Analysis of Impact of Urbanization Development on the Deterioration of Ecological State of Rivers

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Abstract. The peculiarity of small rivers is the dependence of erosion-accumulative processes in their beds on the intensity of soil erosion in the catchment area: the smaller the river, the greater the contact with the catchment area of its channel, where mineral particles, washed off from its area, directly enter it. Soil erosion leads to the entry of an excessive amount of them into the channel of a small river, as a result of which sediment accumulation begins in it, siltation of the channel occurs. It leads to changes in the water regime of small rivers - a decrease in inter-soil runoff (up to the drying up of rivers), a sharp reduction in underground power supply. In the humid zone, due to the high water content, the siltation of small rivers is poorly expressed and has a local character. Siltation of small rivers is especially characteristic for the forest-steppe and steppe zones, as well as for the south of the forest zone. In the steppe zone of the European part of Russia, as a result of siltation, rivers of the first order completely disappeared, up to the fourth (up to 40-50 km long), leading to a total reduction of the river network by up to 30 %. In the humid zone, due to the disappearance of sources, the number of rivers of the first and second orders (up to 20 km long) decreased by 2.2 times. During the agricultural period (about 300 years), a layer of sediment with a thickness of 0.5 to 1 m accumulated in the beds and floodplains of small rivers in the southern half of the European part. The erosion of small riverbeds reaches on average only 20 % of washed off products, which is about 60 % of the total river sediment runoff. The rate of siltation of small rivers in the Don basin is 6-12 mm / year with a length of up to 25 km and about 1 mm/year with a length of 100 km and above. Siltation of small rivers is not typical for regions where the soil is washed away by meltwater, since the maximum flow of sediment into the rivers coincides with high water, when the channel-forming activity of water flows is most active.

1. Introduction

The main factor in the disappearance of small rivers is the change in their water regime. The siltation of rivers is facilitated by aquatic vegetation, which is caused by the eutrophication of rivers. Soil erosion is accompanied by the removal of dissolved chemicals into rivers, including fertilizers applied to plowed lands. Water vegetation changes the hydraulic characteristics of the flow (speed, roughness of the channel), as a result of which its transporting capacity decreases. The accumulation of silt on the near-sea shallows, enriched with biogenic elements, favors their overgrowth [1].

In regions where the main factor of soil erosion is rain precipitation, the greatest runoff and removal of mineral and chemical substances into rivers is carried out in the lowlands. Due to the low flow rates and limited water exchange between the millponds, the latter are silted up first of all, their coastal parts...
are covered with aquatic vegetation [2].

The overgrowth of the riverbed sandbanks contributes to the accumulation of sediments in all phases of the water regime, which is the beginning of complete siltation of rivers. The small river first splits into a system of deep pools, which are the remnants of millpond depressions, and then turns into an elongated swampy depression. In the forest zone, siltation of small rivers is often associated with molar wood rafting. Tree trunks get stuck on rifts, shoals, on bends and form creases that sharply reduce the carrying capacity of the channels. Creases, performing the functions of dams, lead to flooding and waterlogging of floodplains [3], increase sediment accumulation. Siltation of small rivers significantly worsens the water supply of regions, leads to the expansion of swampy areas that are unsuitable for use, reduces or eliminates the recreational qualities of rivers.

2. Materials and methods
On small and most of the medium-sized rivers, the channel process against the background of an excess of incoming sediments proceeds in violation of the classical scheme, which is expressed in the development of meanders, the formation of sidewalls, millponds and rifts. The movement of these channel forms is traced very poorly, or not at all [4].

In the floodplains of the rivers Sal, Tuzlov, there are old trees as evidence of the sliding of bends, the formation of washouts between the tops of bends, etc. But these processes took place when the vegetation had not yet fixed the riverbed, and the old trees are the former relict beds. Geologists believe that floodplain deposits belong to the Pre-Holocene epoch on many rivers from the edge of the shore to the foot of the slopes of the valleys. It allows us to assume that the channels of small rivers have been located for thousands of years at the place where they were formed [5].

In the conditions of small rivers, the change in the regime of formation of liquid and solid runoff was manifested in the form of a decrease in water flow and an increase in its turbidity. The main type of deformation of the riverbed is its siltation [6].

The deformation of banks of small rivers occurs only as a result of any human activity (loss or reduction of vegetation, bypassing the flow of earthen dams that have stood in the channel, etc.). There are also cases of sliding of soil masses of the steep banks under the influence of large gradients of the filter flow, which occur when the channel loses its drainage ability due to siltation [7].

The mechanical essence of channel processes in the most general form can be characterized as the interaction between the velocity structure of the channel flow and its boundary surface-the channel [8] defines this interaction as the process of displaying the features of water movement and sediments moved by it by the surface of a solid medium [9, 10]. The flow in a potentially eroded channel changes the shape of the boundary surface; the new shape of the channel creates a new velocity field inherent in it; there is an endless process of mutual correction of the channel by the flow and the flow by the channel. This process manifests itself in the form of channel deformations: erosion or deposition of erosion products connected by sediment transportation. In a dynamically balanced channel, this transport is carried out by equally large washouts and deposits. The predominance of siltation processes in the beds of small steppe rivers leads to complete degradation of the riverbed, i.e. to its extinction.

Consequences of degradation of small rivers [11]:
- reduction of water flow in rivers;
- changing the flow capacity of the riverbed;
- loss of productivity of floodplain massifs;
- reduction or loss of cleaning processes of the river flow;
- deterioration of water quality;
- suppression and oppression of beneficial biocenoses;
- loss of fishery significance;
- loss of recreational value.

