DISTRIBUTION OF INORGANIC NITROGEN COMPOUNDS IN PURIFICATION OF STORM WASTEWATER OF THE ENGINE-BUILDING MANUFACTORY

**Purpose.** To define peculiarities of distribution of nitrates, nitrites, ammonium ions in water and their ratio at biological treatment of storm wastewater of the engine-building manufactory from petroleum products.

**Methodology.** The efficiency of treatment was tested at real treatment facilities of STF No. 24 Motor Sich Plant, where on different sites of a clearing construction there was determined the content of the Nitrogen compounds in experimental and two control sections of a settler in parallel during purification of wastewater of petroleum products. In the experimental section, purification of storm waters was conducted by means of 76 set “rafts” with a carrier of the “VIYA” type, and in control sections — by means of a biosorbent of “Ekolan-M”.

**Findings.** Comparative characteristic of space-time distribution of ammonium ions, nitrites and nitrates at biological purification of storm wastewater from petroleum products using the synthetic carrier for an immobilization of microorganisms and a biosorbent was given on the basis of the processed data on the Nitrogen inorganic compounds content in water of a clearing construction. According to the results of calculation of the coefficient of relative utilization of Nitrogen by microorganisms during the process of purification of storm wastewater from petroleum products, we found out that process of ammonium nitrification during the summer season is more intense than during the autumn season. A biotechnology for purification of storm wastewater of oil products is offered with use of the floating bearing elements with a fibrous carrier of the “VIYA” type.

**Originality.** Biological treatment of storm wastewater from oil products using a carrier of the “VIYA” type is a relevant and primary on the way to environmental safety of surface water. Applying this biotechnology, it is possible to reduce the content of inorganic Nitrogen compounds if a vertical placement of the artificial “VIYA” carrier is additionally implemented to the entire depth of the sewage treatment plant channel (down to 3 m). To do this, we proposed to use the design of “rafts” with additional vertical frames with a carrier of “VIYA” type.

**Practical value.** When using “rafts” with a carrier of the “VIYA” type for the treatment of oil-contaminated storm wastewater, the economic indicators improved significantly and operating costs decreased at treatment facilities of Motor Sich JSC. The results obtained are the basis for upgrading existing water biotechnologies and developing new ones where for an intensification of processes of purification of storm wastewater of the industrial enterprises of petroleum products the immobilized microbiocenoses are used. Complex use of the fibrous carrier of the “VIYA” type and higher water plants for biological purification of storm wastewater from petroleum products and Nitrogen inorganic compounds will become the subject of our further research studies.

**Keywords:** storm wastewater, petroleum products, biological purification of water, nitrates, nitrites, ammonium

---

The main role in solving the problem of protecting Ukraine’s water resources from pollution belongs to the process of treatment of storm sewage. Among the existing methods of wastewater treatment, biological methods are the cheapest and most affordable. Often they are the only methods that can be used in practice. Modern biological wastewater treatment methods are developed, in most cases, using artificial biocenoses in aeration tanks and biofilters. Microorganisms are the main biological agents that carry out biodegradation, since they have a wide variety of enzymatic systems and are characterized by high metabolic liability. They are able to decompose a wide range of chemically stable compounds, including polycyclic petroleum products and their derivatives [4]. Microorganisms have such a metabolic apparatus that allows them to use oil products and oil as a source of energy and carbon [5].

**Literature review.** Active strains of microorganisms—destructors are used for biological purification of water from toxic substances — pathogens, but as the research has shown it is not enough. They must be kept in treatment facilities; also special conditions must be created to prevent them from being washed out by a continuous stream of purified water. For this purpose, it is necessary to attach (fix) microorganisms in any carriers inside the treatment apparatus [6]. Carriers of the...
“VIYA” type made of thin chemical textured fiber (TU 996990-89) are increasingly used in Ukraine to immobilize micro biota.

Nowadays, immobilized biocenoses with the participation of microbes and fouling organisms are also finding increasing application for wastewater treatment in sewage treatment plants and liquid toxic waste storage ponds. The possibility of effective treatment of storm sewage from oil products using immobilized microorganisms and fouling organisms on the carrier – “VIYA” was proved on practice [7].

For the effective treatment of storm sewage from industrial enterprises, it is necessary to create additional biological hydraulic structures. The intensification of storm water treatment is based on the fact that floating elements – “rafts” are used as hydraulic structures, in the lower surface of which the fiber carrier “VIYA” is fixed, which just increases the ability of biological treatment of storm sewage. Information about the use of such biotechnologies for the effective treatment of surface and wastewater in Ukraine, where floating load-bearing elements in the form of “rafts” with a carrier of “VIYA” type were used, is presented in research work [8].

