

WASTEWATER TREATMENT FROM NITROGEN COMPOUNDS

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National University of Food Technology***Suleyko T.***Assistant,**National University of Food Technology***Reshetniak L.***Ph.D of Technical Science, Associate Professor of the department of biotechnology**National Aviation University***Abstract**

Increasing the concentration of nitrogen compounds in wastewater has led to a deterioration of surface water quality, which is the main source of economic drinking water supply for the vast majority of Ukrainians. The Government of reservoirs in the territory of Ukraine recorded an excess of norms for ammonia nitrogen - 2-15 times, nitrates - 7-20 times. The consequences of contamination with nitrogen compounds are eutrophication, which is caused by hypertrophied development of algae ("flowering"); reducing oxygen content.

Keywords: immobilized organisms, anaerobic-aerobic purification technology, sewage, biological treatment, bioreactor.

Ammonia, ammonium compounds, nitrites, and especially nitrates, create adverse conditions for the vital activity of reservoir biocenoses. Groundwater contains excessive concentrations of nitrates (100-500 mg /dm³), and the constant use of such water has a negative impact on human health. Compared to the last decade, the content of nitrogen compounds in wastewater receiving treatment has increased by at least 5-7 times. However, the vast majority of existing biological wastewater treatment plants cannot provide the required quality of purified water for nitrogen compounds today [2].

Modern foreign technologies for biological treatment of wastewater from nitrogen compounds, such as Ludzak-Ettinger, Bardenpho, Biodenitro, Carrousel, JHB, UCT, MUCT, A2/O, are characterized by significant energy and material consumption, waste volumes, so the development of new technology that will ensure high efficiency of wastewater treatment from nitrogen compounds in accordance with current standards with minimal cost of both economic and material resources [1, 3].

The purpose of the study was to screen and develop wastewater treatment technology using immobilized microorganisms with high efficiency of removal of nitrogen compounds while maintaining operating standards, with minimal energy consumption and low waste.

To achieve this goal, it is necessary to solve the following problems:

- to identify the features and systematize the existing methodological technologies of wastewater treatment from nitrogen and nitrate compounds in directflow bioreactors with immobilized microorganisms;
- to investigate the effect of hydraulic loading and initial concentration of ammonia nitrogen on the rate of oxidation of ammonia nitrogen, the load on the bioreactor and its basic capacity on ammonia nitrogen;
- to study the effect of aeration system placement in bioreactors with immobilized microorganisms on the oxidizing power and efficiency of ammonia nitrogen wastewater treatment;
- to study the composition of biocenosis immobilized on the fibrous carrier of the biofilm by optical microscopy;
- to investigate in the production conditions of biological film hydrobionts during the periodic operation of structures and changes in ambient air temperature;
- to develop a mathematical model of aerobic wastewater from ammonium using immobilized microorganisms and hold it tested in the laboratory;
- to develop anaerobic-aerobic technology for purification of wastewater from nitrogen compounds using immobilized microorganisms.

The object of study is sewage containing nitrogen compounds.

The subject of the study is the processes of anaerobic purification of wastewater from nitrogen compounds using immobilized organisms.

The experiments used photocolometry, potentiometry, gravimetry, pH-metry, optical microscopy. Process modeling and statistical results processing were performed using personal computer software (Mathcad, Excel).

As a result of research:

1. The regularities of the processes of sewage treatment from nitrogen compounds in bioreactors using immobilized organisms with high oxidizing power ($80-110 \text{ g}/(\text{m}^3 \cdot \text{d})$) were established and the technology of sewage treatment with the efficiency of ammonia nitrogen removal was developed 98,2-99,4%.

2. First installed that the use of perpendicular motion of air jets in the bioreactors relative to the direction of movement of wastewater and lengthwise relative to the carrier of immobilized microorganisms allows to increase the rate of oxidation of ammonium nitrogen at the initial aerobic stage by 40% compared with the lengthwise placement.

