Reducing the Anthropogenic Impact of Natural Risks on Small Rivers in the South of Russia

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Abstract. The rapid development of society, increase in the population, land urbanization, growth of human economic activity contribute to the involvement in economic turnover of an increasing number of natural resources, the main part of which is water. Along with the depletion of water bodies, their pollution is also intensively occurring. The analysis of ecological state of basins of small rivers in the South of Russia shows a constant increase in the emission of pollutants into their channels. On the territory of Rostov region there are 5,572 rivers with a total length of 36,064 km. 90 % of rivers of Rostov region are less than 10 km long. On average, a local runoff in the amount of 3.36 billion m³ is formed on the territory of Rostov region per year. Increased anthropogenic activity leads to the disruption of functioning and stability of natural systems, which has a significant impact on small rivers, which are the most common elements of the hydrographic network. About 30 % of urban and about 90 % of rural population live in catchments of small rivers, while the greatest density is observed in the immediate vicinity of water banks. Small rivers significantly affect the hydrological, biological and biochemical regime of landscapes, maintaining the balance and redistribution of moisture and are important for water supply of the population.

1. Introduction
Over the past 200 years there has been revealed a reduction in the length of the river network from 35 % to 59 %, a significant deterioration in water quality and the accumulation of sediments of anthropogenic origin, which prevents the natural course of restoration of small rivers. The technogenic silt deposited in channels changes the water quality, leads to a violation of the biological balance, suppression of self-purification of the reservoir, and changes in the ecosystem. The cleaning of small rivers from bottom sediments is made by the need to restore silted and dying riverbeds, since it is associated with ensuring the environmental safety of population and preserving clean water sources for future generation [1]. In addition, the reclamation of small rivers reduces the threat of flooding of territories and the destruction of dams, dikes and other hydraulic structures. Contradictions in the relationship between society and nature in the second half of the XX century became threatening. A thorough analysis of causes of destruction of the ozone shield, acid rain, chemical and radioactive pollution of environment was required. As a biological species, man affects the natural environment with his vital activity, but this influence is incomparable with the huge impact that human labor has on nature [2].

In the process of increasing the number of urban settlements, the growth and development of cities takes place. This is a powerful environmental factor [3], accompanied by transformation of the landscape
IOP Conf. Series: Earth and Environmental Science 988 (2022) 042037  doi:10.1088/1755-1315/988/4/042037

[4], land and water resources [5], mass production of waste entering the atmosphere [6], water and terrestrial ecosystems [7]. The development of urban environment has posed a number of environmental problems, among which the most acute are: vulnerability of urban systems, migration and population concentration, poor quality of the habitat, loss of fertile land, waste disposal [8].

Consuming an extremely large amount of natural resources, a modern city produces a large amount of waste. For example, a city with a million inhabitants annually emits about 11 million tons of water vapor, 2 million tons of dust, 1.5 million tons of carbon dioxide, 0.25 million tons of sulfur dioxide, 0.3 million tons of nitrogen oxides into the atmosphere and produces an extremely large amount of industrial and household waste [9]. The larger the city, the further a person moves away from wildlife, the more difficult it is to solve the environmental problem generated by it.

In large cities of Russia, industrial waste accounts for 45 %; waste generated at water supply and sanitation treatment facilities – 31 %; solid household waste – 17 %; precipitation from storm water treatment facilities – 4.8 %; waste from the city's green economy – 2.17 %; radioactive waste – 0.03 % [10].

The accumulation of pollutants in small rivers in concentrations exceeding the maximum permissible concentrations worsens their sanitary and epidemiological condition, reduces water management potential, reduces the possibility of their use for economic and recreational purposes, changes the natural environment, leads to degradation of aquatic ecosystems, changes in the habitat and human health [11]. Assessing the state of small rivers on the basis of ecosystem analysis, it should be noted that at present most of them are ecologically defective, i.e. unable to perform the main function – to maintain the biological diversity and balance that has developed as a result of long-term evolution.

The human need for fresh water is met mainly from surface and underground sources, and here small rivers play a key role – they are the most important component of the hydrological network. Despite their size, small rivers form medium and large rivers, determining their hydrological, hydrochemical, biological and biochemical regimes, acting as a regulator of landscapes, maintaining balance and redistribution of moisture. But it is their ecological condition, especially in the European part of the country, as a result of sharply increased anthropogenic load on them, that is assessed as catastrophic. In some regions, due to uncontrolled water intake, many small rivers dry up and silt up. In Russia, many small rivers disappear every year [12]. They turn into beams (dry drains) without constant runoff or into chains of low-flow drying reservoirs.