Unsolved aspects of the problem. Due to the increase in anthropogenic influences on water bodies, the problem of the quality of water and the aquatic environment has become especially acute, which makes it necessary to elucidate the mechanisms by which nutrients enter aquatic ecosystems. Biogenic elements in municipal wastewater, especially compounds of phosphorus and nitrogen are getting into water bodies and lead to eutrophication. To obtain reasonable efficiency in removing biogenic elements from wastewater, it is necessary to create a system of clear and unambiguous standardization of the maximum permissible discharges of these elements into water bodies with wastewater [9]. The cycle of inorganic nitrogen compounds is of great interest. The degree of trophicity of water bodies and the quality of water in them depend on the quantitative and qualitative composition of nitrogen-containing substances. Nitrogen compounds are characterized by high biological activity; they participate in the metabolic processes of aquatic organisms, and significantly impair the organoleptic properties of water. The main sources of inorganic nitrogen compounds in water are organic substances, as well as industrial and agricultural wastewater.

The content of nitrates, nitrites and ammonium ions is an important indicator of the chemical composition of water; it is used in environmental assessment and normalization of the quality of natural waters [2]. In addition to assessing water quality, information on the content of various forms of nitrogen in water bodies is required when addressing the balance of nutrients, the relationship between the vital processes of aquatic organisms and the chemical composition of water, and others. The issue of the content of nitrates, nitrites, ammonium in the water of a treatment plant during the biological treatment of storm sewage from oil products in the available literature to us is unexplored. For this reason, studies of the fraction of nitrogen-containing compounds during the treatment of storm sewage from oil products in a sewage treatment plant is an urgent and primary task on the path to the environmental safety of surface water bodies that receive storm water after its treatment.

Purpose. The aim of the work is to determine the characteristics of the distribution of nitrates, nitrites, ammonium in water and their ratio in the biological treatment of wastewater of a motor plant from oil products.

Methods. The studies were carried out at the storm water treatment plant (STP) No. 54 of the motor Sich plant. The technology of biological wastewater treatment from oil products at the plant’s sewage treatment plant involves the use of the Ekolan-M biosorbent in four sections of the sewage treatment plant and water purification due to the expanded clay batch biofilm located at the end of each section of the sewage treatment plant. Therefore, in order to clarify the issue of the efficiency of refining wastewater from oil products, we carried out experimental studies, where in the control of water purification we performed according to the traditional technology, and in experiments, we were applying modern biotechnologies, where immobilized microorganisms and periphyton organisms were used on a fibrous carrier of the “VIYA” type.

The essence of the biotechnology using immobilized biota on a carrier of the “VIYA” type proposed by the authors is illustrated by drawings (Figs. 1, 2). In the experimental section 1, metal mounting brackets 3 are mounted to the side walls 2 and wooden beams 5 are mounted to vertical guides 4 of the mounted brackets 3. They are attached to halyards 6 connected to “rafts” 7, 8. The “rafts” 7, 8 have a perforated bottom 9, which is made of plastic, (e.g. polypropylene). To the perforated bottom 9 of the “rafts” 7, 8, a fiber carrier of the “VIYA” type is fixed along their entire lower plane. Storm wastewater 10 entering the experimental section 1 is cleaned from oil by immobilized microorganisms-destructors and other peripheral organisms on a fibrous carrier. Wastewater treatment occurs at the end of the section through the expanded clay batch biofilm 11. After expanded clay batch 11, purified water 12 is discharged into the river Mokra Moskovka.

For the treatment of wastewater from oil products 76 “rafts” with a carrier of the “VIYA” type were mounted and installed in the experimental section. The rafts (1.50 × 0.54 m in size) were installed in such a way that they overlapped the entire water surface area of the experimental section of the sewage treatment plant. Fig. 3.

The fibrous carrier of the “rafts” is located in the upper layer of the water column of the sedimentation tank of the treatment plant. In the surface layer of water (15–20 cm), a significant amount of oil products accumulate, which are in-

![Fig. 1. Overall view of the experimental section of the treatment plant with installed “raft”](image)

![Fig. 2. The intersection of the mounting bracket on A–A](image)
tensively oxidized and decomposed by immobilized aerobic microorganisms. A large number of microorganisms—destructors of oil products, formed through the process of immobilization, efficiently use wastewater oil products as a source of energy and carbon. Therefore, the “rafts” with a fibrous support, which are located at the beginning of the experimental section, are not silted with oil, and the mineral substances formed after the decomposition of hydrocarbons gradually settle at the bottom of the treatment plant.