3. It has been established that the process of sewage treatment in bioreactors with immobilized organisms can be carried out in the conditions of periodic operation of treatment plants and at low temperatures of ambient air (up to -32°C) with self-healing of biomass of hydrobionts while providing the necessary technological modes of operation of facilities.

The anaerobic-aerobic technology of sewage treatment from nitrogen compounds has been developed, which is realized stepwise in buildings immobilized on the carrier organisms. The rational technological modes of sewage treatment from nitrogen compounds, technological parameters of bioreactors with immobilized microorganisms for realization of technology at sewage treatment plants are offered. The use of bioreactors with the proposed perpendicular placement of the aeration system with respect to the direction of wastewater movement allows to increase the oxidation capacity of the bioreactor.

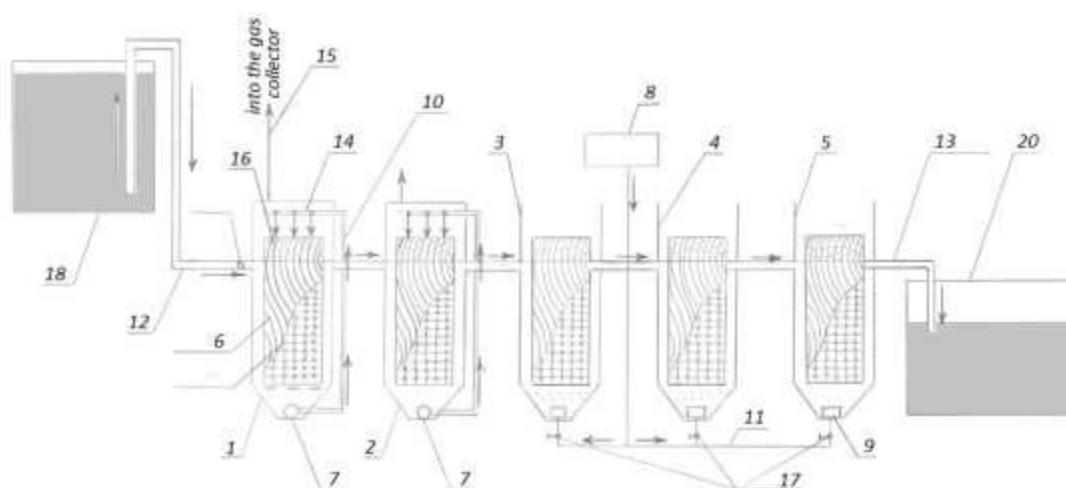


Figure 1 Scheme of laboratory installation

1, 2 - anaerobic bioreactors; 3, 4, 5 - aerobic bioreactors; 6 - mineral carrier; 7 - circulation pump; 8 - compressor; 9 - small bubble aerator spray; 10 - recirculation pipeline; 11 - air duct; 12 - waste water supply pipeline; 13 - a pipeline for drainage of purified water; 14 - perforated tube; 15 - gas pipe to the gas tank; 16 - the valve; 17 - valve for regulating air supply; 18 - consumption tank; 19 - support frame; 20 - collection of purified water.

The studies were performed on an artificially created model solution that is imitating the wastewater of a malt plant and an index of COD - $600-1500 \text{ mg O}_2/\text{dm}^3$, concentrations of organic nitrogen - $8-20 \text{ mg}/\text{dm}^3$, ammonium nitrogen - $6-14 \text{ mg}/\text{dm}^3$.

Known for immobilization of facets of biofilms is a mineral carrier. This carrier consists of separate elements in the form of cloths made of synthetic textured fibers and fixed.

Each panel is made of polyamide fibers, top and bottom areas is woven in the form of loops, each panel secured with wire installed in the loop. The cloth has a length of 1-3 m, a width of 2-5 m, a loop diameter of 0,15 - 0,20 m.

The use of polyamide fiber allows you to attach more organisms to it by increasing the adhesive capacity of polyamide fibers.

