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Intensification of storm water treatment of wood transfering wood termination facilities

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Abstract. The study presents the experience of operating water treatment plants, analyzes the dangerous consequences of pre-chlorination during the discoloration of natural waters, and examines the mechanisms of action of chlorine-containing components on organic impurities contained in untreated water. The necessity of pretreatment of water before prechlorination, which ensures the mandatory destruction of organo-complex compounds, has been determined. The principles of pretreatment of natural waters in a biologically active environment are substantiated, which will eliminate the formation of toxic substances and pathogenic microorganisms.

Keywords: water purification, dissolved organic substances, chromaticity, danger of bacteriological contamination, toxic products

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Экологизация обработки природных вод, содержащих растворенные органические вещества

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Аннотация. Представлен опыт эксплуатации водоочистных комплексов, проведен анализ опасных последствий предварительного хлорирования при обесцвечивании природных вод, рассмотрены механизмы воздействия хлорсодержащих компонентов на органические примеси, содержащиеся в неочищенной воде. Определена необходимость предварительной обработки воды до предхлорирования, обеспечивающей обязательную деструкцию комплексоорганических соединений. Обоснованы принципы предварительной обработки природных вод в биологически активной среде, что позволит исключить образование токсичных веществ и патогенных микроорганизмов.

Ключевые слова: очистка воды, растворенные органические вещества, цветность, опасность бактериологического загрязнения, токсичные продукты

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Introduction

The world practice of purification of highly coloured natural waters in water supply systems shows that in recent years, even with the complexity of technologies, it is not possible to achieve a sufficient removal of dangerous impurities from the water. One of the reasons for this problem is insufficient account of transformation of various chemicals used in water preparation actively interacting with dissolved organic matters (DOM), some of which determines the coloring of water – colorability. The toxic substances and bacteriological products generated in water purification processes can often be no less hazardous than known natural and anthropogenic pollutants from water sources [1; 2].

Thus, it becomes clear that when using traditional water treatment technologies in which the basis is the use of chemicals – chlorine in primary chlorination (pre-chlorination), coagulants, flocculants and other reagents, The nature of water impurities is not fully taken into account, and the result of the interaction may significantly change the properties of water to the point where toxic substances are present [3]. Therefore, the task of greening water preparation as an improvement and rational use of technologies becomes relevant, meeting the modern requirements to ensure the required quality of the purified water while eliminating the risk of hazardous products and preserving all the main environmental properties.

Materials and methods

In the world practice of water treatment until recently for high color waters containing dissolved organic matters (DOM), Reagent purification methods with pre-chlorination and water lightening in septic tanks or lighters with a layer of suspended sludge are used mainly when filtering it through the granulated feed. However, experience with such technologies shows that in most cases the cleaning efficiency is very low [3; 4].

It was previously thought that the elimination of organochlorine compounds in drinking water could be achieved by using UV-radiation instead of primary chlorination [5]. It was also noted that this solution is applicable to source water from surface sources with low organic pollution. This conclusion can be based only on the supposition that a microbial UV-radiation suppressor is present in water containing DOM and chlorinated compounds are not formed in the absence of chlorine reagents. The UV exposure cannot influence the reduction of DOM concentration. Only the enzymes of microorganisms that are necessarily present in the treated water can have a destructive effect on complex, stable DOM. At the same time, the number of microorganisms according to Shelford's tolerance law always corresponds to the volume of "food products" in the environment. It should also be borne in mind that the use of UV decontamination with a certain energy capacity also entails the risk of toxic and mutagenic products forming when different compounds present in the treated water are transformed [5].

Preliminary ozone disinfection has been considered for a long time as an appropriate option even in the treatment of natural waters containing DOM [6]. However, it turns out that even more toxic than chlororganics are formed in this case and the absence of active species of microorganisms is not guaranteed. Therefore, biocorrosion of metal structures and formation of carcinogenic components based on DOM are not excluded. The mechanism of ozone action on organic compounds in water modifies them to carcinogens that may have adverse effects on human health [7]. The effect of increasing pathogenic micro-organisms, which is caused by biodegradable organic compounds [8–10], is also found in the water pipes during the ozonation. Also known to be a more dangerous toxic ingredient than chlorine, it enhances corrosion processes, can explode, requires trained maintenance personnel and special safety measures [11–13].

Results and discussion

The pre-removal technology for DOM must include effective destructive treatment – active exposure to complex organic substances, ensuring their elimination. It should be simple enough and inexpensive. Thus, the destructive effects on DOM for their removal should be carried out before water is introduced into the purification devices during the pre-cleaning stage. The enhancement of ROP degradation is possible under artificially created optimal conditions of microorganism immobilization in special devices – bioreactors, in which a specific microbe is formed. It should be borne in mind that the quantitative and qualitative composition of microorganisms will always be formed and modified according to changing conditions of the environment – water containing DOM.