In the control sections, the treatment of storm sewage from oil products was carried out according to traditional technology, with the use of Ekolan-M biosorbent. Due to the fact that the wastewater treatment plant workers use biosorbent only when they visually detect oil pollution in the certain spot of the section, two control sections were used to obtain more reliable results on the effectiveness of wastewater treatment from oil products using this technology.

The composition of the “Ekolan-M” preparation includes carbohydrate-oxidizing actinobacteria Dietzia maris IMB B-7278, Gordonia rubropertincta IMB Ac-5005, Rhodococcus erythropolis IMB B-7012, Rhodococcus erythropolis IMB B-7277 [10] immobilized on a pulverized oil-absorbing sorbent (charcoal).

The option where Ekolan-M biosorbent and “rafts” with a carrier like “VIYA” were not used for the treatment of storm sewage from oil products, was not taken into account due to the number of reasons: firstly, this technology is not provided for by the plant’s water treatment scheme, and, secondly, this technology cannot effectively purify storm sewage from oil products and reduce the concentration of oil products in water to the limits of the MPP (as stipulated by the standard of the treatment plant).

The installed “rafts” with a fibrous carrier can be used throughout the year for the treatment of storm sewage during 10–15 years, and then they are replaced. In winter a decrease in water temperature affects the metabolic processes of bacteria; as a result, the intensity of degradation of oil products decreases. But under conditions of ZPF No. 54, the water temperature in the sections does not decrease below 12–13 °C, which does not lead to a complete loss of the destructive ability of the bacterial biofilm on a carrier of the “VIYA” type. In general, to increase the efficiency of wastewater treatment not only from oil products, but also from general pollution in the autumn and winter seasons, it is necessary to use a “VIYA” carrier not only in the surface water layer, but also in the water column using frames with a fibrous carrier. It is worth noting that after installing the rafts, it is not necessary to conduct their constant inspection during their exploitation at the treatment facilities.

The primary immobilization of microorganisms and periphyton organisms on a fiber carrier “VIYA” was carried out in the aerotank of the Central sewage treatment plant of the left bank No. 1 (TsOS-1) of the Zaporizhzhia Vodokanal enterprise for 24 days. Then the fibrous carrier with immobilized organisms was excluded from the TsOS-1 aerotank and transported to ZPF No. 54 of the plant of Motor Sich JSC, where it was placed at the beginning of the experimental section of the sewage treatment plant in front of the “raft” with the fibrous carrier. This was done so that the selected hydrobionesis would be faster fixed on a carrier of the “VIYA” type of these floating elements.

At STP No. 54, water samples were taken at the beginning of studied sections, at the end of these sections, and on exit (after expanded clay loading). In the experimental section, water samples were additionally taken in the middle of the section (after 40 “rafts”). In the summer season (June-August) water samples were taken 3 times a month, and in the autumn season in September — 2 times a month, and in November — once a month. Totally, 102 water samples were taken for chemical analysis.

The nitrite content in water was determined by diazotization by the Griss reagent with the formation of a red-violet color 1-Naphthylamine diazocompound, which was photometric at a wavelength of 520 nm. The measurement of the mass concentration of nitrate ions was determined colorimetrically by phenol disulfonic acid with the formation of yellow nitrogen-containing phenol. The ammonium content was carried out by the photocolorimetric method in a qualitative reaction with the Nessler reagent at a wavelength of 420 nm.

The concentration of oil products in wastewater was determined by atomic absorption spectrophotometry with the use of electrothermal analyzer — a spectrophotometer “Perkin Elmer” and a flame analyzer “Hitachi 1–80” at a wavelength corresponding to the maximum absorption of the investigated element. The concentration of these chemicals in water was determined in the integrated sanitary laboratory of the Motor Sich JSC accredited to technical competence.

Using the concentrations of different forms of mineral nitrogen, we calculated the rate of relative utilization of nitrogen by aequous microorganisms (KN) according to the formula [11]

$$K_N = \frac{0.78 \cdot a}{0.30 \cdot 6 + 0.23 \cdot c}$$

where $a, b, c$ are the concentrations of $NH_4^+$, $NO_2^-$, and $NO_3^-$, respectively, and 0.78, 0.30, 0.23 are the mass fraction of Nitrogen in these ions.

The value of $K_N > 1$ indicates a low level of nitrification of ammonium Nitrogen in the water of the treatment plant. The value $KN < 1$ indicates a low activity of the processes of protein ammonification in water. Using the values of this coefficient allows us to evaluate the completeness of the process of Nitrogen transformation in a treatment plant, its completion or violation.

The goal of the implementation of this biotechnology was not a significant decrease in the concentration of nitrogen compounds in storm sewage. This biotechnology was used specifically for the treatment of wastewater from oil products.