The water flow regime plays a crucial role in the functioning of all components of the river ecosystem. The levels, flow rates, processes in the riverbed and on the floodplain, the processes of self-purification of water, the life of phyto- and zoobiocenoses depend on it [12, 13]. When restoring
reservoirs, the main goal of regulating water consumption is to improve the condition of the riverbed, it is what allows preventing the degradation of the river and reducing its productivity. The second task of regulating water consumption should be considered the rational use of water resources [14].

The main means of regulating water consumption are reservoirs. The leading factors in choosing the location of the reservoir are: a) compliance of the flow with the tasks of regulating the river in the present site; b) satisfactory conditions for creating a reservoir (topography, geology, residential areas, etc.).

Specific regulatory tasks are defined for each object, in particular:
- providing flow velocities for flushing the riverbed from silty sediments covering outcrops in the channel of permeable soils [15];
- ensuring environmental and sanitary flow in the riverbed;
- improvement of landscape and recreational value in the riverbed;
- improvement of the landscape and recreational value of the river;
- flood control;
- special passes to ensure the regulation of water flow in the rivers of the highest order;
- rational use of water resources;
- water-charging flooding of productive floodplain massifs [16].

When clearing small rivers in the areas of their passage through the territories of settlements and cities, it is most effective to use dredgers with containers made of high-strength geotextile materials in the form of long cylindrical shells. It allows the work to be carried out without causing damage to the coastal territories. The pulp from the dredger is fed directly into the geotextile container via a flexible pipeline, which allows preventing the ingress of bottom sediments to nearby shores. The feed rate of the slurry pulp into the container is about 400 m$^3$/h. The volume of the container with a length of 100 m is designed for 625 m$^3$-4690 m$^3$ of pulp. Over time, the water leaves the container, and the solid fractions remain. Dehydrated containers made of high-strength polypropylene are convenient for loading, transportation and storage, and their burial is also possible. It is enough to have 120-130 such containers for a pulp volume of 500 thousand m$^3$ [17].

Containers are made of high-strength, durable in soil conditions technical fabrics by stitching on industrial sewing equipment or by thermal welding according to special technical regulations. The material is selected taking into account its resistance to the effects of salt water, aggressive environments, ultraviolet radiation, multiple cycles of freezing and thawing; it must also have high physical and mechanical characteristics. When building a specific object, it is necessary to take into account the most popular qualities of materials that are required at this object. Geotextile containers differ in shape, geometric dimensions and filling volume depending on the place and conditions of their use [18].

Geotextile containers used in Russia are made of woven material Geolon, the manufacturer of which is the Dutch company Ten Cate Nicolon. Geolon is made of strips (tares) of polypropylene (Geolon PP) or multi-thread polyester (Geolon PE) [19]. Geotextile performs a number of functions – reinforcement and strengthening, soil separation, stabilization, and therefore the distribution of local loads, preventing the leaching of soil particles. The filtration properties of the domestic TLF-5-2 filter cloth for use as containers for bottom sediments dewatering were evaluated in comparison with the imported Geolon PP80 fabric (Ten Cate, Holland) used for these purposes [20].

For this purpose, laboratory studies were conducted (Figure 1). Samples of containers were made from these fabrics according to the method of similarity from natural size on a scale of 1:5 with following dimensions: width 40 cm, height 50 cm.
The experimental containers were filled with silty bottom sediments (pulp of consistency 1:6) with a volume of 30 liters and mounted on a tripod. In order to determine the chemical composition of the filtrate, a pallet for collecting it was installed under each container. During the experiment, the height of the sediment, the volume of water flowing out and the air temperature were measured in dynamics [21].

The main tasks of regulating the flow and channel processes during the restoration of small rivers are [22]:
1) elimination of the consequences of degradation of rivers and reservoirs – their siltation or erosion;
2) reduction of the flow load by sediments;
3) prevention of secondary siltation of riverbeds, reducing the intensity of siltation of ponds and reservoirs;
4) formation of stable regimes (stabilization of the riverbed process) for economic use.

These tasks are solved by reclamation measures "Regulation of the alluvial regime" and "Regulation of morphometric parameters" [23].

Regulation of the alluvial regime of rivers and reservoirs is carried out by accumulation, removal, redistribution of sediments. The complexity of solving such problems is that it is necessary to focus not only on the current state of rivers and reservoirs, but also to take into account the prospect of using these water bodies during and after restoration.

The regulation of the alluvial regime and morphometric parameters can be attributed to the measures of purely technical land reclamation, since only technical units are used for their implementation [24].

As mentioned above, the methods of regulating the alluvial regime include accumulation, removal, and redistribution of sediments. But, according to the conditions of their application and the nature of the means of influence, as well as the reaction of aquatic environment to these means, a wide variety of options arise (as evidenced by the experience of operating regulated sections of rivers, water intake waterworks, engineering communications, etc.) [25, 26, 27].

Accumulation of excess sediments in the riverbed, especially silty and clay particles (they account for up to 90% of suspended sediment), can be considered as a temporary measure to protect the downstream section of the river before finding out and eliminating the true cause of the flow overload with sediments.

3. Conclusion
Russia has accumulated sufficient experience in carrying out works on clearing and dredging of small rivers by means of hydro-mechanization with the implementation of a complex of water protection measures aimed at improving the water regime and the ecological situation of the water body as a whole.
The clearing of small rivers by means of hydro-mechanization is associated with natural difficulties – mainly bottom sediments, represented by heavy soils, overgrown with aquatic vegetation and reeds.

The channels of small rivers are cleared simultaneously with the implementation of a complex of water protection measures in the coastal strip, which significantly improves the water regime and ecology of small rivers. An increase in the width and depth of the riverbed contributes to the opening of springs and an increase in the inflow of clean water. Along with the water management and environmental significance, the cleaning and restoration of small rivers in Russia have a great social aspect: clean rivers with "living" water are the physical and moral health of the nation.

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