows on alluvium of different mechanical composition and have a profile well-differenced on genetic horizons with a distinctly expressed granular or lumpy granular structure. The thickness of the soil profile is 80-130 cm.

Large areas are occupied by alluvial sod-gley soils, confined to flat areas, along hills and shallow intergrass depressions of the central floodplain. In these soils, sod and gley processes simultaneously are combined. Alluvial sod-gley soils develop mainly on loam and sandy loam under moist forests of the central floodplain, as well as under sedge and swampy meadow grasslands.

Figure 2. The riverside floodplain of Tom river.

These soils are under conditions of prolonged moistening. The signs of gleying in the form of bluish spots are usually present already from the surface. The thickness of the humus horizon changes from 12 to 28 cm [8]. Alluvial silty-gley soils are confined mainly to the central floodplain and take deep depressions on the periphery of the oxbows and the ducts under the willow thickets and sedge meadows. The profile of alluvial silty-gley soils is represented by a soggy silty mass strongly saturated with water, not dissected into horizons. These soils are characterized by heavy clay mechanical composition.

Alluvial peat-gley soils form in the depressions of the central floodplain under moist forest and shrubby vegetation. In these soils, peaty horiizon consists of poorly decomposed plant remains of brown color up to 50 cm thick. A ferruginated and gleyed horizon of heavy mechanical composition is distinguished under the peat layer.

Peat bogs are ubiquitous to the floodplain areas near terraces and can also exploit flat depressions of the central floodplain under the cover of willow-birch shrubs and sedge bogs. The peat deposits reach a thickness of 2 m and more and is divided into several horizons according to the degree of decomposition, enrichment of the corms and dead plant remains. The degree of decomposition of peat, as a rule, increases down the profile.

4. The role of soils in the floodplain landscapes of Siberian Rivers

A distinctive feature of the soil generally is in the fact that it has properties and processes of both biotic and abiotic factors. This is link between biotic and abiotic components, substance and energy exchange between them goes through the soil.

The soil where the processes of infiltration and transformation of the precipitation into underground and surface runoff occur, exert great influence on the formation of runoff and the water balance in general. The soil cover, serving the intermediary between the climate and the river, transforms meteorological phenomena into a hydrological one. Hydrological value of soil cover is

mainly determined by water permeability (infiltration ability), and water-holding capacity of the soil, on which the size of the surface runoff, evaporation and groundwater recharge depend on. Soils have different permeability and moisture capacity, depending not only on the natural properties, but also on human impacts (plowing and cultivation). Sandy soils having high permeability can usually almost completely absorb the precipitation of any intensity, and therefore, the surface runoff plays a subordinate role in relation to the underground runoff.

Soil acts as a liaison between the plant community and external systems and in relation to phytocenosis [9]. The influence of soil conditions on the dynamics of vegetation is manifested in the variation of the reserves of productive soil moisture, their temperature and nutrient content. In different years, optimal for the absorption of moisture and nutrient conditions are formed at different depths. Phytocoenosis responds to the heterogeneity of water-physical and agrochemical properties of horizons of soils on the selection of ecologically and biologically different plant species and their natural placement on the territory.

Reserves of productive moisture in the soil are an integral characteristic of the hydrological regime of the habitat (flood, weather, and groundwater levels) and acts as the main control factor of the floodplain landscape, defining the change of the biomass and transformation of the structure of ecosystem. "For floodplain lands, soil moisture and its change during the warm period and of the whole year, eventually determines the ecological and resource potential of floodplain" [10, p. 46].

Soils in the floodplain landscapes of Siberian Rivers, peculiar group of hydromorphic soils, are different from many others soils in that they are constantly growing up. The increased dynamics of soil-formation in the direction from the watershed to the floodplain is also reflected in the increase in the intensity of the biological cycle of substances, reducing the content of many mobile elements in soils, in the strengthening of the morphologically pronounced accumulations in the form of humus, iron-humus and mineralized horizons [11]. Also layering, buried humus horizons and mosaicity are inherent for the floodplain soils.

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