Utilization of hydrobionts biomass to increase the efficiency of biological treatment of surface water

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Abstract. The article deals with the actual scientific and practical problem of improving the ecological state of the hydrosphere through the use of wastewater and surface water treatment methods from hydrobionts. The paper describes the cleaning technology in areas inhabited by a certain type of hydrobionts (freshwater organisms), in the process of sequential passage of the polluted water environment through these areas. At the same time, at all stages of purification by hydrobionts, which are components of biological technology, excess biomass is formed. The biomass obtained during the cleaning process must be removed and disposed of. The utilization of accumulated hydrobiont biomass in wastewater and surface water treatment technologies discussed in the study has found its application in agriculture in the form of animal feed as compost, as well as in agricultural technology as raw materials for the production of organic or mineral fertilizers. It is proposed to technologically integrate wastewater and surface water treatment by colonizing reservoirs with various types of hydrobionts: anaerobic bacteria, aerobic microorganisms (oligotrophs, protozoa), filter-feeding hydrobionts, and predators. These artificially created biocenoses mimic the environment. The authors describe the process of studying the concentration of microalgae using electric current, including the process of collecting accumulated biomass of macroalgae, aquatic plants, and plants of artificially created wetlands. The life cycle of hydrobionts is analyzed, and the features of using various types of hydrobionts in the technology of cleaning polluted water environments are studied. The process of rehabilitation of a water body was considered on the example of Lake Tikhoe, located in the city of Tyumen.

1 Introduction

There are many studies devoted to the treatment of contaminated wastewater using aquatic organisms. As a result of the construction of artificial reservoirs, the number of areas with shallow depths that are well warmed by the sun has increased [1]. Uncontrolled and rapid growth of algae, mainly brown-green and blue-green, leads to" blooming " of water bodies, which is a pronounced example of the impact that pollutes surface water in the waters surrounding human settlements. Pollution of the aquatic environment with human waste

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products, such as phosphorus and nitrogen compounds, led to the fact that algae received suitable conditions for their growth and development [2]. They help to purify water from pollution, however, being at the stage of dying off, algae create secondary pollution, releasing toxic substances into the atmosphere and hydrosphere. Many different technologies are used to maximize the effect of filtering polluted water areas. A significant number of research papers by many authors are devoted to the treatment of polluted wastewater using aquatic plants. N. V. Morozov in his works suggests highly efficient wastewater treatment by colonizing them with various types of hydrobionts [3]. Dubovets D. L. suggests using live aquatic organisms (plants, microorganisms, protozoa) for populating artificial reservoirs (ponds with artificial and natural aeration) for the purpose of wastewater treatment [4]. M..V.. Dvadnenko suggests populating reservoirs with water hyacinth [5].

2 Problem statement

This study provides an overview of the pros and cons of various methods used to treat both surface and wastewater. It has been found that existing cleaning methods, while effective, often involve high energy consumption and use of a significant amount of resources. The proposed purification methods pay considerable attention to the natural inhabitants of freshwater reservoirs-oligotrophic microorganisms that develop in less mineralized soils, the main purpose of which is to process excess organic matter in the reservoir. According to this technology, the growing mass of organisms from all areas of the biological space is not destroyed, but extracted from the treatment system and used as material for energy production and agricultural needs. Many studies prove that the use of cyanobacteria to clean contaminated water is an effective method. However, if these plants are not stopped, they will begin to spread uncontrollably, which can pose a threat to the environment during their death. To achieve these goals, various aquatic plants are often used, such as reeds, lake reeds, yellow iris, reed warbler, arrowhead, amphibian buckwheat, iris, and others. Currently, the most widely used plant for cleaning polluted surface waters is water hyacinth (eichornia) [5]. Eichhornia is actively used in many countries for disinfection of wastewater, purification of polluted water resources, elimination of unpleasant odors and production of biomass for various purposes.

3 Research methods

Ammonium nitrogen, heavy metals - components of pollution of organic products of plant life in wetlands, create a big problem of water resources use [6]. A significant part of the research is aimed at effective biological treatment of surface waters. The authors described a study on the settlement of the water plateau by specific representatives of the underwater flora. The most prominent representatives of the evolutionary process are hydrobionts adapted to survive in extreme conditions for several million years. These plants, rooting in the water, create a beautiful view of the shoreline from the bioplatto, the shape is clearly defined for species of various representatives of the underwater world . In the coastal zone, it is recommended to use cane, barley, oats, corn, rye, and willow to form a biological plateau (a natural water filter). Near the shore, hydrophytic plants grow in the water - reeds, cattails, sedge. Hydrophytes are replaced by hydrophytes - plants submerged in water, but with floating leaves - lotus, duckweed, water lilies, water chestnut. Further, the water space is inhabited by plants completely submerged in water - floating algae, elodea, hornwort. Hydrophytes also include plants that float on the surface (duckweed, water hyacinth) [7]. Mass forms of hydrobionts include species whose population growth under certain

conditions in water bodies becomes explosive, and their biomass begins to significantly predominate in comparison with competing species.