**Results.** Analyzing the data in Table 1, we can note that during June-August, the $NH_4^+$ content in the experimental section of the sump at the outlet of the treatment plant was 1.12 and 1.14 times lower (average values) than its concentration after storm water treatment in the control sections (No. 1 and No. 2), respectively.

It can be seen from the above data that at the outlet of the treatment plant (after expanded clay loading), the concentration of ammonium nitrogen exceeded the maximum permissible discharge (MPD) (0.552 mg/dm³) in all three studied sections of the clarifier of the treatment plant. During purification of oil-contaminated wastewater by using the “Ekolan” biosorbent in the control sections of the sewage treatment plant, the concen-
The spatial distribution of nitrogen compounds in water during the treatment of storm sewage from oil products of the Motor Sich JSC plant in the summer season of 2017 (M ± m; n = 6)

| Wastewater collection point | Concentration, mg/dm³ | Forms of Nitrogen | Quantitative ratio | Quality ratio |
|-----------------------------|------------------------|-------------------|-------------------|------------|
|                             | [NH₄⁺] | [NO₂⁻] | [NO₃⁻] | \([\text{NH}_4^+] > [\text{NO}_3^-] > [\text{NO}_2^-]\) | \([\text{NH}_4^+] > [\text{NO}_3^-] > [\text{NO}_2^-]\) |
| The experimental section of the sump, where “VIYA” fiber carrier was used | | | | | |
| At the inlet | 1.21 ± 0.13 | 0.59 ± 0.11 | 4.14 ± 0.44 | 1.00 : 0.49 : 3.42 | \([\text{NO}_3^-] > [\text{NH}_4^+] > [\text{NO}_2^-]\) |
| Middle of the section | 1.15 ± 0.16 | 0.62 ± 0.16 | 4.17 ± 0.50 | 1.00 : 0.54 : 3.63 | \([\text{NO}_3^-] > [\text{NH}_4^+] > [\text{NO}_2^-]\) |
| End of the section | 1.18 ± 0.23 | 0.55 ± 0.13 | 4.58 ± 0.54 | 1.00 : 0.47 : 3.88 | \([\text{NO}_3^-] > [\text{NH}_4^+] > [\text{NO}_2^-]\) |
| At the outlet | 1.19 ± 0.22 | 0.42 ± 0.04 | 4.66 ± 0.46 | 1.00 : 0.35 : 3.92 | \([\text{NO}_3^-] > [\text{NH}_4^+] > [\text{NO}_2^-]\) |
| Control section No. 1, where the “Ekolan” biosorbent was used | | | | | |
| At the inlet | 1.38 ± 0.13 | 0.68 ± 0.01 | 4.55 ± 0.42 | 1.00 : 0.49 : 3.30 | \([\text{NO}_3^-] > [\text{NH}_4^+] > [\text{NO}_2^-]\) |
| End of the section | 1.50 ± 0.23 | 0.57 ± 0.04 | 5.11 ± 0.67 | 1.00 : 0.38 : 3.41 | \([\text{NO}_3^-] > [\text{NH}_4^+] > [\text{NO}_2^-]\) |
| At the outlet | 1.33 ± 0.23 | 0.59 ± 0.09 | 4.87 ± 0.57 | 1.00 : 0.44 : 3.66 | \([\text{NO}_3^-] > [\text{NH}_4^+] > [\text{NO}_2^-]\) |
| Control section No. 2, where the “Ekolan” biosorbent was used | | | | | |
| At the inlet | 1.38 ± 0.22 | 0.61 ± 0.12 | 5.00 ± 0.38 | 1.00 : 0.44 : 3.62 | \([\text{NO}_3^-] > [\text{NH}_4^+] > [\text{NO}_2^-]\) |
| End of the section | 1.30 ± 0.17 | 0.58 ± 0.11 | 4.70 ± 0.37 | 1.00 : 0.45 : 3.62 | \([\text{NO}_3^-] > [\text{NH}_4^+] > [\text{NO}_2^-]\) |
| At the outlet | 1.36 ± 0.24 | 0.55 ± 0.06 | 5.26 ± 0.42 | 1.00 : 0.40 : 3.87 | \([\text{NO}_3^-] > [\text{NH}_4^+] > [\text{NO}_2^-]\) |

During oil-contaminated wastewater treating in the control sections of the sewage treatment plant, the concentration of nitrates in the treated water (at the outlet) exceeded the MPD in 10 out of 12 samples (83%). On the whole, the concentration of MPD of nitrates in purified water of the control sections in the summer season was recorded at an average of 1.1 to 2.4 times (an average of 1.5 times). According to the results of the mid-summer nitrite content during storm water treatment, it was found that at the outlet of the treatment plant, the nitrite concentration in water exceeded the MPD in control section No. 1 by 1.4 times, and in control section No. 2 by 1.3 times.

