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STUDY OF THE WASTEWATER TREATMENT PROCESS IN THE SECOND-FOURTH CORRIDORS OF THE AERATION TANK-MIXER

Wastewater entering the reservoir after use in industrial and domestic processes contains organic and inorganic pollutants. A peculiarity of wastewater in settlements, the territory of which is saturated with transport, industrial facilities, residential complexes, is a significant unevenness of flow during the day and fluctuations in the concentration of pollutants. This significantly complicates the operation of structures and leads to periodic violations in their operation mode [1]. As a result, insufficiently purified wastewater enters reservoirs and provokes deterioration of the environment, outbreaks of infectious diseases [2, 3]. Such situations occur periodically, but due to the self-cleaning ability of water bodies, they do not have catastrophic consequences.

At the same time, with a constant excess of pollutant concentrations in wastewater, treatment plants do not provide standard cleaning quality and may become inoperable altogether. Such a situation is more typical for biological treatment facilities, which occurs due to the vital activity of aerobic microorganisms inhabiting activated sludge. The loss or death of activated sludge is a local environmental disaster, the consequences of which will be felt by every inhabitant of the settlement [4]. The problem of ensuring the regulatory quality of wastewater treatment at biological treatment facilities remains relevant, which determined the direction of the presented work.

The state has undertaken to protect citizens from loads, risks to health and well-being associated with the environment [5, 6]. Among the strategic goals and indicators of their achievement, the first goal is aimed at "ensuring equal access to high-quality and safe drinking water for human health and appropriate sanitary and preventive measures" [6]. One of the indicators of this goal is the quality of wastewater discharges from treatment facilities into water bodies. A set of various legal, financial, organizational and technical measures must be directed towards its achievement.

One of these measures is improving the quality of wastewater treatment at municipal facilities. Given that reconstruction and modernization require large amounts of money, it is worth paying attention to the possibility of increasing the efficiency of cleaning by improving the

technological mode of operation of objects [7]. Scientists in Ukraine and abroad are dealing with these issues. They work in different directions and consider possible ways to improve the technological scheme of biological purification.

Despite the large volume of scientific works, unfortunately, it cannot be asserted that there has been a qualitative improvement of the water condition in water bodies into which treated wastewater is discharged. The problem of ensuring the regulatory quality of wastewater treatment is currently relevant and requires further scientific research. In order to solve it, it is proposed to investigate the course of the cleaning process in the aeration tank-mixer and to propose measures aimed at compliance with the technological regulations for the operation of biological wastewater treatment facilities.

The purpose of the work is to investigate the peculiarities of wastewater treatment processes in the aeration tank-mixer and to propose measures aimed at observing the technological mode of operation of biological treatment facilities.

Achieving the set goal involves solving the following tasks:

- analyze the stages of wastewater treatment;
- determine the factors affecting the course of cleaning processes;
- propose measures to ensure the regulatory quality of wastewater treatment at biological treatment plants.

The scientific novelty of the obtained results lies in the improvement of the model describing the process of wastewater treatment in an aeration tank-mixer. In fig. 1 shows a section of an aeration tank with four corridors. In the first corridor (Fig. 1, point 1), regeneration of activated sludge takes place, that is, restoration of its oxidizing capacity. Compressed air is constantly supplied to maintain the sediment in a suspended state and to activate the oxidation of organic substances. For this, filter pipes are laid along the bottom of the corridor, which provide aeration of the liquid throughout the entire volume. By pumping sediment from the receiving tank of the pumping station, the circulation of activated sludge in the aeration tank-secondary sedimentation system is ensured.