Bioreactors can be placed directly in reservoirs or in premises on the territory within water treatment complexes. An important condition for the operation of bioreactors is to create optimal conditions for immobilized microbiome, which are determined by chemostat regime. Optimal conditions of metabolic activity of immobilized microorganisms in bioreactors can be created by using mesh carriers with an advanced surface, the design of such devices is developed at Far Eastern Research Institute of Hydraulic Engineering and Land Reclamation [10]. These biocatalysts ensure uniform flow in the working area of the nutrient substrate – treated water containing organic matter, and also provide spontaneous discharge of excess biomass and simplified regeneration of the attachment. The mechanism of decomposition of micro-organisms is complex enough and is explained by the Some microorganisms use the organic part of the molecule or the energy of the reaction to convert such compounds to support their life. Such microorganisms in the course of their metabolism use to sustain their life the organic part of complex compounds and for the destruction of these molecules use some metabolic products, such as hydrogen peroxide, which is significantly "save" energy to ensure this process.

To control microbial species composition in bioreactors to reduce the risk of pathogenic and potentially pathogenic microflora, it is possible to introduce into the purified water microbiological preparations that include only strains of non-pathogenic species, for example "Em-Bio Aqua", produced in the Primorsky Krai. They must be numerically superior, thus enabling the suppression of competing species, including pathogenic and potentially pathogenic micro-organisms. It should be noted that the PRV biotransformation involving microorganisms occurs at a molecular level and is considered to be significantly (by several orders of magnitude) faster than physical-chemical methods of destruction.

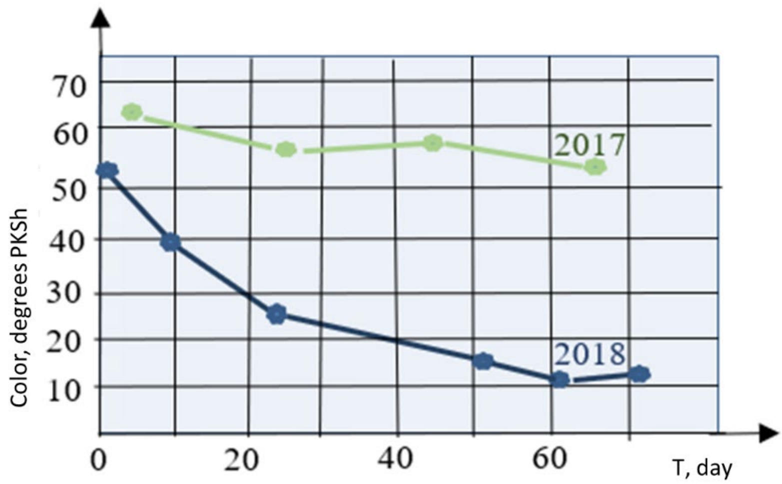
Pre-treatment of water directly in the reservoir [6] has some advantages, as the resulting sediment remains in the reservoir and does not enter the treatment facilities. In the free volume when introducing microbiological preparations, the process of DOM degradation is significantly slowed down, which is especially noticeable at low water turbidity and is confirmed by the results of studies on a natural site.

Studies on the reduction of DOM with the aid of the drug “Em-Bio Aqua” were conducted on an artificially formed pond for recreational purposes in one of the neighborhoods of the village Luchegorsk (Primorsky Krai) [6; 13]. The pond is a shallow water of up to 1.5 m deep and has a total volume of up to 3.2 thousand m^3. For a long time in the warm season, the water had an increased color within 50–60 degrees PCS, which indicated the presence of dissolved organic matter in the water, with a smell up to 4–6 points. The preparation “Em-Bio Aqua” with a total volume of up to 200 l was applied once relatively evenly sprinkling on the surface of the pond. At the same time, clay galls were introduced into the pond water. In the experiment, 230 clay galls (about 1 gall per 10 m^2) were injected into the pond, which is approximately 20 times less than the established standard. Clay galls – EM-clayballs, obtained from clay mixed with a microbiological preparation with the addition of pathogen (nutrient), in which non-pathogenic microorganisms contained in “Em-Bio Aqua” develop intensively. When placed in water, the clay galls are a long-term source of microorganisms capable of causing DOM degradation.

The determination of colorability after application of the drug showed that only after 30–60 days the colorability decreased to 10–20 degrees PCS. For comparison, the color chart is given for the same season (July-August) 2017, when the drug was not introduced and the color remained relatively high throughout the warm period of the year (Figure).

The results of the experiment prove that, if the regulation and the dose of microbiological preparation are carefully justified, it is possible to carry out a preliminary treatment of water directly in the reservoir. It should be noted that at a significantly understated concentration of the drug “Em-Bio Aqua” is reported to be quite high efficiency of DOM reduction, even if we judge only by water coloring substances. It is also noted the effect of deodorization of water in the pond – within 20–30 days, the level of odor was reduced by half from 4–5 to 2 points.