In the autumn season, in the experimental section of the sedimentation tank, the nitrite content in the water at first decreased in the middle and at the end of the section, then, on the contrary, it increased and was within the MPD. In the control sections of the sump during this period, an increase in the MPD of nitrates in purified water was found only in control section No. 1 at a level of 1.2 to 1.3 times. Here, it was also found that the concentration of nitrites in wastewater at the inlet increased by 1.2 times compared to the treated water at the outlet of the treatment plant, on average, Table 2.

The nitrate content in the wastewater during the summer period of the experimental and control sections of the sump at the end of the section and at the outlet after water treatment increased. It was also found that at the outlet of the treatment plant (after expanded clay loading), the concentration of nitrates exceeded the MPD (4.06 mg/dm³) in the experimental section in 50% of the samples, and in the control sections in 58% of the samples. In general, the excess of the MPD of nitrates in the purified water of the experimental section and the control sections in the summer season was recorded at an average of 1.4 times.

In the autumn season, the nitrate content in the wastewater, which fell into the experimental and control sections of the sump of the sewage treatment plant, was almost similar. After the process of purification of storm water from oil products in the experimental section and in the control sections, the nitrate content in the purified water increased. During the fall period, the study of excess MPD (4.06 mg/dm³), the content of nitrates in the treated water of the treatment plant was not found. During oil-contaminated storm sewage of the plant purification in the summer-autumn period, it was found that in the water...
The spatial distribution of nitrogen compounds in water during the treatment of storm sewage from oil products of the Motor Sich JSC plant in the autumn season of 2017 ($M \pm m; n = 3$)

| Wastewater collection point | Concentration, mg/dm$^3$ | Forms of Nitrogen | Quantitative ratio | Quality ratio |
|-----------------------------|--------------------------|------------------|-------------------|--------------|
|                             | [NH$_3$]                 | [NO$_3$]         | [NO$_2$]          |              |
| At the inlet                | $1.34 \pm 0.26$          | $0.37 \pm 0.06$  | $2.81 \pm 0.87$   | $1.00 : 0.28 : 2.10$ | [NO$_3$] $>$ [NH$_3$] $>$ NO$_2$ |
| Middle of the section       | $1.26 \pm 0.29$          | $0.32 \pm 0.02$  | $2.89 \pm 0.87$   | $1.00 : 0.25 : 2.29$ | [NO$_3$] $>$ [NH$_3$] $>$ NO$_2$ |
| End of the section          | $1.22 \pm 0.27$          | $0.30 \pm 0.01$  | $2.93 \pm 0.88$   | $1.00 : 0.25 : 2.40$ | [NO$_3$] $>$ [NH$_3$] $>$ NO$_2$ |
| At the outlet               | $1.07 \pm 0.32$          | $0.38 \pm 0.02$  | $2.96 \pm 0.89$   | $1.00 : 0.36 : 2.77$ | [NO$_3$] $>$ [NH$_3$] $>$ NO$_2$ |

Control section No. 1, where the “Ekolan” biosorbent was used

| At the inlet                | $1.39 \pm 0.28$          | $0.39 \pm 0.04$  | $2.95 \pm 0.92$   | $1.00 : 0.28 : 2.12$ | [NO$_3$] $>$ [NH$_3$] $>$ NO$_2$ |
| End of the section          | $1.25 \pm 0.36$          | $0.37 \pm 0.03$  | $3.04 \pm 0.94$   | $1.00 : 0.30 : 2.43$ | [NO$_3$] $>$ [NH$_3$] $>$ NO$_2$ |
| At the outlet               | $1.18 \pm 0.35$          | $0.46 \pm 0.06$  | $3.10 \pm 0.94$   | $1.00 : 0.39 : 2.63$ | [NO$_3$] $>$ [NH$_3$] $>$ NO$_2$ |

Control section No. 2, where the “Ekolan” biosorbent was used

| At the inlet                | $1.48 \pm 0.26$          | $0.38 \pm 0.05$  | $3.25 \pm 0.41$   | $1.00 : 0.26 : 2.20$ | [NO$_3$] $>$ [NH$_3$] $>$ NO$_2$ |
| End of the section          | $1.39 \pm 0.38$          | $0.34 \pm 0.04$  | $3.28 \pm 0.46$   | $1.00 : 0.25 : 2.36$ | [NO$_3$] $>$ [NH$_3$] $>$ NO$_2$ |
| At the outlet               | $1.31 \pm 0.21$          | $0.37 \pm 0.02$  | $3.31 \pm 0.50$   | $1.00 : 0.28 : 2.53$ | [NO$_3$] $>$ [NH$_3$] $>$ NO$_2$ |

The average values of the $K_N$ coefficient of wastewater from the studies of sedimentation sections in the autumn period were maximum at the inlet to the sewage treatment plant and slightly decreased at the outlet after wastewater treatment. A $K_N$ value of more than one indicates at a low level of the process of nitrification of ammonium nitrogen compared to the summer period. Thus, in the autumn season, there is an imbalance in the processes of mineralization of nitrogen organic substances in the site structure of the plant.

