IDENTIFICATION OF POLLUTION SOURCES OF THE BÂC RIVER

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Abstract. Accessible and indispensible freshwater resources for ecosystems and humans represent only 0.26% of total freshwater resources and are found in lakes, reservoirs, and rivers (the rest being confined to glaciers, permanent snow, groundwater, and in the form of vapors). Unfortunately, water pollution is a phenomenon as undesirable as it is frequent and widespread, being for the most part the result of anthropogenic (human) activities. As a result of pollution, water can undergo both physical and chemical changes that can lead to the degradation or destruction of aquatic ecosystems and limit the possibilities of use for various socio-economic purposes. This paper presents a preliminary study on the quality assessment of one of the most important rivers in the Republic of Moldova - the Bâc River, which crosses the capital Chişinău. Bâc River has an extremely high degree of pollution, as a result of poor management of water resources and lack of measures to protect its quality. The aim of the paper is to identify the main sources of pollution of the Bâc River and to identify the impact generated by them on the studied watercourse and surroundings. The identification of the pollution sources was done step by step, through satellite observations, from the source to the discharge point, completed with field observations. The impact generated by the identified pollution sources was highlighted by applying the method of impact networks. Thus, taking into account the identified pollution sources, we made recommendations to eliminate/reduce pollution and implicitly its effects, by identifying practical solutions and prevention measures, and considering that these actions will ensure the protection of the aquatic ecosystem and the overall environment.

Keywords: Bâc River, water pollution, pollution sources

INTRODUCTION

The Bâc River basin (Figure 1) is part of the Dniester River basin, has a length of 155 km, an area of 2213.62 km^2, and is located right in the center of the Republic of Moldova, including its capital, Chişinău, and district centers Călărași, Strășeni, Ialoveni, and Anenii Noi (Boboc,, 2013). The studied river basin has the following geographical coordinates: 46° 46'- 47° 23' north latitude and 27° 58'- 29° 27' east longitude.
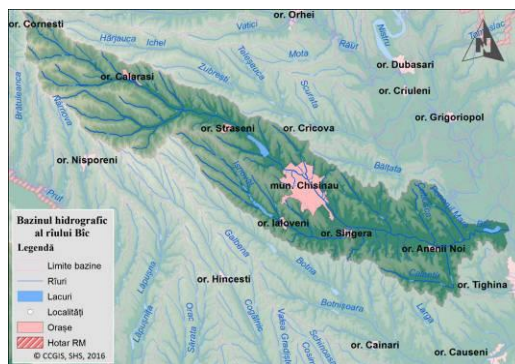

Fig. 1. The Bâc River basin (MINISTERUL MEDIULUI, 2015)

Water pollution is a widespread phenomenon in the Republic of Moldova due to inadequate management which leads to continuous deterioration of their quality.

The Bâc River suffers from an extremely high degree of pollution (COMISIA ECONOMICĂ PENTRU EUROPA, 2005). Researches (BULAT ET AL, 2018; BULAT, 2009; MUSTEA, 2013) have shown a radical worsening of the ecological status of Bâc River. The low transparency of the water, the deplorable organoleptic qualities (smell, color), and the total absence of fish species in the sectors downstream of the treatment plants in Chișinău and Călărași certainly indicate an ecological catastrophe of national proportions. The impossibility of self-purifying the water downstream from the Chișinău treatment plant makes it impossible for the fish to survive till the discharge into the Dniester River. A significant, but not sufficient, influence is the Ghidighici artificial lake, representing a source of enrichment of the lotic ichthyocenosis, as well as the presence of favorable habitats for many fish species in this area.

Domestic and industrial wastewaters represent a major source of surface and underground water pollution as most biological wastewater treatment plants no longer operate or do not work properly. As a result, the amount of untreated or insufficiently treated wastewater has increased sharply. Another major source of pollution is sewage leaks from the domestic sector, 70% of the residential space not being connected to the sewerage system (MUSTEA, 2013). To these are added other sources of pollution that have been identified in this paper.