4 Microalgae and bacteria

Aquatic (planktonic) microorganisms are often referred to as blue-green algae because of their photosynthetic effect. Cyanobacteria are unpretentious in their existence and development. Supportsupport, they use inorganic compounds of phosphorus Na_3PO_4, chlorine KCl, nitrates as a source of nitrogen NH_3, KNO_3 and microadditives of elements such as iron, sulfur, zinc, copper, magnesium, cobalt, molybdenum, as well as organic substances of natural and anthropogenic origin (surfactants, petroleum products).

Wastewater and surface water treatment elements using various types of hydrobionts are widely used, and the scope of such treatment methods is growing. Practical aspects of the introduction of technologies in their dialectical development have shifted from the use of certain types of hydrobionts for cleaning purposes to the use of artificially created consortia (associations) of microorganisms (activated sludge). Then - to a combination of different biological treatment zones (anaerobic-aerobic zone, biological plateau or artificially created wetlands). The beginning of this development was the creation of artificial biocenoses inhabited by the corresponding types of hydrobionts and defining natural ecosystems

Natural water purification in an artificial reservoir is carried out with the help of marsh plants that are not planted in the reservoir itself, but live next to it in a specially prepared shallow area. The result is a two-level water system - the main pond at the bottom, and a little higher - an additional shallow water area with vegetation. It is proposed to combine zones "inhabited" by various types of hydrobionts in cleaning technologies: anaerobic bacteria, aerobic microorganisms (oligotrophs, protozoa), filtering hydrobionts and predators. These artificially created biocenoses imitate the environment up to the creation and functioning of biological chains for various types of hydrobionts [8]. Both the polluted environment and the biomass of the organisms themselves become food for them. The proposed technology can be used for the treatment of any wastewater (stormwater, natural, industrial or domestic) containing pollutants (including organic compounds, toxic compounds, mutagenic and carcinogenic compounds), the concentrations of which are in high limits. The advantage of the proposed technology is the utilization of excess biomass, which inevitably increases as a result of the absorption of water pollutants by hydrobionts and is purified "inside" the purification technology - in the formed biological chains in which it is consumed and mineralized. It is believed that creating a chain of 2-3 links in the technological cycle can reduce the amount of accumulated biomass by 100-1000 times. Despite the advantages of the technology, it is also possible to identify disadvantages: a significant part of the space in the proposed technology is occupied by oligotrophs, whose main task is to dispose of excess biomass, but they do not take a direct part in cleaning up the polluted aquatic environment. Excess biomass, which is a valuable raw material for various energy and agricultural needs, is used in the purification technology itself. If the accumulated biomass from all areas of the biosystem is not disposed of in biological chains, but is removed from the treatment system and used as raw materials in energy and agricultural areas, then the disadvantages can be avoided [9-11]. A mandatory operation is the selection of accumulated biomass in order to prevent its uncontrolled biological decomposition. The selected excess biomass is of particular interest as a raw material for the production of biofuels and bio-products from it. This will make it possible to use this approach as one of the elements of integrated filtrate purification technologies with low capital and operating costs, which will ensure a sufficient degree of purification and consider the prospects for its use in the future.

5 Rehabilitation of water space on the example of Lake Tikhoe, located in the city of Tyumen in the microdistrict microdistrict

Tihoe (Gypsy) Lake is one of the staritsa lakes formed in the floodplain of the Tura River. For a long time, it was fed by the flood of the Tura River during the flood period. Currently, the main water supply is rainwater and meltwater. Back in the 60s of the twentieth century, the lake was connected by canals to neighboring lakes. Gypsy Lake got its name because of its proximity to the gypsy camp. For a long time, the area around the lake was not improved, waste and sewage were dumped into it. The developer of the microdistrict "" decided to include the lake in the development project.