When biological treatment of storm sewage from oil products using the fiber carrier “VIYA” it was found that in the summer season in the experimental section of the sump, the concentration of oil products at the inlet was in the range of 0.82–0.86 at the inlet to (0.74–0.78) at the outlet of the treatment plant, and the output was on average 0.121 mg/dm$^3$, it means that, it decreased almost 4 times. In two control sections, the concentration of oil products increased and ranged within 1.630–2.853 mg/dm$^3$. After expanded clay loading, the average concentration of oil products in the purified water of the control sections at the outlet ranged from 0.190 mg/dm$^3$ to 0.493 mg/dm$^3$. The efficiency of wastewater treatment from oil products in the control sections of the treatment plant using the Ekolan-M biosorbent according to the average indicators at the end of the sections and at the outlet of the treatment plant were 11 and 39 %, respectively, Table 4.

In the autumn season, the concentration of oil products in the experimental section at the inlet was on average 0.447 mg/dm$^3$. During the wastewater treatment process (middle and end of the section), the oil content in the water decreased, and the output was on average 0.121 mg/dm$^3$, it means that, it decreased almost 4 times. In two control sections, the concentra-

Table 2

Average values of the $K_N$ coefficient for the treatment of storm sewage from oil products of the plant of Motor Sich JSC in 2017 ($M \pm m; n = 3–6$)

| Sump of treatment facility ZTF No. 54 | Wastewater collection point | At the inlet | Middle | End | At the outlet |
|---------------------------------------|-----------------------------|-------------|--------|-----|--------------|
| Summer season                         |                             |             |        |     |              |
| Experimental section                  |                            | $0.83 \pm 0.02$ | $0.79 \pm 0.03$ | $0.73 \pm 0.09$ | $0.75 \pm 0.09$ |
| Control section No. 1                 |                            | $0.86 \pm 0.04$ | $0.85 \pm 0.04$ | $0.78 \pm 0.06$ |
| Control section No. 2                 |                            | $0.82 \pm 0.04$ | $0.80 \pm 0.05$ | $0.74 \pm 0.09$ |
| Autumn season                         |                             |             |        |     |              |
| Experimental section                  |                            | $1.50 \pm 0.18$ | $1.34 \pm 0.08$ | $1.28 \pm 0.08$ | $1.01 \pm 0.07$ |
| Control section No. 1                 |                            | $1.46 \pm 0.18$ | $1.20 \pm 0.03$ | $1.07 \pm 0.03$ |
| Control section No. 2                 |                            | $1.32 \pm 0.10$ | $1.24 \pm 0.12$ | $1.17 \pm 0.04$ |
tion of oil products in wastewater was 0.472–0.989 mg/dm³, according to average indicators in September-November at the inlet. At the end of these sections, the oil content in the water ranged within 0.164–0.169 mg/dm³, and at the outlet of the treatment plant – 0.128–0.168 mg/dm³. The effectiveness of the treatment of storm sewage from oil products in the experimental and control sections of this treatment plant during the study period, according to average indicators at the outlet of the treatment plant, was at the level of 65 and 61 %, respectively.

Thus, it was experimentally established that the efficiency of the plant’s treatment of storm sewage from oil products using a fibrous carrier in the summer of 2017 at the end of the section and at the exit, after expanded clay loading, was 6.5 and 2.2 times higher compared to the traditional wastewater treatment technology of this enterprise.

On the whole, the efficiency of treatment of storm sewage from oil products of the Motor Sich JSC plant in the experimental section after 76 rafts with a fiber carrier “VIYA” at the end of the sump was at the average level of 79 %. In the control sections (without the use of a fibrous carrier), the average degree of wastewater purification from oil products using the Ekolan-M biosorbent in the summer-autumn period was 51 %. That is, the data presented confirm that the efficiency of purification of storm water of a plant from oil products using a fibrous carrier is 1.6 times more efficient than with the classical technology using the Ekolan-M biosorbent.