MATERIAL AND METHODS

In order to identify the sources of pollution and their impact, we divided the course of the Bâc River into sectors delimited by the spring, the sampling/monitoring points of the water for analysis, and the mouth of the river (Figure 2.a-d).
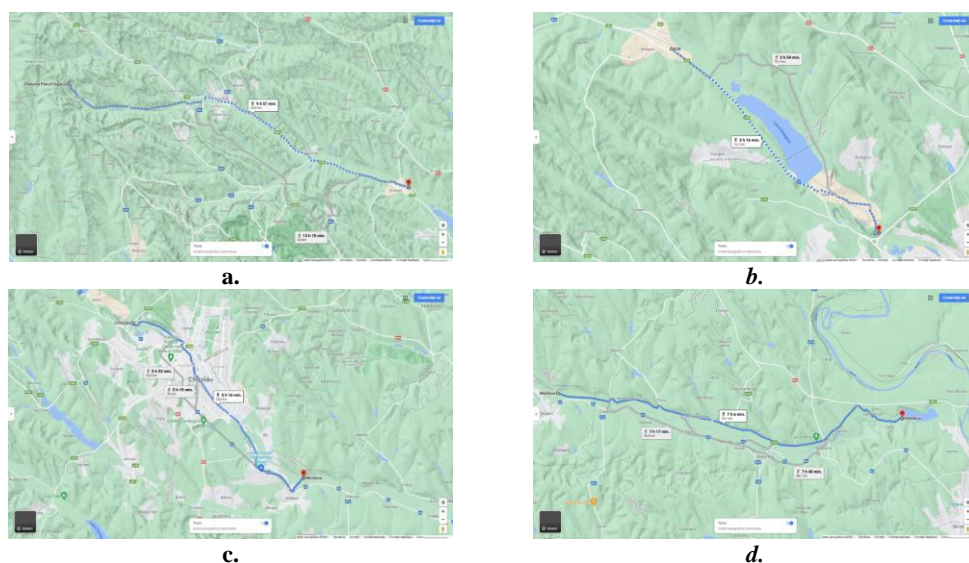

Fig. 2. Delimitation of sectors; a. Sector 1-2; b. Sector 2-3; c. Sector 3-4; d. Sector 4-5.

The first sector (sector 1-2) is delimited by the source of the Bâc River, located at the edge of the Natural Reservation "Pădurea Plaiul Fagului" near the Temeleuți village and the first water sampling point located downstream of the Strășeni city, after an industrial park. This interval is the longest, respectively one third of the total length of the Bâc River.

The second sector (sector 2-3), between the sampling points downstream of the Strășeni city and upstream of the Chișinău municipality, is the shortest interval. Along the river in this interval is the Ghidighici artificial lake. The Ghidighici lake volume reaches 40 million m^3, and the average length and width are 8.5 km, respectively 0.940 km.

The third sector (sector 3-4) has an average length and crosses Chișinău municipality. Due to this, most of the pollution sources are registered here, among which the Wastewater Treatment Plant from Chișinău municipality is listed, which discharges the wastewater, insufficiently treated, into the Bâc River.

The last sector (sector 4-5) is between the sampling point located downstream of Chișinău and the sampling point located where Bâc River discharges its water into the Dniester River, near the Gura Bâcului village. The quality of the water in this range suffers a lot due to the excessive pollution from the previous sectors, the concentrations of the compounds exceeding several times the maximum admissible concentrations.

Through satellite observations completed with observations made in the field, we identified the sources of pollution located on the Bâc River or with influence on it, from spring to the discharge point.

The impact generated by the identified sources was highlighted by applying the method of impact networks (LAZĂR AND DUMITRESCU, 2006; LAZĂR AND FAUR, 2011; MUNTEANU, 2011). Impact networks reconstruct chains of events, or potential effects, induced by specific project actions on the initial environmental conditions, potential changes in environmental conditions, multiple effects of the impact, and possible corrective interventions that may be proposed. Impact networks make it possible to highlight, more systematically than matrices, the primary and secondary effects, direct and indirect, the existence of multiple cause-effect relationships (CIOLEA AND DUMITRESCU, 2012; CIOLEA, 2012; FAUR ET AL., 2021).

RESULTS AND DISCUSSIONS
Sources of pollution identified along the Bâc River

Along the river, from spring to discharge point, there are local and national roads. The most intense traffic is in Chișinău; medium intensity traffic is between the Călărași and Anenii Noi cities, and reduced traffic from the source of the river, to the Călărași city and from Anenii Noi to the discharge point. Also, next to the river, there is a railway line, the train traffic being reduced.

Pollution sources identified in sector 1-2

Starting with the source of the river, up to the first sampling point downstream from the Strășeni city, the course of the river passes through 7 rural localities and 2 urban localities, and at least 8 tributaries flow into the river. The surface next to the river, outside the localities, consists, in particular, of agricultural lands, abandoned lands, orchards, and forested areas.

