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USE OF FE-EDTA AS A COAGULANT FOR REGULATION OF CYANOBACTERIA AMOUNT

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The work is devoted to the study of the effectiveness of iron-based coagulants in combating cyanobacteria, in particular Microcystis sp., in the aquatic environment. During the experiment, the effect of various compounds (FeSO4 and Fe-EDTA) on morphological changes in the cyanobacterial culture, changes in the pH of the medium, and the toxicity of these compounds was evaluated. It was found that iron-based coagulants contribute to the formation of flocs and a decrease in the optical density of the culture, which indicates the efficiency of cell sedimentation. At the same time, the use of the chelated form of iron (Fe-EDTA) demonstrated the best results, with minimal changes in pH and a low level of toxicity. The study confirmed the prospects of using iron-based coagulants to reduce the number of cyanobacteria, which is important for improving water quality and combating algal blooms.

Keywords: coagulants, coagulation, cyanobacterial bloom, Microcystis pulverea, cyanobacteria, cyanotoxins

Introduction. Water bloom caused by intensive reproduction of cyanobacteria is one of the key global environmental problems that threatens aquatic ecosystems and human health. The main factor in this phenomenon is eutrophication of water, caused by anthropogenic pollution, including frequent use of mineral fertilizers, discharge of wastewater and organic waste. This creates optimal conditions for the accelerated development of cyanobacteria, in particular Microcystis pulverea. They produce toxins that are products of specialized metabolism of cyanobacteria. According to the clinical manifestation and main action, cyanotoxins can be divided into: hepatotoxins, neurotoxins, dermatotoxins, endotoxins and other toxins.

Coagulants - substances that are able to reduce the concentration of suspended particles, including cyanobacteria, by forming flocs and their subsequent sedimentation. The use of coagulants is one of the most promising approaches to regulate the abundance of cyanobacteria, as they allow for the effective precipitation of algae cells and minimize their toxic effects. Fe-EDTA (iron chelate complex with ethylenediaminetetraacetic acid) acts as a coagulant that provides iron in a stable chelated form. In this form, iron ions are bound to the EDTA ligand, which helps maintain their solubility and increases resistance to oxidation. Although Fe-EDTA does not precipitate impurities as quickly as some other forms of iron, it guarantees long-term stability and controlled release of iron in the system. This helps maintain optimal conditions for coagulation and effective algae removal. Among the key advantages of Fe-EDTA is the ability to regulate the solubility and availability of iron, which is an important factor in water purification processes.

Therefore, the aim of the work was to evaluate the effect of Fe-EDTA on Microcystis pulverea cells, with their subsequent use for regulating the abundance of cyanobacteria in aquatic ecosystems.

Materials and methods. Microcystis pulverea was cultivated using Fitzgerald medium for 21 days at a temperature of 20±2 °C with a photoperiod of 16 hours. After the completion of the cultivation process, the cell concentration in the culture reached 5.4×10^6 cells/ml. This model culture was divided into 5 ml aliquots, and the samples were added with the chelate form of iron Fe_2SO_4 end Fe-EDTA in concentrations from 5 to 50 mgFe/l. Incubation lasted 7 days, after which the pH of the medium, the density of the culture, the number of live and dead cells, and the toxicity of the studied compounds were analyzed.

To determine the ratio of live and dead cells of Microcystis pulverea, a differential staining method using methylene blue and neutral red dyes was used. This approach allows visualization of cell viability based on their ability to retain or exclude dyes.

After incubation, 1 ml of culture medium was taken from the sample under study. 1 ml of a solution prepared in a ratio of 1:5000 for each of the dyes — methylene blue and neutral red — was added to the sample. The mixed sample was kept for 1 hour at room temperature, ensuring complete interaction of the cells with the dyes. After incubation with the dyes, the study was carried out in a Fuchs-Rosenthal chamber. The chamber allowed for accurate counting of the number of cells in a given volume of the sample. Live cells turned

red, while dead cells turned intensely blue due to the dye penetrating through the damaged cell membrane.

Results and discussion. After the incubation, the color of the culture remained almost unchanged, which indicates a minimal effect of the drug on the pigments of cyanobacteria. When the tube was moved, the formed flocs were clearly visible and retained their shape. Microscopic examination showed that the flocs had a well-defined structure and demonstrated a high degree of cell aggregation, confirming the effectiveness of the coagulant used for sedimentation of *Microcystis pulverea* cells.