Restoration of Lake Tikhoe was carried out by the Russian Ecological Society, Tyumen State University and the Ecostandart Lingonberry Group of Companies in several stages. As part of the rehabilitation, a hydrological study was conducted, the composition of coastal soils was analyzed, and the state of flora and fauna was studied. Then the lake was cleared of silt and its area was increased. An artificial dam was built between the existing and swampy parts of the lake and, after pumping 26 thousand cubic meters of water from one part to another, about 20 thousand cubic meters of bottom sediments were removed. This increased the depth of the reservoir. Figure 1 shows the rehabilitation of Lake Tikhoe.

Fig. 1. Rehabilitation of Lake Tikhoe.

Brusnika's innovative approach to wastewater treatment and restoration of the Lake Tikhoe ecosystem is a comprehensive project that includes several interrelated stages aimed at creating a self-regulating and sustainable water environment. The system is based on the principle of natural filtration, implemented through cascading rain gardens. These gardens are a series of sequentially arranged pools with different types of soil and vegetation that effectively trap and filter rainwater flowing from the surrounding areas, including the roadway. Special attention is paid to preventing the ingress of pollutants from the road directly into the lake: for this purpose, a whole network of drainage ditches and trays has been created, directing the runoff to the cascade garden system. Before the water reaches the lake, it undergoes a multi-stage purification process, during which large particles are mechanically removed, and then biological purification is carried out due to the activity of microorganisms in the soil and the root system of plants. The choice of vegetation for rain gardens is also not accidental. Experts have selected species that are highly resistant to flooding and can survive in conditions of variable water levels. This step is critical to prevent soil erosion and ensure the continuity of the filtration process. After passing

through rain gardens, water enters the buffer zone around the lake, planted with hydrophytic plants that additionally purify the water and prevent erosion of the coastline. This buffer serves as a natural barrier that softens the impact on the lake and prevents the soil from being washed away into the water area. The lake itself has a rich and diverse aquatic ecosystem. Planted hydrobionts, such as umbrella cane, racemose mountain ash (probably meaning marsh willow, since mountain ash is not an aquatic plant), marigolds, turcha marsh, bindweed straight and false sedge, perform the functions of biological purification, absorbing dissolved nutrients and pollutants from the water. These plants, especially reeds, also serve as a shelter for small aquatic animals and contribute to the enrichment of water with oxygen. In addition, artificially created floating islands (plateaus) with wetland vegetation increase biodiversity and serve as nesting sites for waterfowl such as ducks or herons, depending on the landscape and climatic conditions of the region (Figure 2). To restore the balance of the biocenosis, carp, crucian carp and perch were released into Lake Tikhoe. This step is aimed at creating a balanced food chain in which predatory fish will control the population size of herbivorous fish, preventing overpopulation and adverse effects on aquatic vegetation. The choice of these fish species is also determined by their adaptation to local conditions and their ability to reproduce in a given ecosystem. It is important to note that prior to the release of the fish, appropriate studies were probably conducted to assess the potential impact on the already existing flora and fauna of the lake.

Fig. 2. Vegetation ecosystem of Lake Tikhoe.

6 Discussions and results

In the Komi Scientific Center of the Ural Branch of the Russian Academy of Sciences, Russian scientists from the Institute of Biology of the Siberian Branch of the Russian Academy of Sciences conducted a large-scale study on the role of biocatalysts based on enzymes, microorganisms for processing plant raw materials, obtaining biologically active substances, and biofuels in cleaning polluted soils and waters.

Cleaning of the polluted environment at the initial stage of the life cycle of aquatic organisms is affected by their type, location of sites with different types of aquatic organisms. External conditions are also important: climatic conditions, temperature, illumination, hydrodynamics, chemical composition of water environment factors, various pollutants that "require" cleaning measures, etc., for the normal functioning of aquatic organisms [12]. Therefore, the optimal conditions for the implementation of this stage, the

degree of purification of the aquatic environment and the amount of accumulated biomass should be determined for each specific biological treatment scheme. A large number of studies are devoted to the use of aerobic and anaerobic microorganisms, microalgae and algae plants, and aquatic aquatic organisms. Cleaning of polluted water environment in artificially organized wetlands is also considered in the future [13].

7 Conclusion

Thus, the article presents an analytical review of the life cycle of hydrobionts, examines the features of using various types of hydrobionts in the technology of cleaning polluted water environments, and also outlines the prospects for using various types of hydrobionts for water resources treatment. The process of rehabilitation of a water body is considered on the example of Lake Tikhoe, located in the territorial limits of the city of Tyumen. Problems of selection of excess biomass of aquatic aquatic plants are described. It is proposed to use special technological equipment for cleaning aquatic organisms: specialized water combines, floating mowers that collect the biological mass of aquatic plants. The use of surface and wastewater treatment methods significantly improves the ecological state of the hydrosphere.

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