The villages in this part of the river basin have damaged sewerage systems and the treatment plants do not work. Wastewater, collected from local public institutions and from a part of the population that is connected to the aqueduct, is accumulated in septic tanks. Due to unsealed septic tanks, it is possible for residues to enter the soil, thus causing pollution of groundwater and surface water. Wastewater, resulting from the population that is not connected to the sewerage system, is discharged directly into the natural environment (MINISTERUL MEDIULUI, 2015).

In Călărași city, wastewater is received and discharged through the sewerage system at the treatment plant (Figure 3) which has a projected capacity of 1400 m3 / day, too small for the total volume of wastewater. Under these conditions, insufficiently treated waters result, and they end up being discharged into the Bâc River.

In Strășeni city, the water received by the sewerage system accumulates in a biological pond. From here, through a pumping station, a volume of 800 m³/day is discharged into the waters of the Bâc River.

In the Călărași and Strășeni districts, economic activities are carried out by 1216 economic units, of which 106 are industrial enterprises: food and drinks industry, light industry, farms, slaughterhouses, constructions, gas stations, service stations, industrial refrigerators, service providers, etc.

In this sector, 46 landfills were counted, some of them being located at short distances from the Bâc River or its tributaries. Most of them are built without projects and approvals. Unfortunately, the volumes of waste stored are not known, as there is no record of the transported waste, and in some cases, the transport is carried out individually by the inhabitants.

Pollution sources identified in sector 2-3

Within this sector, the river flows through only one locality - the Vatra city. On the first quarter of the length of the sector, around the river, there are agricultural lands and abandoned lands. In the next part, which is about half the length of the sector, the river flows into the Ghidighici reservoir, after which, from the reservoir dam, the Bâc River continues its course for the last quarter of the interval through the Vatra city. On this sector, the river has 9 tributaries, of which 3 flow directly into the accumulation lake.

The Ghidighici lake was built for irrigating arable land (Figure 4), fishing, regulating the water level of the Bâc River, but in the meantime, it has also become a recreation area (Figure 5). On the shores of the lake, there are several tourist guesthouses, private rest homes, fishing clubs, yachting clubs, sports clubs, etc., but there are also agricultural lands, especially vineyards.

Wastes from the city are collected and transported by truck to the landfill located next to Strășeni city (Figure 6).

Fig. 3. Călărași wastewater treatment plant

Fig. 4. Agricultural lands next to Ghidighici lake, upstream the Chișinău municipality

Fig. 5. Ghidighici lake

Fig. 6. Strășeni landfill

In Vatra city, 72 economic agents are registered. The economic activities are carried out by furniture factories, stone processing plants, car workshops, warehouses, oil stations, service units, production workshops, production sections, commercial units, pharmacies, advertising units, etc. The existing sewerage system with a length of 16 km, provides only 70% of the population and economic operators, receives wastewater, and discharges it through a pressure collector to the treatment plant in Chișinău (MINISTERUL MEDIULUI, 2015).

Pollution sources identified in sector 3-4

This sector includes almost the entire municipality of Chișinău, including its suburbs. On the territory of Chișinău municipality, the Bâc River collects 6 streams and rainwater from several drainage channels, in some parts being swamped, and in others growing vegetation.

In this sector, the Bâc River undergoes numerous changes in terms of chemical, physical, organoleptic, and bacteriological status as a result of illegal discharges of numerous pollutants by economic agents and discharges of wastewater, insufficiently treated from the wastewater treatment plant from Chișinău, which is considered the largest source of pollution of the river (Figures 7 - 8).

In Chișinău, there are 85600 economic agents, 301 industrial enterprises, 5636 commercial units. The economic activities are carried out by 30842 enterprises in agriculture, forestry, manufacturing industry, electric and thermal energy, gas, water, constructions, wholesale and retail trade, transport and communications, and others.

There is an asphalt plant in the Pruncul industrial area. The Bâc River is dammed with construction waste, and on the lower course "dams" were formed from waste, mainly plastic. The riparian protection area in the Pruncul segment - the railway bridge, where there is a wholesale agricultural market and an extensive industrial area, is covered with reeds, trees, and shrubs.

In the agricultural market region, water is used by public transport vehicles drivers for their washing, an inappropriate practice but not properly verified and sanctioned by local authorities.