2. Materials and methods

Agriculture of the Russian Federation and the land reclamation complex as its component are one of the largest consumers of water resources of small rivers. The agro-industrial complex consumes 24 % of total volume of water taken. The water intake is used for water supply of rural settlements, irrigation, encroachment, rice growing and development of pond fisheries. So, for such industries as agriculture, hunting and forestry, more than 18 km³/year of water is taken from water bodies. The main water consumer in the agro-industrial complex is the reclamation complex, which uses 8 km³/year for land irrigation. Reclamation lands occupy 7.9 % of total arable land area and provide about 15 % of gross production. They currently produce up to 70 % of vegetables, all rice, more than 20 % of coarse and juicy feed and other products [13].

Today, agricultural producers use 9.1 million hectares of reclaimed land, including 4.3 million hectares of irrigated and 4.8 million hectares of drained land. The main irrigated masses are located in the south of Russia, which is to a greater extent due to the increased load on small rivers in this region of the country [14].

Due to uncontrolled water intake from the basins of small rivers, and not only for agriculture, the problems of the water management complex are expressed in the south of the country, which will have to be solved in the coming years. The main ones are [15]:

- irrational use of water resources of small rivers;
- presence of a shortage of water resources of small rivers in certain regions;
- non-compliance of the quality of drinking water consumed by a significant part of population with hygienic standards, as well as a limited level of public access to centralized water supply systems. According to the parliamentary hearings "Ecology of small rivers of Russia: problems and ways to solve them", small rivers account for from 10 % to 85 % of the volume of river flow in different regions or 50 % on average in Russia [16].

The ecological state of small rivers in the South of Russia, located in the conditions of dense floodplain development, can be characterized by the example of environmental indicators of the Temernik River. Small rivers flowing in urban environment are more or less subject to anthropogenic influence. The main environmental problem for all small rivers is unfavorable situations, which are expressed, first of all, in the pollution of river basins with various waste products of economic activity, especially household and industrial wastewater [17].

In connection with the withdrawal of water for economic needs, the problem of quantitative depletions of water resources of small rivers is acute, especially in the southern regions. At the same time, small rivers are the initial link in the formation of the country's water resources, and the quantitative and qualitative state of medium and large rivers and reservoirs largely depends on their condition. Therefore, the trouble currently observed on large rivers and reservoirs in Russia is largely a consequence of state of small rivers [18].

Sections of small rivers located in the conditions of a natural and man-made landscape (catchment areas of industrial cities and rural settlements, intensive agricultural production) are more susceptible to pollution compared to areas located in an undisturbed landscape. The waste of production and consumption formed as a result of nature management and entering the terrain, being in a different aggregate state and having different degrees of danger, can cause adverse changes in the components of natural environment of the entire river [19].

Small rivers, being natural and natural-technogenic elements of landscape-geochemical systems, are the final link in the runoff accumulation of mobile technogenic substances. Most of the pollutants get into small rivers from sources of diffusive distribution of pollutants together with the products of water erosion caused by surface runoff. As practice shows, pollutants get into water bodies mainly with surface runoff, which makes up more than 50 % of their total water supply [20].

Some of pollutants get into small rivers with ground runoff, which makes up about 46 % of their total water supply. In urban conditions, groundwater is often polluted due to leaks from water and sewer networks, as well as filtrates coming from the strata of man-made rocks, unauthorized landfills and unorganized landfills for disposal of industrial and consumer waste.

Surface water pollution as a result of discharge of all types of untreated wastewater often leads to undesirable changes in the physical, chemical and biological properties of water in small rivers. Bacterial and radioactive contamination is also an urgent problem. Bacterial contamination of small rivers occurs mainly due to the discharge of untreated wastewater of various origins. Pathogenic microbes, including typhoid and cholera microbes remain viable in water for quite a long time [21].

Radioisotopes discharged from wastewater into rivers can accumulate in bottom sediments and various substrates of animal and plant origin, posing a threat to aquatic ecosystems. As practice shows, the accumulation of chemical pollutants in small rivers, including biogenic elements (nitrogen, phosphorus, silicon, iron, trace elements, etc.) actively provokes eutrophication processes and forms hydrochemical anomalies.

Various physico-chemical and biochemical processes take place in natural environment of rivers. They are conditionally divided into processes that contribute to purification of a water body (reducing the concentration of undesirable components), and processes that pollute or hinder the development of cleaning processes (increasing the content of harmful components) [22].

Polluting factors include the build-up of organic mass by aquatic plants due to eutrophication, bottom sediments, dead trees, garbage and other objects.

