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To cite this article: Yu A Ponomareva and A V Andrianova 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **537** 062040

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## Application of hydrobiological analysis for improving the efficiency of water treatment

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**Abstract.** The study was conducted on the open water intake Gremyachiy Log. A period of tighten control at all stages of water treatment was established according to the turbidity of natural water and the quantitative content of algae. It was found that diatoms form the basis of the floristic list in the Yenisei River (66% of the total species composition), they prevail in plankton in all seasons of the year. The patterns of phytoplankton development and its influence on the operation of water intake structures were revealed. The possibilities of optimizing the operation of the Gremyachy Log water intake filtering and treatment facilities by controlling the amount of reagents, used in water treatment, and controlling technological processes, were considered.

### 1. Introduction

Nowadays, the problem of water quality and rational use of water resources is particularly acute. One of the reasons for the unsatisfactory quality of drinking water is massive pollution of surface water bodies due to discharges of untreated and insufficiently treated industrial, household and agricultural wastewater, storm and melt water from fields, territories of villages and cities. As a result, everywhere in the world, water supply from surface sources is confronted with the need to purify water, characterized by a very extensive and multifaceted spectrum of pollutants.

One of the most difficult and dangerous consequences of anthropogenic pollution is the intensive development of aquatic vegetation in surface sources in almost all climatic zones [1-2]. The functional role of vegetation in aquatic ecosystems is multifaceted and ambiguous. Among the many factors causing the processes of self-purification of natural surface waters, an important role belongs to the phytoplankton community (microalgae, developing in the water column). Phytoplankton is a producer of autochthonous organic matter, an important agent of self-purification and photosynthetic aeration of water. However, the massive development of algae can lead to negative consequences not only for the life of the reservoir inhabitants, but also for water consumers. When algae die off, toxins enter the water – these are products of their metabolism, which significantly impair the consumer properties of water, giving it different flavors and tastes, increasing oxidability, turbidity and water color [3].



A large amount of algae significantly complicates the work of waterworks. An increase in the amount of plankton entering the treatment plant leads to a disruption in their normal operation, a decrease in productivity and an increase in water consumption for own needs. The problem of algae control is equally relevant both for the intake and in the treatment of water for water supply of any objects.

Krasnoyarsk is the capital of the Krasnoyarsk Region, the largest industrial center of Siberia with a population of over a million people. The main waterway in the region is the Yenisei River - one of the largest rivers in the world. The watercourse is intensively used for energy, water supply, transport, fisheries and recreation. A long-term anthropogenic press led to negative consequences for the river ecosystem and its water quality. At present, the water in the Yenisei is assessed as “polluted” and “dirty”, the deterioration of water quality is observed below the settlements, while the main toxicants in the river are metals and oil products [1].

Systematic hydrobiological monitoring of a water source, together with hydrochemical indicators, makes it possible to establish the degree of water pollution and control the mode of operation of water treatment facilities. Such comprehensive studies are the basis for the organization and planning of water management.

The purpose of this work is to evaluate the effectiveness of water treatment technology at one of the water intakes in Krasnoyarsk, taking into account the seasonal succession of the phytoplankton of the river Yenisei.

## **2. Research results**

The centralized Krasnoyarsk water supply system includes seven water intake structures, six of which are of the infiltration type, and only the water intake “Gremyachiy Log” is of the open (surface) type. This water intake (design capacity is 163 thousand m<sup>3</sup>/day) supplies with the household and drinking water the Oktyabrskiy and Zheleznodorozhniy districts of the Krasnoyarsk, and also supplies general pipeline with water to the Tsentralniy district and the Solnechniy microdistrict. In sanitary terms, surface water is less reliable compared to groundwater, therefore systematic monitoring of the quality of surface water is necessary in the Gremyachiy Log water intake zone.