Pipes of different sizes are present along the whole watercourse, through which rainwater is discharged directly into the waters of Bâc River, received through the networks built in the municipality, as well as part of the wastewater resulting from the economic units illegally connected to these networks, conditioning water pollution (Figure 9). Often, these networks are not able to capture all the rainwater, thus creating superficial leaks or even floods, and the water, after washing all roads of dust, waste, oils, and fuels reaches the Bâc River.

The centralized sewerage system, with a length of about 1050 km and an average age of over 3 decades, serves a part of economic agents, public institutions, and the population in a proportion of 98.8% in urban localities and 77,7% in rural areas. The wastewater received through the pumping stations is discharged to the Chișinău treatment plant, with a capacity of 340 thousand m^3/day. The station takes over 130-140 thousand m^3/day of wastewater, discharged after purification into the Bâc River.

According to the report (MINISTRY OF ENVIRONMENT, 2015), the results of water monitoring from sampling points showed that the pollution of the waters of the Bâc River is an active process, and the water downstream of Chișinău is defined as "dead water" and the Bâc River as "dead river".

Pollution sources identified in sector 4-5

From downstream of Chișinău to the discharge point of the river into the Dniester, we listed 16 localities, all belonging to Anenii Noi district.

Agricultural lands extend on the banks of the river. Even if the locals know that the water from Bâc is polluted, they continue to use it to irrigate the land, then the products reach

the commercial markets. Six localities do not have sewerage networks and others, even if they have sewerage networks, do not have a treatment plant, and the wastewater is discharged on fields or directly into the Bâc River.

The economic activities are carried out by 741 economic units, of which 37 are industrial enterprises: food and drinks industry, light industry, construction, farms, industrial refrigerators, gas stations, deposits, commercial enterprises, provision of services, agriculture, and others.

Approximately 5-7 km from the discharge point, in the perimeter of Calfa locality, about 5 tons of unusable pesticides were detected, and the storage conditions are inadequate.

In addition, there are at least 8 landfills, some unauthorized, in this sector, of which the largest is near Țânțăreni. Waste from the perimeter of Chișinău municipality is deposited at this landfill, more than 5000 m^3 of waste being transported daily (Figures 10-11).

Fig. 7. Chișinău wastewater treatment plant - decanters

Fig. 8. Chișinău wastewater treatment plant - filters

Fig. 9. Discharge of water from the Chișinău treatment plant into the Bâc River

Fig. 10. Uauthorized landfill on the banks of the Bâc River

Fig. 11. Landfill near Țânțăreni locality, Anenii Noi district

Identification of impacts using the impact network method

Increased impact on soil, air, and especially water was identified on the entire analyzed surface. The largest sources of pollution identified are: agriculture, industry, and urbanization through the discharge of domestic and industrial wastewater, the existence of non-appropriate

landfills, and the formation of leachate in the area of landfills. Figures 12 to 14 show the impact networks developed for the three anthropogenic activities with an impact on the environment, especially on water.
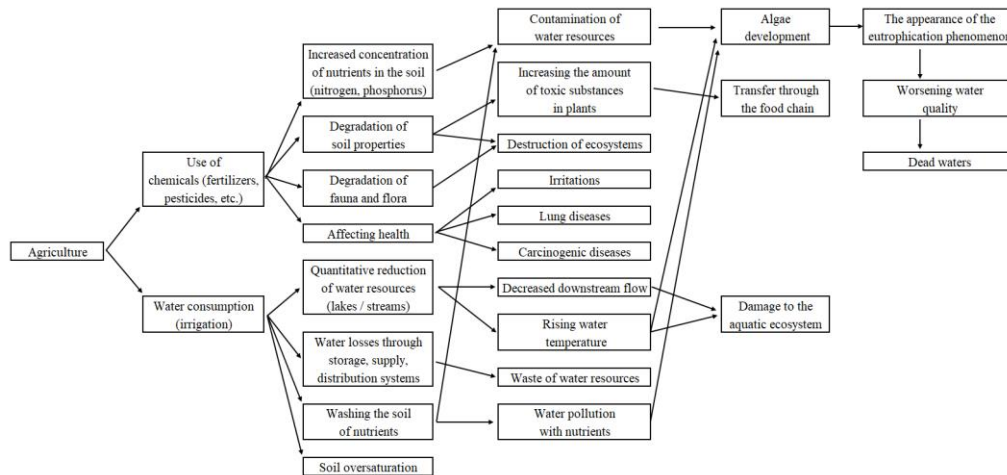