The effect of placement of the aeration system on the oxidation capacity of the bioreactor, the rate of oxidation of ammonium nitrogen and the efficiency of purification from ammonium nitrogen were investigated at the experimental plant № 2 (Figure 2), which consisted of three aerobic sections. The flow diagram of wastewater is direct-flow. The aerators are placed perpendicular to the movement of the wastewater and parallel to the media cassettes.

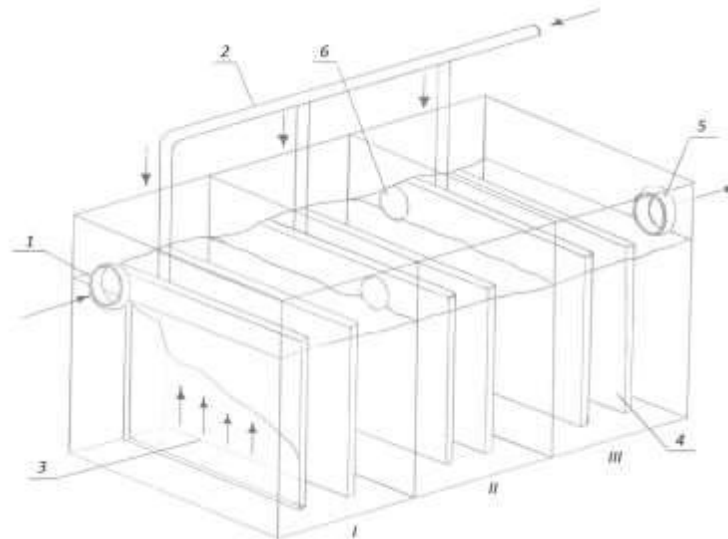


Figure 2 Scheme of laboratory installation № 2

1- supply of waste water; 2- air duct with air flow control valves from compressor; 3- perforated air duct; 4- cartridges with mineral carriers; 5- diversion of purified water into the drainage tank; 6- openings for water flow through sections; I, II, III - respectively 1, 2, 3 aerobic sections.

The next section presents the results of studies of the processes of conversion of ammonia nitrogen, nitrites, nitrates by anaerobic-aerobic technology and determined rational technological parameters. It has been found that when treating wastewater containing nitrogen compounds using anaerobic-aerobic technology after the anaerobic stage, the concentration of ammonium nitrogen entering the aerobic bioreactors increases 2-3 times (Figure 3).

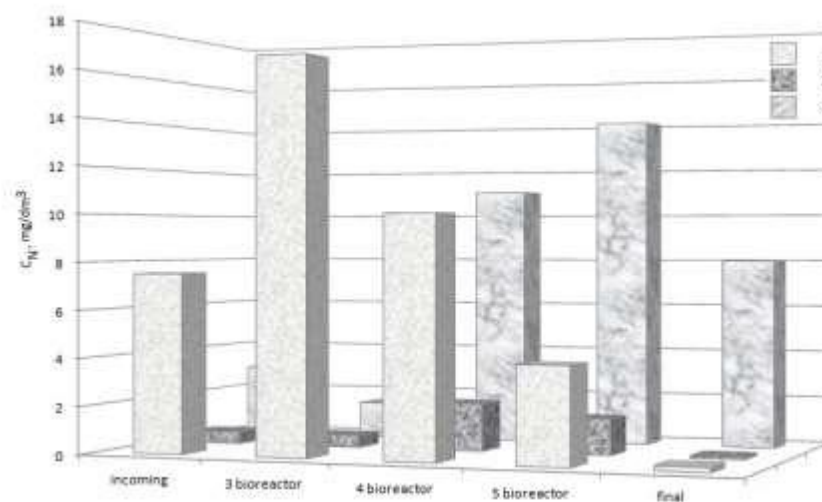


Figure 3 Change of concentrations of nitrogen compounds in the process of sewage treatment under hydraulic load $4.3 \text{ m}^3/(\text{m}^3 \cdot \text{day})$: 1 - NH_4^+ ; 2 - NO_2^- ; 3 - NO_3^-