It should be noted that the Ekolan-M biosorbent at ZTF No. 54 is used in an amount of 50–60 kg of the preparation for one week. Considering that 1 kg of the sorbent costs 150–152 UAH, then counting for 10 years of operation of the treatment plant, we need to spend 3900 thousand UAH. By using rafts with a fibrous carrier, at ZTF No. 54, 76 + 4 = 304 rafts are required. The cost of 1 raft at the prices of 2017 is 1350 UAH. Therefore, it is necessary to spend only 410.4 thousand UAH. Thus, it can be seen that the use of biosorbent leads to a significant increase in financial costs for the maintenance of the treatment plant system. This is 9.5 times more expensive than with the classical technology using the Ekolan-M biosorbent.

Conclusion. In storm sewage entering the treatment plant, the content of ammonium, nitrates and nitrates was in the range of 1.21–1.48 mg/dm³, 0.37–0.68 mg/dm³, 2.81–5.00 mg/dm³, respectively. According to the content of ammonium and nitrite in the water during the process of wastewater treatment from petroleum products, such a pattern is observed: concentrations of nitrate and nitrite at the outlet of the treatment plant system. This is 9.5 times more expensive than with the classical technology using the Ekolan-M biosorbent.

The recorded average values of the coefficient of relative utilization of mineral nitrogen compounds by microorganisms over the summer period of the research indicate the prevalence of nitrification processes over ammonification processes. In the autumn season, there is an imbalance in the processes of mineralization of nitrogen organic matter in the treatment plant, which is confirmed by NTK values that were more than unity.

It has been established that the treatment of storm sewage from the Motor Sich JSC plant with petroleum products using a fiber carrier of the “VIYA” type is 1.6 times more efficient than with the classical technology using the Ekolan-M biosorbent.

References.
1. Isaenko, V. M., Madzh, S. M., Panchenko, A. O., & Bondae, A. M. (2018). Water-supervision measures for enhancing environmental safety of industrial wastewater industrial enterprise. Science-based technologies, 4(40), 437-442. https://doi.org/10.18372/2310-5461.40.1329
2. Kulikova, D. V., & Pivlychenko, A. V. (2016). Estimation of ecological state of surface water bodies in coal mining regions as based on the complex of hydrochemical indicators. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, 4, 62-70.
3. The main indicators of water use of Ukraine for 2002. Kiev: State Committee for Water Management of Ukraine.
4. Soroka, Ya. M., Samoilenko, L. S., & Gvozdiak, P. I. (2001). Strains Pseudomonas fluorescens 3 and Arthrobacter sp. 2 — deconstructors of polycyclic aromatic hydrocarbons. Microbiological journal, 63(3), 65-70.
5. Gudzenko, T. V., Gorskhova, E. G., Beliaeva, T. A., Rakitska, S. I., Lisijutin, G. V., & Ivantsiya, V. A. (2015). Biotechnology for the improvement of the marine environment using immobilized microorganism. Scientific Issues Terenopil Volodomyr Hnatuk National Pedagogical University Series: Biology, 3-4(64), 146-149.
6. Gcola, L. I., & Gvozdiak, P. I. (2015). The biological rendering of chemical pathogens harmless is in a water environment. Gigiena i sanitariya, 94(1), 46-50.
7. Ryalskii, A. F., Dombrovskii, K. O., Krupey, K. S., & Petru­sha, Yu. Yu. (2016). Biological Treatment of Storm Wastewater at Industrial Enterprise Using the Immobilized Microorganisms and Hydrobiions. Journal of Water Chemistry and Technology, 38(4), 232-237. https://doi.org/10.3103/S1063455X16040081.
8. Dombrovskii, K., & Gvozdyak, P. (2018). Biological afterpurifi­cation of industrial sewage from hexamethylene diamine us­ing Periphyton communities on the “VIYA” fibrous carrier and on the root system of Eichhornia crassipes. Hydrobiological Journal, 54(4), 63-71. https://doi.org/10.1615/Hydrobol.v54.i4.60.
9. Shamsancki, S., & Boichenko, S. (2018). Standardization of maximum permissible discharges of biogenic elements into water bodies with wastewater in Ukraine. Ecological Sciences, 2(21), 119-126.
10. Podgorskiy, V. S., Nogina, T. M., Dumanskaya, T. U., & Ostapchuk, A. N. (2015). The change of the composition of the paraffin-naphthenic hydrocarbon fraction in the process of biological purification of water from oil. Journal of water chemistry and technology, 37(6), 553-563.
11. Rotay, T. (2016). Enhancement of environmental security of deployment processes water polutants in ecosystems of eastern sports. Transactions of Kremenchuk Mykhailo Ostrobraskyi National University, 5(1002), 100-104.