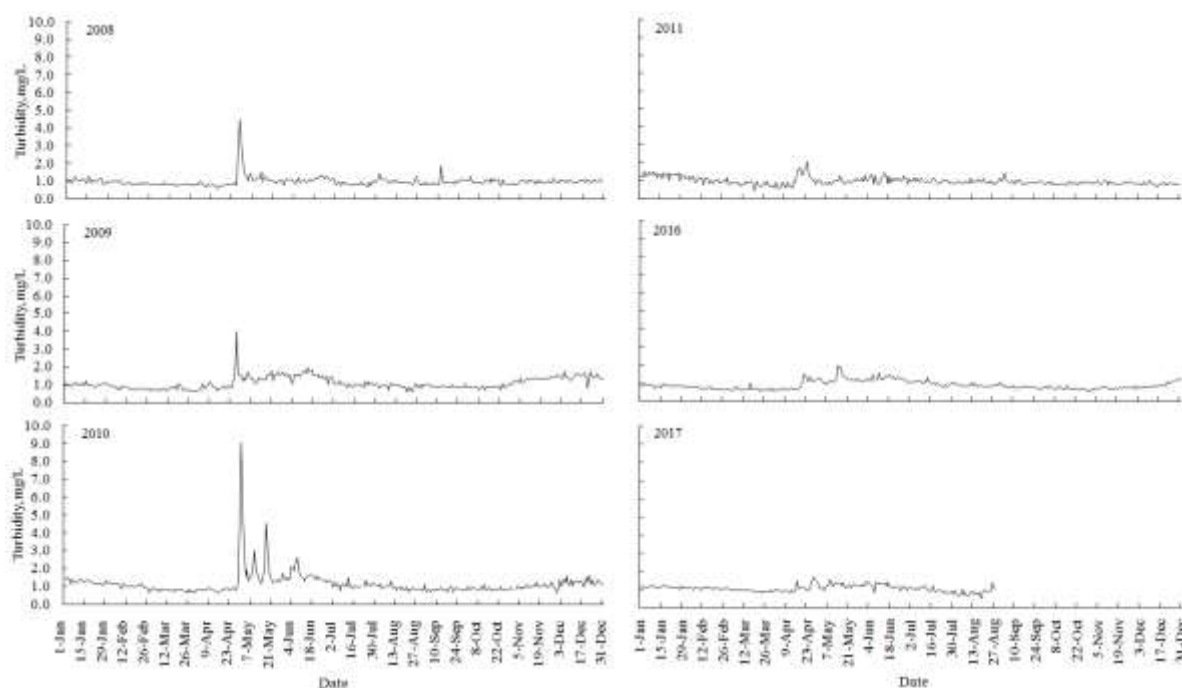
According to the water treatment method (decontamination, filtering with or without coagulation), the “Gremyachiy Log” water intake belongs to class 1. Technological scheme of water purification at the water intake is as follows. River water through the tip by gravity is fed to the pumping station of the first lift, after which it is fed by the pumping units into two reservoirs of the source water. In the pipeline with river water in front of each reservoir with the source water chlorine water is injected to reduce the mud load on the structures. From the reservoirs of the source water, water is supplied to the drum grids, which are used for protection from clogging with coarse particles and releasing from suspended solids with a size fraction of more than 5 mm. After the drum grids, water enters the corridor of the contact chamber, where water is mixed with the coagulant (at elevated turbidity). Then, the flow of water is supplied to the filters, which, in addition to freeing water from suspended substances, retain most of the microorganisms and microflora and reduce the color of the water. Water is filtered through a layer of granodiorite, sand and gravel. After the filters the purified water flows by gravity into two tanks of pure water, from where it is supplied to the consumer by the pumping station of the second lift.

Directly at the “Gremyachiy Log” water intake, water quality is regularly assessed before and after water treatment according to 81 indicators, including sanitary and biological, radiological and chemical. Yenisei water refers to ultra-fresh according to mineralization, oligogumous in color and characterized by a low concentration of biogenic elements [2; 3; 4-10]. The oxygen regime in the river is pleasant, with an average water temperature from 2 to 12°C. This site is characterized by a low content of biogenic elements in water and a slight excess of MAC for fishery reservoirs for copper and zinc (for iron and manganese below MAC).

Among the recommended organoleptic indicators for monitoring the water quality of the water source, the priority at the “Gremyachiy Log” water intake is turbidity, which increases in spring. The values of this indicator are also used in the production and technological control of the operation of drinking water treatment facilities. Timely assessment of changes in the turbidity of natural water makes

it possible to make adjustments to the technological process, designating the most effective mode of operation of facilities.

Regular monitoring of the Yenisei river in the area of the water intake “Gremyachiy Log” revealed an annual regular short-term increase in turbidity during the flood period (figure 1). In addition, one of the reasons for the increase in the values of pollutants in the spring and autumn periods of the year is the unorganized discharge of melt water and rainwater in the areas of cottage villages.