Analysis of the ratio of live to dead cells is an important stage of the study, as it allows us to assess the effect of coagulants on the viability of Microcystis pulverea. Maintaining the majority of cells in a viable state after treatment is critically important, since the death of cyanobacteria can lead to the release of cyanotoxins into the environment, which poses a significant danger to the ecosystem.

The results of staining the samples with methylene blue and neutral red showed that the use of iron sulfate ($FeSO_4$) led to a sharp increase in the number of dead cells, especially at high concentrations of the coagulant. This indicates the destructive effect of $FeSO_4$ on the cellular structure and metabolism of cyanobacteria.

The best results were obtained in samples with Fe-EDTA. After treatment with dyes, the cells showed a pronounced contrast, which made it easier to determine their condition. Even at high concentrations of this coagulant, the number of dead cells remained insignificant. This indicates that the formation of flocs using Fe-EDTA ensured the aggregation of cells in a viable state, minimizing damage to cellular structures.

Thus, the results of the study show that the Fe-EDTA chelate complex is the most effective coagulant in the context of preserving the viability of *Microcystis pulverea* cells, reducing the risks of releasing cyanotoxins into the environment.

An important aspect of the study is the assessment of the toxicity of coagulants, since an effective reagent for the removal of cyanobacteria should not only ensure the formation of flocs, but also not cause significant harm to microorganisms and the ecosystem. Excessive toxicity can lead to cell death, which in turn increases the risk of cyanotoxins being released into the environment.

The results of the toxicity assessment showed that the highest toxicity among the studied coagulants was ferrous sulfate. At a concentration of 50 mg Fe/l, the toxicity level reached 42.9%, which indicates a pronounced destructive effect of this reagent on Microcystis pulverea cells. The best results were obtained with the Fe-EDTA chelate complex. Its toxicity remained consistently low, even at high concentrations. The maximum toxicity of this coagulant was only 12.1% at a concentration of 50 mg Fe/l, which is within acceptable limits and safe for microorganisms.

As a result, the toxicity assessment confirms that the Fe-EDTA chelate complex is the most environmentally safe coagulant, providing effective precipitation of cyanobacteria with minimal negative impact on their viability and the surrounding environment.

The Fe-EDTA chelate complex showed the best results among all the compounds tested. Its use ensured pH stability, efficient flocculation, and minimal impact on cell viability.

Conclusions. The addition of coagulants to the Microcystis pulverea culture causes morphological changes, including a change in cell color and medium viscosity, sediment formation, and the formation of clear flocs, which is clearly visible during microscopic analysis. The most pronounced changes in the culture were observed under conditions of incubation with Fe-EDTA: clear and well-formed flocs, resistant to mechanical stress.

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For the regulation of the number of cyanobacteria Microcystis pulverea by coagulation, it is recommended to use 40 mg/l Fe-EDTA with subsequent separation of the precipitated biomass.

***Conflict of interest**. The research was conducted in the absence of any commercial or financial relationship that could be interpreted as a potential conflict of interest.*

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ВИКОРИСТАННЯ FE-EDTA ЯК КОАГУЛЯНТА ДЛЯ РЕГУЛЮВАННЯ КІЛЬКОСТІ ЦІАНОБАКТЕРІЙ

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Робота присвячена дослідженню ефективності коагулянтів на основі заліза у боротьбі з ціанобактеріями, зокрема Microcystis sp., у водному середовищі. У ході експерименту було оцінено вплив різних сполук (FeSO4 та Fe-EDTA) на морфологічні зміни культури ціанобактерій, зміни pH середовища та токсичність цих сполук. Встановлено, що коагулянти на основі заліза сприяють утворенню флокул і зменшенню оптичної густини культури, що вказує на ефективність осадження клітин. При цьому, застосування хелатної форми заліза (Fe-EDTA) продемонструвало найкращі результати, з мінімальними змінами pH і низьким рівнем токсичності. Дослідження підтвердило перспективність використання коагулянтів на основі заліза для зниження чисельності ціанобактерій, що є важливим для покращення якості води та боротьби з водоростевими цвітіннями.

Ключові слова: коагулянти, коагуляція, цвітіння ціанобактерій, Microcystis pulverea, ціанобактерії, ціанотоксини.

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