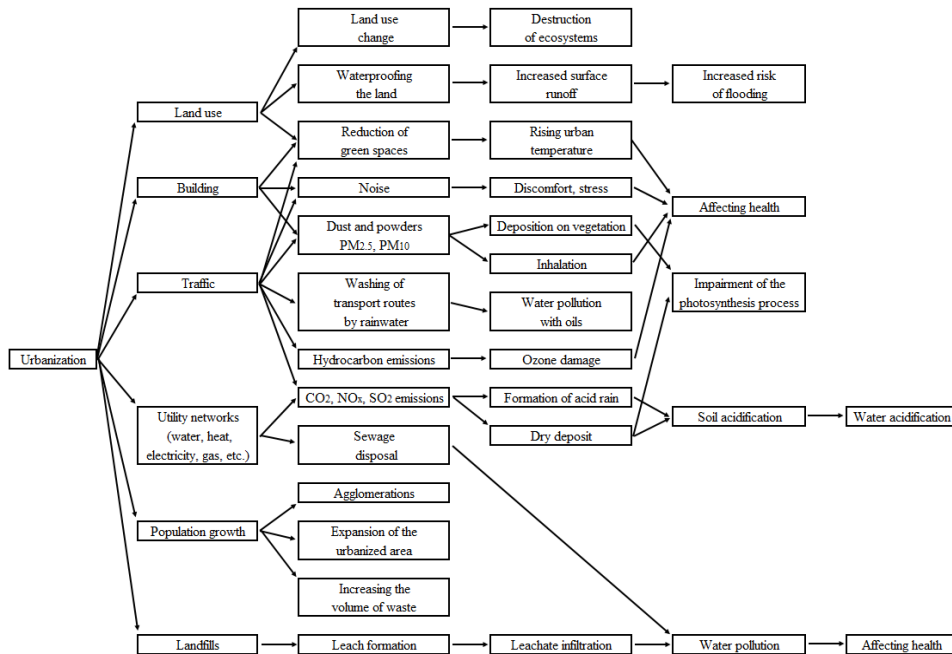Fig. 12. The potential impact network generated by agriculture

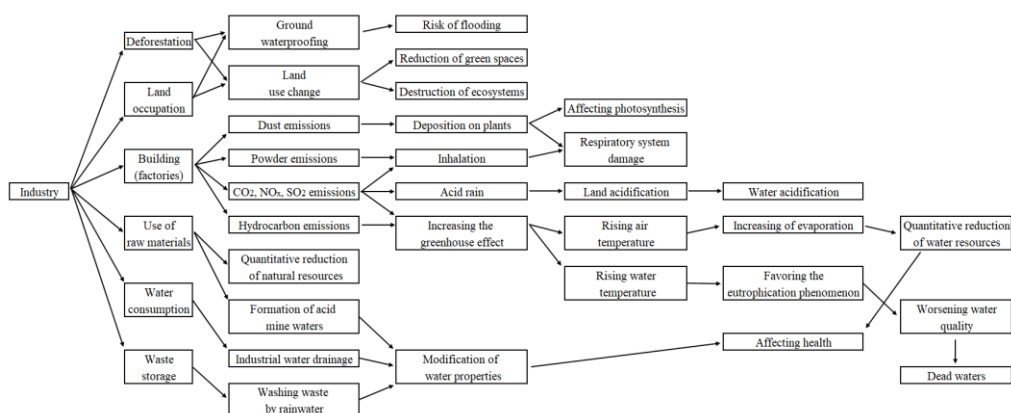Fig. 13. The potential impact network generated by urbanization

Fig. 14. The potential impact network generated by industry

The impact of urbanization and industrialization is amplified by the lack of efficiently functioning modern treatment plants and the lack of controlled landfills, while the impact of agriculture is generated by the inappropriate use of pesticides and chemical fertilizers. On the banks of the Bâc River, there are numerous agricultural lands belonging to individuals and legal entities. Both subsistence farming and large-scale agriculture are practiced for commercial purposes. The use of pesticides, herbicides, and other chemicals leads, by washing them on agricultural land, to the pollution of groundwater and surface water.