It is established that when using anaerobic-aerobic technology the total effect of purification on ammonium nitrogen is 96,3-98,5 %, and the concentration of nitrate and nitrite in treated water comply with discharge into natural reservoirs of fishery purposes. According to the results of studies, the concentrations of

nitrogen compounds were: ammonium – 0,5-1,5 mg/dm³, nitrites – 0,01-0,04 mg/dm³ and nitrates - 8-12 mg/dm³. As the hydraulic load decreases, the duration of cleaning and therefore the volume of the structure increases. The choice of a rational hydraulic load is based on the combination of a minimum cleaning duration with the maximum ammonium nitrogen removal effect. It is established that the efficiency of sewage treatment by ammonium nitrogen reaches 98,2-98,5 % (Figure 4) and is provided by the following values of technological parameters: hydraulic load - 5,5-5,8 m³/(m³·day)); total cleaning time - 20-22 h; duration at each stage - 4-4,4 hours; load on ammonia nitrogen - 8- 20 mg/(g·day); ammonia nitrogen oxidation rate - 4-12 mg/(g·day); oxidation capacity up to 80 g/(m³·day).

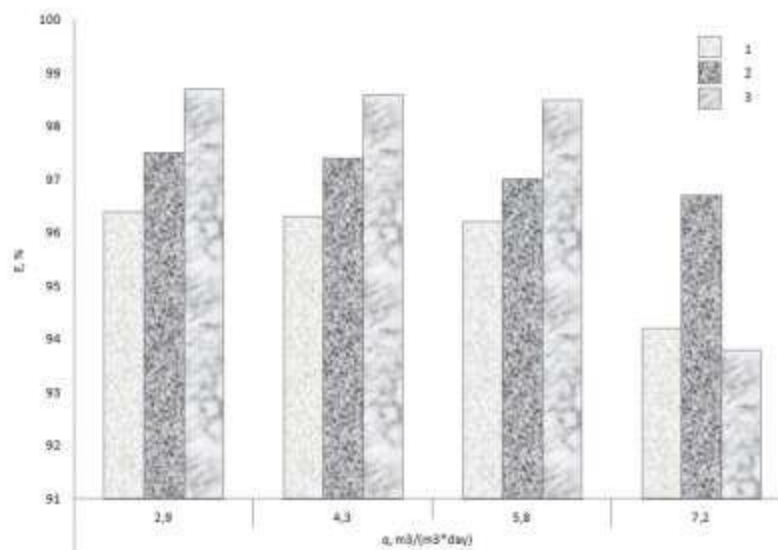


Figure 4

Dependence of removal efficiency of ammonia nitrogen E on hydraulic load q at concentrations of ammonia nitrogen at the beginning of aerobic stage $C_{incoming}NH_4^+$ start: 1 – 11 mg/dm³; 2 - 22 mg/dm³; 3 - 32 mg/dm³.

The concentration of ammonium nitrogen in aerobic conditions depends on the duration of purification in bioreactors. The major amount of ammonia nitrogen is removed in the first stages of the aerobic process (3,4 bioreactors). The decrease in the value of the oxidizing power in the fifth bioreactor, as well as the oxidation rate, is explained by the low concentration of ammonia nitrogen (5-10 % of the maximum CNH₄). Oxidizing power at high load on ammonia nitrogen (24-26 mg/(g·day)) is 100-110 g/(m³·day), which exceeds the values of oxidizing power on ammonia nitrogen in aerotanks of 20-5 g/(m³·day).

