

Dissertation abstract

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" Development of technology for wastewater treatment of mining enterprises from inorganic nitrogen compounds in the conditions of the northern latitudes of Russia"

Relevance

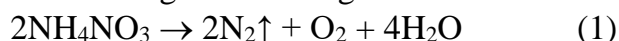
Water resources play a key role in maintaining human life and ecosystems. They are necessary for drinking water supply, agriculture and industry. Water pollution is a global environmental problem.

One example of pollution of lake and river systems due to mining activities is the Kenti River system, which was exposed to the Karelian Okatysh JSC enterprise in the city of Kostomuksha, Republic of Karelia, in Northwestern Russia. This company specializes in the extraction and processing of iron ore, and its share in the total volume of iron ore pellets in Russia is 20%. Mining is conducted in an open-ended manner, using explosives for civilian purposes. The company has a man-made impact on the lake and river systems of Karelia. In particular, in the basin of Lake Kostomukshskoye (the upper lake of the lake-river system of the Kenti River), a tailings dump has been created for the disposal of enrichment hosts (production waste) and a circulating water sump. Since 1994, regulated wastewater discharge has been carried out into the Kenti River system.

According to the decision of the Arbitration Court of the city of St. Petersburg and the Leningrad Region in case No. A56-109026/2019 dated December 05, 2019, Karelsky Okatysh JSC was ordered to fulfill the following requirements: "stop dumping pollutants discharged into Okunevoye Lake and Bezymyanny Creek"; "prevent violation of water quality requirements for water bodies of fisheries importance – Okunevoe Lake and Bezymyanny Creek, including standards for maximum permissible concentrations of harmful substances in wastewater collection sites." This court decision indicates the relevance of developing technologies for water purification from inorganic nitrogen compounds. "There is an excess of pollutants in wastewater discharged by Karelian Okatysh JSC into Okunevoye Lake according to the following indicators:... ammonium ion – 1.52 times (fact - 0.76 mg/dm³, standard – 0.5 mg/dm³); nitrate ion – 1.1 times (fact – 28.94 mg/dm³, standard – 26.2 mg/dm³)".

The mining company's activities have led to a change in the chemical composition of water in the lake-river system. There is an increase in the concentration of nitrates, as well as potassium, sulfates, lithium, and nickel. Unlike suspended particles, inorganic nitrogen compounds in water do not precipitate, and they cannot be removed by chemical and physical methods. Biological methods are used to purify wastewater from the tailing dump from inorganic nitrogen compounds before discharge into natural reservoirs, but their use in the climatic conditions of Karelia is difficult.

During the explosion, ammonium nitrate decomposes with the release of energy and heat into oxygen, water and nitrogen according to formula 1.



Nitrogen formed by the formula is gaseous and does not contribute to water pollution, but volatilizes with air. However, during the explosion, not all of the nitrogen mass turns into a gaseous form. Some explosives undergo incomplete decomposition. This is why there are inorganic nitrogen compounds in wastewater: ammonium salts; free ammonia, nitrates, and nitrites.

Approximately 4% of the total mass of nitrogen compounds from explosives enters the water after blasting operations. Wastewater discharge into open water bodies leads to water and soil pollution, causing negative impacts on ecosystems and human health. The requirements of the best available technologies (BAT), which mining enterprises must meet, apply both to emissions of pollutants into the atmospheric air and to their discharges into natural water bodies. Therefore, the development of technological and technical solutions to ensure proper wastewater treatment from inorganic nitrogen compounds, as well as the justification of technological indicators of NDT for mining enterprises, is an urgent problem.

Currently, the company does not have an effective system for cleaning man-made wastewater from nitrogen-containing compounds. The development of technologies for wastewater treatment from inorganic nitrogen compounds is required.

The purpose. The purpose of this dissertation is to identify the features of wastewater treatment of mining enterprises from inorganic nitrogen compounds using cultures of microalgae *Chlorella vulgaris*.

Research objectives:

1. To evaluate the possibility of stimulating the growth of *C. vulgaris* algae culture by electromagnetic radiation of extremely high frequencies.

2. To identify the ability of *C. vulgaris* microalgae to absorb inorganic nitrogen compounds from wastewater under various conditions.

3. To evaluate the possibility of using EHF EMR to improve mining wastewater treatment technologies from inorganic nitrogen compounds.

4. Select optimal conditions for the disposal of inorganic nitrogen compounds from *C. vulgaris* wastewater, including temperature, duration and frequency of irradiation, composition of the culture medium, and method of culture preparation.

The novelty of the research

1. It has been shown for the first time that the use of EHF 40GHz EMR for 120 minutes makes it possible to intensify the process of biomass cultivation of *C. vulgaris* algae culture by 6.8 times.

2. Technological solutions have been proposed to intensify the process of biological wastewater treatment from inorganic nitrogen compounds by irradiating algae cultures with EHF EMR; the efficiency of ammonium utilization increases by 10% and nitrates by 4% compared with experiments without EHF EMR irradiation.

3. It is established that *C. vulgaris* grown on nitrogen-free media begins to utilize ammonium at lower temperatures and is able to utilize nitrates to a greater extent than *C. vulgaris* grown on Tamium medium.

The paper studies the effect of millimeter electromagnetic fields in the range of 37-53 GHz on the microalgae *C. vulgaris*. Studies of this frequency range on other living objects have shown the promise of its use as a stimulating and inhibitory factor. This determines the novelty of studying the effects of this range on *C. vulgaris* for subsequent use.

The theoretical and practical significance of the work. The study identified optimal conditions for the cultivation of *C. vulgaris* algae for the effective removal of inorganic nitrogen compounds from wastewater. A nitrogen removal scheme using *C. vulgaris* algae has been developed. The results obtained indicate the potential of using *C. vulgaris* for wastewater treatment in industries with limited spillway volume, where effective treatment can be carried out in bioreactors.

The results of the work can be applied at algae cultivation enterprises, as well as to improve technologies for cleaning water bodies using algae.

The results of the work may also be useful for planning future research on the development of biotechnologies using electromagnetic radiation to stimulate the growth of microorganisms and related technologies.

To date, ITS NDT has established a standard for the nitrate content in purified waters of 75 mg/dm³. The results indicate that the value below has been cleared. There are no requirements for ammonium. The results of the work can form the basis of BAT for clarifying standards on nitrates and developing standards on ammonium.

Provisions to be defended:

1. The conditions for growing *C. vulgaris* algae in water have been determined, which make it possible to increase biomass growth by 6.8 times per day due to irradiation with EHF EMR of 40 GHz for 120 minutes before the start of cultivation.

2. *C. vulgaris* is capable of increasing biomass to 5.6 g/m³ in 14 days when cultivated on a Tamium medium at a temperature of 26 ° C and aeration in polluted waters of a tailings dam or its settling tanks.

3. *C. vulgaris* is suitable for the utilization of nitrogen of inorganic compounds from wastewater from a tailings dump. Utilization efficiency can reach 96% for nitrates in 11 days and 93% for ammonium in 4 days when purification takes place at a temperature of 26 ° C, aeration, and the culture is prepared on a special medium without nitrogen sources.

4. Irradiation of *C. vulgaris* together with the waters of the EHF EMR tailing dump before cultivation makes it possible to increase the concentration of biomass by 15%, as a result, it increases the efficiency of ammonium utilization by 10% and nitrates by 4%.