Agriculture is considered one of the main anthropogenic activities responsible for water pollution in this area. Agriculture is polluted and polluting due to the following specific activities (LAZĂR AND DUMITRESCU, 2006; LAZĂR AND FAUR, 2011; STOYANOVA AND HARIZANOVA, 2019):

- the use of chemical fertilizers to increase production and the development of modern agriculture, but at the same time, these chemicals are responsible for one of the worst environmental impacts generated by agriculture. Nitrogen and phosphorus fertilizers contribute to the contamination of surface and groundwater, the consequence being to stimulate the development of algae and the occurrence of eutrophication.
- the use of pesticides in order to destroy parasites and pathogens, to control the development of affected plants, and to ensure the achievement of high quality standards of agricultural production. In general, pesticides are toxic (in some cases even carcinogenic) substances, and their improper or unauthorized use can lead to major health risks.
- irrigation in case of soils with poor water regime. Irrigation has a negative impact on environmental factors due to the fact that it causes large water losses through storage, supply and distribution systems, thus contributing to the waste of an important natural resource or due to the increased risk of water pollution by nitrates by their entrainment in depth. Among the negative effects of irrigation are also mentioned: increasing the level of groundwater, oversaturation and wilting of soils, salinization of soils and favoring the appearance of outbreaks of infection.
- uncontrolled deforestation;
- favoring soil erosion and landslides;
- intensive grazing;
- agricultural and zootechnical waste.

Modernization, resizing of sewerage systems and wastewater treatment plants and the construction of new such stations are necessary to eliminate water pollution. Sewerage systems must ensure an efficient process of transporting wastewater from consumers to the treatment plant, and the latter must meet the quality conditions for the discharged water.

Landfills have a negative impact on environmental components, and their mismanagement increases the impact exponentially. The lack of impermeable layers at the base of landfills favors the infiltration of leachate into the soil, which consists of rainwater that washes waste, mixing with various chemical and biological compounds, organic and inorganic, becoming a substance extremely harmful and dangerous to the environment and health. The decomposition of some waste into the sun's rays releases gases that are dangerous for health and the environment. Heavier compounds are entrained by meteoric waters, the substances reaching surface or groundwater. In this way, heavy metals, organic compounds, nitrites, nitrates, phosphates, etc. reach the river.

Pollution prevention measures

In order to prevent water pollution, it is recommended to apply the following measures and solutions (KUMAR REDDY AND LEE, 2012; LAZĂR, 2001):

- elaboration of feasibility studies and technical projects for water supply, sewerage, and wastewater treatment systems, as well as for the adequate management system of solid and organic waste in all localities located in the Bâc River basin;
- modernization and extension of sewerage systems and treatment plants, in order to stop the discharge of wastewater into the natural environment, which subsequently reaches surface and groundwater;
- construction of sewerage systems and treatment plants, simultaneously with water supply systems, in order to avoid pollution of the natural environment, including surface and groundwater;
- release, cleaning, and arrangement of captured springs and search for alternative sources of the water supply of the population, institutions, and economic agents by drilling artesian wells, expansion of regional water supply systems (Chișinău - Strășeni - Călărași), and water supply of small towns with the help of tankers;
- the maintenance of the systems in each locality located in the Bâc River basin by the enterprises managing the water supply, sewerage, and wastewater treatment services. Training of personnel responsible for systems management;
- regular monitoring of the quality of surface water in the river basin, of the water in the supply system, and of the treated wastewater before its discharge into the natural environment;
- regular monitoring of compliance with the conditions imposed on the related institutions by environmental inspections;
- creation of an adequate management system for solid and organic waste in all localities located in the Bâc River basin;
- liquidation of landfills in water protection areas;
- liquidation of dams built without authorization, thus ensuring the flow of water of the Bâc River and its tributaries;
- cleaning and arrangement of springs, which supply the Bâc River;
- carrying out the cleaning works of the Ghidighici lake;
- discharge of water from the reservoir in quantities necessary to ensure the appropriate flow downstream of the dam;
- carrying out the works for cleaning the river and arranging the banks within the limits of Chișinău municipality;

- delimitation of the lands of the protection zones of the watercourses and of the water basins;
- creation of forest protection strips along watercourses;
- highlighting economic activities in water protection areas.

CONCLUSIONS

Wastewater treatment plants that do not cope with wastewater treatment, illegal landfills, and that do not meet the requirements of integrated waste management and agriculture through the use of too many pesticides and fertilizers are constant sources of pollution of the natural environment and the Bâc River.

Following the study, we propose the elimination of current pollution sources and investments in order to modernize treatment plants and their size so as to ensure the collection and disposal of the entire amount of domestic and industrial wastewater, construction of compliant landfills, and proper waste management from anthropogenic activities and the proper management of pesticides and fertilizers in agriculture.

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