During the period of biomass growth, which lasted for about 30 days, studies of its species composition were performed using a ULAB XSP137BP binocular microscope. The technology is implemented sequentially in bioreactors with different oxygen conditions: anaerobic and aerobic, according to a direct flow scheme of water movement. At each stage of sewage treatment a specific biocenosis of microorganisms is formed, which is able to perform its functions in these conditions. Mineral carriers have been installed in all sections of the multi-stage scheme to attach and retain biocenosis. In anaerobic bioreactors there are carriers in wastewater and in the gas phase, which allows to increase the contact area of microorganisms with wastewater when using the irrigation system. The use of the anaerobic process in the first stages (1, 2 of the bioreactor) makes it possible to remove the majority of organic contaminants and reduce air flow compared to the initial aerobic stage. The next stage was carried out in bioreactors with aerobic conditions (3, 4, 5 bioreactors). After the passage of wastewater through anaerobic bioreactors, the concentration of organic matter is significantly reduced, which causes the flow of the first stage of nitrification. It should be noted that the presence of organic matter in the environment slows down the development of bacteria-nitrifiers, so nitrification of ammonium nitrogen begins only after almost complete oxidation of organic compounds.

The technological parameters of the aerobic fermentation technology of sewage treatment of the malt plant from nitrogen compounds using immobilized microorganisms are shown in table 1.

Table 1

The technological parameters of aerobic fermentation

Parameters	Units	Value
Load on ammonium nitrogen	mg/(g·day)	8-20
The rate of oxidation of ammonium nitrogen	mg/(g·day)	4-12
Oxidizing power by ammonium nitrogen	g/(m ³ ·day)	80-110
Efficiency of removal of ammonium nitrogen	%	98,2-99,6
Hydraulic load	m ³ /(m ³ ·day)	5,5-5,8

Dissolved oxygen in reactions biochemical oxidation of ammonium nitrogen is electron withdrawing them when moving and producing energy spent on the biosynthesis of cell material and support microorganisms (the concentration of oxygen in aerobic bioreactors 1,5-2 mg/dm³). In the interior of the carrier where there is no access of oxygen, but there is organic matter, conditions are created for the flow of denitrification. At low concentrations or the absence of organic matter under anoxic conditions, the process of anaerobic oxidation of ammonium nitrogen occurs under the conditions of high concentrations of ammonium, nitrite and low concentrations of organic carbon. As a result of the research, the concentrations of ammonium nitrogen, nitrates and nitrites were determined depending on the initial chemical composition and the flow of wastewater entering the production plant. Ammonium nitrogen comes in concentrations of 5-15 mg/dm³, but after anaerobic processes in the first two bioreactors its concentration increases 2-4 times due to the destruction of nitrogen-containing boundary compounds. At the inlet of the aerobic bioreactor there is a decrease in the concentration of organic matter and an increase in the concentration of inorganic, including ammonium compounds. In the aerobic bioreactors due to the active nitrification process is the oxidation of ammonium nitrogen to nitrites and nitrates, in addition, at the depth of the fibers is anaerobic oxidation of ammonium with the formation of molecular nitrogen, at the outlet in purified water is observed to reduce the concentration.

The article decided to scientific and technical objectives - a study of patterns of processes wastewater from nitrogen compounds using immobilized microorganisms and development in this technology-based anaerobic-aerobic purification with high efficiency removal of nitrogen while respecting existing regulations with minimal power consumption and a small amount in volume of waste.

As a result of researches it is established that when using the developed technology the efficiency of sewage treatment by ammonium nitrogen is 98,2-98,5 % and is provided by the following values of technological parameters: hydraulic load of 5,5-5,8 m³/(m³·day); total cleaning time - 20-22 h; duration at each stage - 2-4,4 h; load on ammonium nitrogen in aerobic bioreactors - 8-20 mg/(g·day); the rate of oxidation by ammonium nitrogen is 4-12 mg/(g·day), at initial concentrations of ammonium nitrogen at aerobic stages 11-32 mg/dm³.

It is established that the use in the bioreactors with immobilized microorganisms perpendicular to the movement of air jets relative to the direction of movement of wastewater affects the efficiency of the purification process. Provides an increase of the oxidation power by 30-40% at the initial stage of the aerobic process and the removal efficiency of ammonium nitrogen 98,4-99,6 % at C_{incoming}NH₄ to 30 mg/dm₃, hydraulic load of 5,5-5,8 m³/(m³·day) compared to the lengthwise placement of the aerators under the same process conditions, which allows to reduce the size of structures.

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