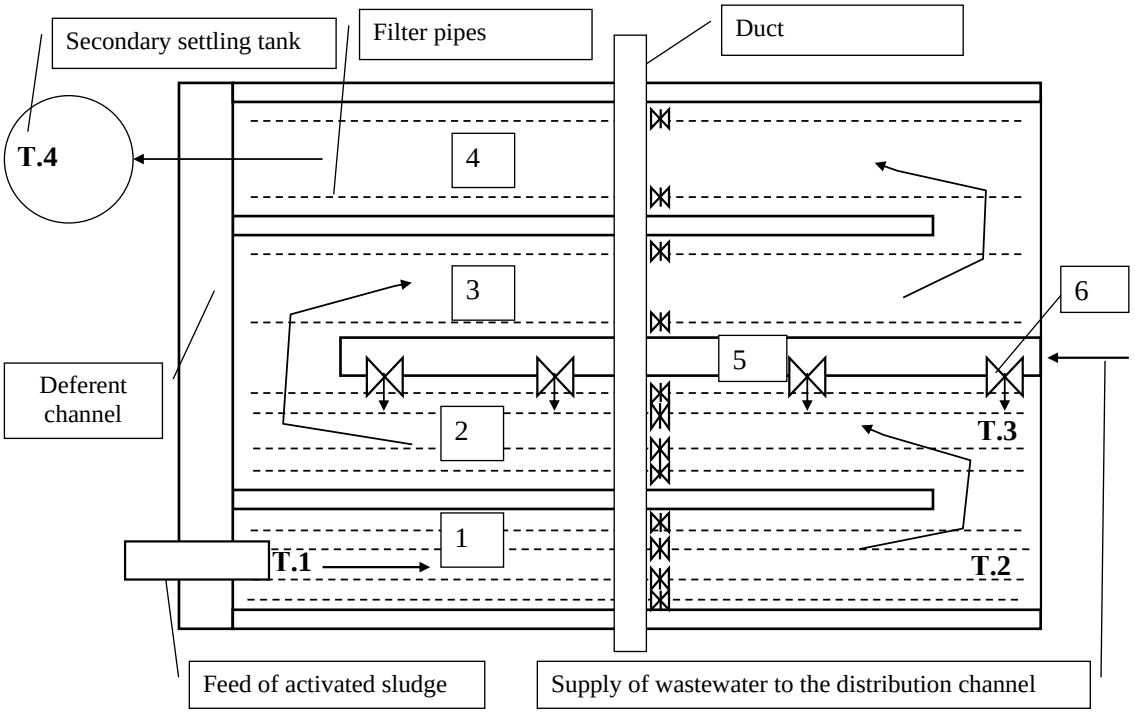

Fig. 1. **Scheme of the aeration tank-mixer section:**
1 – regenerator (first corridor), 2 – second; 3 – the third corridor, 4 – the fourth corridor; 5 – distribution channel; 6 – slide valve

In the second corridor of the aeration tank (Fig. 1, point 2) through the distribution channel, clarified liquid is supplied after mechanical cleaning. Constant supply of a new portion of liquid ensures its movement along the corridors due to extrusion. As a result of the transition of dissolved organic matter from wastewater to activated sludge biomass, a purification process takes place. In the first two corridors, the structures maintain a high level of aeration for oxygen saturation and maintenance of the mixture in a suspended state.

In the third and fourth corridors (Fig. 1, points 3-4), the level of aeration decreases by approximately two times due to the reduction of the number of parallel rows of filter pipes. Next, the mixture enters the secondary settling tank, which is designed to separate water from sediment. Purified water is disinfected, then sent to the tank through channels. Sludge enters the receiving tank of the sludge pumping station through pipes. From here it is pumped into the regenerator, where the process is repeated. After restoration of oxidizing capacity (regeneration), activated sludge enters the second corridor of the aeration tank. Clarified wastewater is also supplied here after mechanical cleaning, which is evenly distributed along the length of the corridor.

The processes occurring in the second-fourth corridors and the secondary settling tank are proposed to be considered together. This is due to the fact that the course of processes in this part of the structure depends on the flow of wastewater, the consumption and concentration of activated sludge, as well as the concentration of oxygen. You can change these indicators in the second corridor. This means that the concentration of pollutants at the exit from biological treatment facilities is primarily influenced by the course of processes in the second-fourth corridors of the aeration tank.

Provisions of the theory of experiment planning [8] were used to prepare and directly conduct the experiment. It involves the determination of input values (factors) that affect the flow of the process in the regenerator. Next, the variables were coded according to the standard method and a plan-matrix was built taking into account a number of factors. The results of laboratory studies were used to determine the limits of factor variation. After analyzing the values of wastewater flow, flow and concentration of activated sludge, oxygen concentration obtained at the biological treatment facilities of the city of Kharkiv, the values and limits of variation of the factors were determined. As a result of processing the results of experimental studies, a model was obtained *(1):*

$$y_{sw} = 0{,}01032 - 0{,}00074 \cdot x_3 + 0{,}00007 \cdot x_4 - 0{,}00209 \cdot x_5 - 0{,}00021 \cdot x_6 + 0{,}00167 \cdot x_3^2 + 0{,}00042 \cdot x_4^2 + 0{,}00293 \cdot x_5^2 + 0{,}00193 \cdot x_6^2 + +0{,}0069 \cdot x_3 \cdot x_4 - 0{,}00119 \cdot x_3 \cdot x_5 + 0.00006 \cdot x_3 \cdot x_6 - 0{,}00006 \cdot x_4 \cdot x_5 - -0{,}00006 \cdot \mathrm{x}_4 \cdot \mathrm{x}_6 - 0.00044 \cdot \mathrm{x}_5 \cdot \mathrm{x}_6 \quad (1)$$