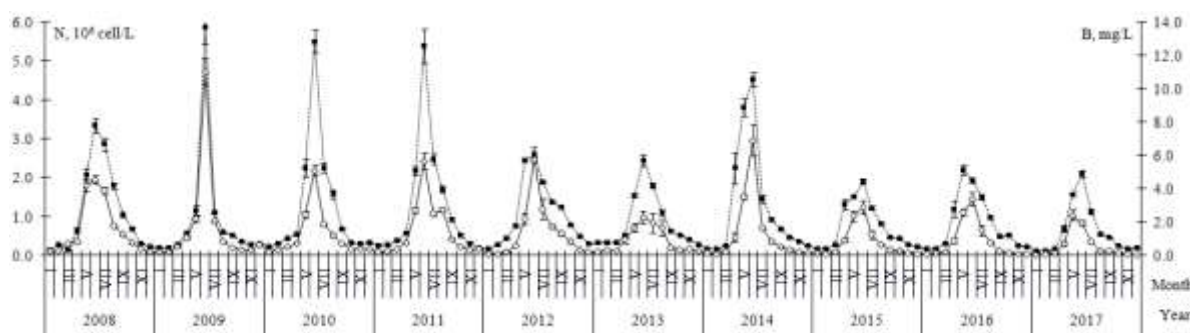


**Figure 1.** Seasonal dynamics of turbidity in the area of water intake “Gremyachiy Log”.

Between the end of April and the beginning of May, the turbidity of the source water increases to 4.0–9.4 mg/l (with an average value of turbidity of 1.1 mg/l). To release water from suspended matter and colloidal substances, in filtering and wastewater treatment plants special coagulant reagents are used, which form flakes in water that adsorb colloids on their surface and are released as sediment. For a long time, aluminum sulphate was used as a coagulant on the “Gremyachiy Log” filtering and wastewater treatment plants; at present, coagulant on the basis of polyaluminum chloride is used. This has made it possible to reduce the dose of injected coagulant, and at its optimal doses, the residual aluminum is within the MAC of water for household purposes.

#### *Hydrobiological monitoring*

Monitoring the development of the Yenisei phytoplankton in the “Gremyachiy Log” water intake area is obligate when monitoring river water quality. Succession changes in the Yenisei phytoplankton are characterized by a certain frequency. Seasonal dynamics is characterized by weak development of algae in winter and autumn, and intensive in spring and summer. The dynamics of the structural indicators within the year has the form of a one-peak curve (figure 2). These peaks are associated primarily with the intensive development of plankton species during the summer period - *Aulacoseira islandica* (O. Müll.) Sim and *Cyclotella radiosa* (Grun.) Lemm.



**Figure 2.** Seasonal dynamics of abundance (N) and biomass (B) of phytoplankton downstream of the Krasnoyarsk HPS, Yenisei River.

The presence (and especially the dominance) of large-sized filamentous diatom *A. islandica* in the river water significantly complicates the operation of the filtering and treatment facilities - the number of filter washes increases, the sanitary condition of the facilities as a whole worsens. In order to prevent the accumulation of plankton organisms in the filter loading, water pre-treatment – oxidation – is carried out. Chlorine is used as an oxidizing agent [11-13]. Pre-chlorination is the main algicidal factor in water purification and allows to reduce the number of phytoplankton cells by up to 40% already in the first stage of the processing chain. The increase in the abundance of *A. islandica* in the downstream in June is obviously caused by a discharge from the upstream, because the deep-water Krasnoyarsk reservoir is characterized by a deep discharge of water through the dam (18-40 m). According to the literature [Krasnoyarskoe vodokhranilishche] in the upstream of the Krasnoyarsk reservoir *A. islandica* occupies a dominant position in the nephatic cold layer (hypolimnion) in May and early June.

### 3. Conclusion

Nowadays, in the area of the water intake “Gremyachiy Log” there is a regular short-term increase in turbidity during the flood period; coagulant on the basis of polyaluminum chloride is used to reduce it. Yenisei water quality satisfies the requirements for water in water bodies for household water use according to all chemical indicators, but at the same time it does not meet the requirements for water in water objects of fishery for a number of indicators (zinc and copper). In order to avoid clogging of the filtering load by phytoplankton in the period of a sharp increase in their number and biomass, an enhanced control has been introduced at all stages of water treatment for the quantitative content of algae. To reduce phytoplankton in the water and to improve the sanitary condition of the facilities, pre-chlorination of the source water is carried out.

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