In some cases, a rather dangerous source of pollution of a water body is the focus of its secondary pollution, concentrated in bottom sediments.
All the elements of the geoecosystem of the river basin closely interact with each other, forming an integral self-regulating system in which the factors of external influences are "absorbed" by it and become components of this system. External sources can affect any element of the system, but once they get into it, they change the state of other elements as well [23]. All this forms a complex chain of cause-and-effect relationships. Thus, siltation of the riverbed causes a decrease in the drainage capacity of the riverbed; in turn, siltation is a consequence of violation of conditions for formation of solid runoff in the basin, hydrographic network, or violation of a level regime. The level regime can be disrupted by the construction of a dam in the riverbed or its overgrowth. In turn, vegetation in the riverbed may be a consequence of a decrease in the water content of the river, in particular, the drainage capacity of the riverbed. Therefore, the main task is to identify the specific causes of changes occurring in the river. This will allow us to determine the range of measures aimed at restoring the lost modes and states of the studied objects.

The catchment area of small rivers is a dynamic system with interrelated elements. Not prudent economic activity inevitably leads to the deterioration in the quality of water and the water body itself. The supply of organic, biogenic substances, pesticides and other components used in agriculture to surface waters increases, i.e. the biogeochemical situation of the formation of surface runoff changes. This flow also leads to a change in the flow characteristics, which indirectly affects the hydrological regime of water bodies, in most cases, worsening it [24].

The pollution of the catchment area of small rivers, and, consequently, the quality of surface water, is significantly affected by gas and smoke emissions from industrial enterprises: mineral particles, organic substances, compounds of ammonium, phosphorus, metals; nitrogen and sulfur oxides; radioactive substances. Pollutants eventually end up in the beds of small rivers and migrate in dissolved form or accumulate in bottom sediments [25].

Rainwater from residential areas belongs to a special category of pollutants [26]. The quality of storm sewage in cities, even with organized storm sewers, strongly depends on the types of economic activity on the territory. Suspended substances, petroleum products, metal compounds, nitrogen-and phosphorus-containing substances, organic matter and other ingredients are the most dangerous in rainwater runoff [27]. As a rule, rainwater from urbanized areas is discharged into small rivers without treatment. The bottom sediments formed in this case are particularly dangerous for hydrobiocenoses of water bodies. Almost all the ingredients received are included in the intra-water processes. The transformation products of "primary" pollutants are often more toxic than the substances contained in the composition of wastewater. The eutrophication of reservoirs is the consequence of it.

The amount of pollution entering small rivers as a result of economic activity far exceeds the permissible barrier beyond which self-purification processes in the riverbed are able to maintain a satisfactory state of natural waters (Figure 1).

![Image](https://example.com/image1.png)

**Figure 1.** Siltation of the riverbed of the Temernik River near the western residential area of the city of Rostov-on-Don, the total volume of bottom sediments in the riverbed is over 1.5 million m$^3$. 

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IOP Conf. Series: Earth and Environmental Science 988 (2022) 042037
doi:10.1088/1755-1315/988/4/042037
Along with the pollution of small rivers, there is cluttering, when unnecessary objects, waste from economic activities, household garbage, etc. are often thrown into the channels and on the floodplain. The influence of urban landfills on the quality of underground water extends within a radius of 3 – 5 km. Littering and cluttering of small rivers is typical for industrial regions, urban agglomerations and transport hubs. Here there is a massive pollution of rivers with construction and household garbage, sediments entering rivers from rain sewers, eutrophication of rivers as a result of sewage discharge, as well as mechanical change of riverbeds by artificial straightening and diverting, construction of engineering structures, complete elimination of rivers when they are taken into pipes.

Technologies of cleaning and restoring rivers have a developed and effective arsenal of measures and impacts. The basis of this arsenal consists of hydraulic structures, technologies of hydraulic engineering and hydraulic reclamation works.

3. Conclusion
To date, the most effective ways of cleaning small rivers are mechanical and hydro-mechanical. In order to develop a promising method for removing bottom sediments and recommendations for improving measures for cleaning and restoring the Temernik riverbed in modern environmental conditions of urbanized territories, we analyzed the technologies for performing these works. During the analysis, both advantages and disadvantages of considered methods of developing bottom sediments were shown.

The analysis allowed us to establish that the mechanized method of developing bottom sediments is easier to perform and more economical, but requires the use of heavy equipment and causes significant damage to coastal territories, which, in turn, makes it cumbersome. This method is almost impossible to implement in conditions of dense floodplain development. Due to the dense development of coastal areas, heavy equipment will not be able to drive up to the place of work or will drive up, destroying recreational areas, which will eventually cause environmental damage.

Taking into account the disadvantages of mechanized removal of bottom sediments, the development was based on a hydro-mechanized method, the advantages of which include, first of all, the mobility of a small-sized dredger. It is easy to deliver it to the riverbed at the place of work, without disturbing the coastal territories. The pulp pipeline from the dredger allows us to remove bottom sediments at the required distance from the riverbed in special settling tanks or platforms.

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