Dependence *(1)* allows, without additional research, to determine the concentration of pollutants in treated wastewater at the outlet of secondary sedimentation tanks, taking into account the dose of activated sludge (x_3) coming after the regenerator, indicators of wastewater (consumption (x_4)) and concentration of pollutants (x_5) in wastewater, dissolved oxygen (x_6). In fig. 2 shows the result of the calculation according to model *(1)*, which was carried out at zero values of the sludge dose (x_3=0) and dissolved oxygen concentration (x_6=0). The analysis of the obtained result allows us to state that the concentration of pollutants in the wastewater that enters the treatment has the greatest influence on the result of the treatment.

Thus, the calculation showed that the quality of biological wastewater treatment depends on the ratio of indicators of wastewater, activated sludge and air. At the same time, the nature of the impact of individual indicators differs depending on their combination. The use of the proposed model (1) allows you to calculate the result of cleaning based on the data on the characteristics of wastewater entering for cleaning and taking into account the operating conditions of the facilities and to propose changes to the technological regulations for the operation of the aeration tank.

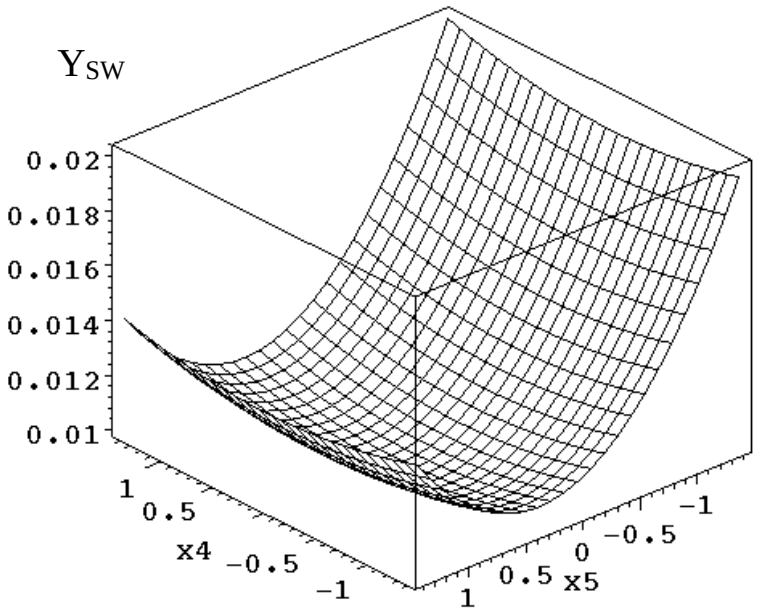

Fig. 2. **Dependence of the concentration of pollutants at the outlet of the secondary sedimentation tank (y_{SW}): from the concentration of pollutants in wastewater (x_5), with which they enter for treatment, and the consumption of wastewater (x_4) at values of the sludge dose (x_3) and the concentration of dissolved oxygen (x_6) at the zero level**

The availability of the calculation results obtained using model (1) allows you to quickly react to changes that occur in the cleaning process, namely the rate at which wastewater enters for cleaning and the concentration of pollutants in it. Thanks to this, the regulatory quality of cleaning will be ensured and the requirements regarding the impact on the quality of water in the reservoir that receives treated wastewater will be met. This approach is aimed at protecting the environment, namely water in water bodies from contamination by organic substances that may enter with insufficiently treated wastewater.

Conclusions. The peculiarities of the operation of biological treatment facilities, which include an aeration tank-mixer and a secondary sedimentation tank, are analyzed. The analysis showed that biological treatment processes can be influenced by adjusting the relationship between the dose and consumption of activated sludge, the concentration and consumption of wastewater, as well as the concentration of dissolved oxygen.

According to the results of processing the results of the experimental study of the cleaning process in the second-fourth corridors of the air container, model *(1)* was obtained. The specified model takes into account the mutual influence of the parameters of wastewater entering for treatment (consumption and concentration of pollutants), activated sludge (consumption and dose), and the presence of dissolved oxygen.

It is proposed to use model (1) to comply with the operating regulations of biological treatment facilities, which are an aeration tank-mixer-secondary settling tank system, which allows you to study the course of the cleaning process without additional experiments, taking into account possible changes. The obtained results are aimed at ensuring the quality of wastewater treatment and preventing insufficiently treated wastewater from entering reservoirs.

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