Interaction of microorganisms with DOM within the reservoir (free volume) ensures the release and accumulation of sediment in the bottom part of it. It is necessary to prevent the introduction of pathogenic bacteria and viruses into water. If the sediment in the water has a high enough concentration of microorganisms, and the concentration of DOM in the water is higher than in the sediment, it becomes a “supplier” of these microorganisms to the aquatic environment.



Change in the color of water in the pond of the village of Luchegorsk when applying the microbiological preparation "Em-Bio Aqua"
Source: compiled by the author T.Yu. Popova.

Influence the composition of microbiota of bottom sediment and form in it a non-pathogenic microflora possible, for example, by applying clay galls made on the basis of the preparation "Em-Bio Aqua" (EM-clayballs). The number and microbiological species of bottom sludge are thus regulated, and the risk of bacterial contamination of water by pathogenic species is reduced. Moreover, experimental studies on a number of Primorsky Krai's water bodies have shown that bottom sediment is self-compacted mainly by the release of associated water due to the destructive effects of microorganisms and the capacity of the silt deposit can be reduced by 4–6 times.

The species composition of the microbe and number of micro-organisms (C_M) – biomass, for example, per unit volume of apparatus (bioreactor or reservoir), depend on a large number of factors, and above all on the nutritional value of the substrate – concentrations of DOM in water (C_{DOM}) and forms of these substances (A_{DOM}), from temperature (t), hydrogen ion concentration (pH), water muddiness (M), flow speed (V), interaction duration – contact time (T) of the DOM with microbiologically active medium. The importance of reactor volume (Wp) and geometry should also be considered, as they determine the mixing activity of products and impurities, flow direction and displacement regime. Some other less important characteristics of the bioreactors are also relevant. The significance of these factors may vary depending on the type of bioreactors and their location, and the reaction mechanism can be presented as a functional dependency as follows:

$$C_M = f \cdot (C_{DOM}, A_{DOM}, t, \text{pH}, M, V, T, W_p). \quad (1)$$

In reactor theory the reaction mechanism is usually considered known, therefore formal kinetics are applied, and although in our case the process of DOM biotransformation cannot be considered sufficiently studied, to consider this process will have to be modeled in the light of macrokinetic views on biochemical reactions. It is necessary to take into account a number of factors, usually not considered in the kinetics, fundamentally related to the course of reaction in the reactor volume, in particular the diverse interaction of competing antagonistic species of microorganisms. The experiment allows to establish that in the reservoir (or pond) processes occur mainly in free volume and when placed on the bottom of clay galls non-pathogenic microorganisms constantly come water, which works like an intermittent bioreactor. The functional dependence (1) and analysis of the results of the experiment allows only preliminary conclusions to be made about the chosen approach in solving the problems of DOM degradation and management of the qualitative microbiological composition is quite acceptable in the practice of water preparation – preliminary water treatment.

In particular, it is necessary to determine the basic design characteristics and optimal doses of microbiological preparation required for DOM destruction and regulation of microbial species composition in reactors and reservoirs. It is known that the non-linearity of these systems is the reason for the preference of numerical methods of solution. Mathematical modelling, widely applied in quantitative microbiology, taking into account the variable concentrations of DOM in the substrate, the source water and analysis using differential equation systems provide an opportunity to substantiate the main conditions for the application of the proposed pre-treatment technology.

Conclusion

The treatment of natural waters containing DOM should take into account the critical features associated with the risk of pre-chlorination. This danger arises for two main reasons. First, because the chlorinated reagents form integrally organic compounds that are resistant to degradation. Secondly, by embedding in the structure of complex DOM molecules, chlorinated agents lose their disinfecting properties and their decontaminating potential is significantly reduced. The toxic and carcinogenic substances and bacteriological products produced in water purification processes can often be as dangerous as known natural pollutants from water sources.

Presence in water of DOM, representing nutritional value for microorganisms, shows active filling of this environment by bacteria of various kinds, The competitive nature of these species and the mutagenic properties of the microflora result in the formation of unpredictable microbial composition and hazard in the water to be treated.

The application of biocatalysts with immobilized microorganisms for the treatment of natural, particularly high-color, waters containing DOM in the first stage of their purification will achieve significant economic effects due to reduced operating costs. This pre-treatment of the water will ensure a reduction in coagulant doses when retaining or illuminating, improve the performance of filters or lighters by increasing the sorption effect of the mineralized pollutants; extend the service life of the supply system – water distribution by reducing the intensity or completely stopping the bio-corrosion processes in pipelines, and will also improve the organoleptic properties of water by eliminating toxic organochlorine compounds and other ingredients associated with increased doses of coagulant.

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