| Terms of the study | The purification effect, % |
|-------------------|----------------------------|
|                   | Middle | End | At the outlet |
| The experimental section of the sump, with “VIYA” fiber carrier | |
| Summer season     | 76.67 ± 4.80 | 86.86 ± 7.20 | 85.40 ± 2.46 |
| Autumn season     | 48.43 ± 15.01 | 42.80 ± 15.81 | 65.13 ± 9.47 |
| Control sections, where the “Ekolan” biosorbent was used | |
| Summer season     | –      | 10.54 ± 6.26 | 38.99 ± 7.79 |
| Autumn season     | –      | 54.90 ± 15.44 | 61.37 ± 15.03 |
Мета. Визначити особливості розподілу нітратів, нітритів, іонів амонію у воді та їх співвідношення при біоло- гічному очищенні стічних вод моторобудівного заводу від нафтопродуктів.

Методика. Експериментальні дослідження проводили в умовах зливових очисних споруд № 54 заводу АТ «Мотор Січ», де на різних ділянках очисної споруди па- ралельно визначали вміст сполук нітроцену в експери- ментальній та двох контрольних сеクціях відстійника, при очищенні стічної води від нафтопродуктів. В експери- ментальній сеクції очищення зливових вод проводили за допомогою 76 встановлених «плотиків» із носієм типу «ВИЯ», а в контрольних сеクціях – за допомогою викорис- тання біосорбенту «Еколан-М».

Результати. На основі опрацьованих даних щодо вмісту неорганічних сполук нітроцену у воді очисної споруди надана порівняльна характеристика просторово-часового розподілу іонів амонію, нітритів та нітратів при біологічному очищенні зливових вод від нафтопродуктів при використанні синтетичного носія, для іммобілізації мікроорганізмів та біосорбенту. За результатами розра- хунку коефіцієнта біологічної утилізації неорганічних сполук нітроцену мікроорганізмами під час процесу очищення зливових стічних вод від нафтопродуктів встановлено, що процес нітрифікації амонію в літній період проходить інтенсивніше, ніж в осінній період. Запропонована біо- технологія з очищення зливових вод від нафтопродуктів з використанням плаваючих несучих елементів з волокнистим носієм типу «ВИЯ».

Наукова новизна. Біологічне очищення зливових стічних вод від нафтопродуктів з використанням носія типу «ВИЯ» є актуальним і першочерговим завданням на шляху до екологічної безпеки поверхневих вод. При застосуванні даної біотехнології можна зменшити вміст неорганічних сполук нітроцену, якщо додатково впровадити вертикальне розміщення штучного носія «ВИЯ» на всю глибину каналу очисної споруди (до 3 м). Для цього наміну було запро- поновано використовувати конструкцію «плотиків» із додатковими вертикальними рамками з носієм типу «ВИЯ».

Практична значимість. При застосуванні «плотиків» з носієм типу «ВИЯ» при очищенні нафтобрудженних зливових стічних вод від нафтопродуктів використовують іммобілізовані мікроорганізми. При використанні біосорбенту «Еколан-М» з носієм типу «ВИЯ» відбувається значне зниження нітратів, нітритів, амонійних форм нітрогена в зливових стічних водах, що призводить до підвищення ефективності біологічного очищення стічних вод. Витрати на очистних сооруженнях зменшуються, а екологічні показники очищених стічних вод покращуються.

Результати. При застосуванні волокнистого носія типу «ВИЯ», а в контрольних сеクціях – за допомогою біосорбенту «Еколан-М», які встановлено, що процес нітрифікації амонію в літній період проходить інтенсивніше, ніж в осінній період. Для цього наміну було запропоновано використовувати конструкцію «плотиків» із додатковими вертикальними рамками з носієм типу «ВИЯ».

Практична значимість. При застосуванні «плотиків» з носієм типу «ВИЯ» в очистних сооруженнях зливових стічних вод від нафтопродуктів використовують іммобілізовані мікроорганізми. При використанні біосорбенту «Еколан-М» з носієм типу «ВИЯ» відбувається значне зниження нітратів, нітритів, амонійних форм нітрогена в зливових стічних водах, що призводить до підвищення ефективності біологічного очищення стічних вод. Витрати на очистних сооруженнях зменшуються, а екологічні показники очищених стічних вод покращуються.

Распределение неорганических соединений нитрата в очистке сточных вод моторостроительного завода

К. О. Домбровский

Ключевые слова: сточные воды, нафтопродукты, биологическое очищение воды, нитраты, нитриты, амоній

Рекомендовано для публикации by V. P. Volkov, Doctor of Technical Sciences. The manuscript was submitted 21.04.19.