

Use of Microbiocenosis Immobilized on Carrer in Technologies of Biological Treatment of Surface and Wastewater

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ABSTRACT

The role of fibrous carrer in the formation of microbiocenosis, which provides purification of aquatic environments, was studied. The prospects of using the "Vija" fibrous carrer for cleaning the watercourses of mountainous areas were studied. The species composition, as well as the kinetics of periphyton formation on fibrous carrer, were established. The species composition of the microbiocenosis, which is formed on carrer in the mode of active aeration of landfill filtrates and the prospects of using the method of aerated lagoon for filtrate treatment were studied.

Keywords: microorganisms, immobilization on carrer, formation of microbiocenosis, periphyton, aerated lagoon, biological treatment.

INTRODUCTION

Surface and wastewater monitoring (Odnorih et al., 2020, Popovych et al., 2020) and the use of effective wastewater treatment methods are the key to achieve the sustainable development goals. Among the methods of wastewater treatment, adsorption using natural sorbents (Malovanyy et al., 2019a, Malovanyy et al., 2020) and biological methods (Blyashyna et al., 2018, Malovanyy et al., 2021, Semenenko et al., 2020) can be distinguished. The authors believe that the use of biological methods for wastewater and surface water treatment is the most rational and natural approach. Biological methods, which are implemented without introducing uncharacteristic substances and energy into ecosystems, mimic the processes of natural self-purification, which occur

tens, and sometimes hundreds of times more intensively due to the special organization of these processes. Among the most common biological methods of wastewater treatment at municipal wastewater treatment plants is the introduction of a specially cultivated microbiocenosis into the treatment system, as well as the formation of microbiocenosis in aerated lagoons for the treatment of landfill filtrates. A number of studies have shown that the accumulated biomass of aquatic organisms in the biological conveyor can be used as raw material for biogas production (Voytovych et al., 2020, Malovanyy et al., 2021).

For all these methods of biological treatment, it is important to create the optimal living conditions for aquatic organisms, which ensures their balanced development and the maximum degree of assimilation of pollutants by the biocenosis.

For the microbiocenosis, it is important to ensure the most developed area of mass transfer, which is achieved by placing in the form of a biofilm by specially equipped carrier. This biofilm is in active contact with the contaminated aquatic environment, using pollutants in supply chains. Numerous recent studies have aimed to establish the optimal type of such carrier and the peculiarities of placing on them a specially cultivated or naturally formed biocenosis.

The authors (Christensson et al., 2004) considered a hybrid process of urban wastewater treatment using activated sludge and biofilm, which was modeled on a pilot plant. In order to enhance nitrification in the process, a new type of carrier with a large effective surface was used. The pilot plant operated for 1.5 years in five different configurations, including pre-denitrification and improved biological removal of phosphorus compounds. The wastewater temperature ranged from 11 °C to 20 °C, and the nominal level of dissolved oxygen (DO) was 5–6 mg/L. The nitrification rate obtained by the new carrier in the hybrid stage was in the range of 0.9–1.2 g NH₄-N /m²/day and night, which corresponds to a volumetric rate of 19–23 g NH₄-N/m³/h. More than 80% of the total nitrification took place on the carrier, the rest – on suspended solids. It was shown that the rate of nitrification correlates with DO. The results confirmed the idea of using a new carrier as a tool to upgrade the installations that do not provide nitrification today.

It has been found that compared to the technology of suspended microorganisms, immobilization has many advantages, in particular resistance to toxic chemicals (Martins et al., 2013, Kilonzo et al., 2012). The study (Zhao et al., 2019) systematized and summarized the advantages and disadvantages of traditional and new carrier used in biofilm-based wastewater treatment technology. The characteristics, performance and mechanism of the new carrier (including slow release carrier, hydrophilic / electrophilic modified carrier, magnetic carrier and redox mediator carrier) in the biological wastewater treatment were analyzed in detail.

The use of the gel-sol inversion method for immobilization of microbial cells was investigated (Wang et al., 2005). A new type of polyester sulfone porous microcapsules with straight pores throughout the thickness was successfully fabricated. The average diameter of the microcapsules was about 2 mm, and the membranes of

the microcapsules contained straight pores. The prepared microcapsules had a large total pore volume, total pore area and porosity (up to 91.7%). The obtained porous microcapsules were used as carrier for immobilization of microbial cells in the process of anaerobic biotreatment of wastewater. Immobilized anaerobic microbial cells were detected both inside the membrane pores and in the internal spaces of the microcapsules. It was proven that the obtained porous microcapsules are effective for immobilization of microbes under anaerobic conditions.

The effect of physicochemical conditions on the partial nitrification and treatment of Anammox with immobilized ammonia oxidants under conditions of ammonium depletion was investigated (Landreau et al., 2020). Aerobic and anaerobic organisms that oxidize ammonia were incorporated into polyvinyl alcohol – sodium alginate balls and in a thin layer of polyethylene glycol hydrogels.

A number of researchers (Bouabidi et al., 2019) have considered the use of various carriers for immobilization of microbial cells in order to employ them for purification of liquid media. Immobilized cell systems have been found to have significant advantages over suspended cell systems in fluid flow. Immobilization increases the stability of microbial cells, ensures the continuity of the process, simplifies the separation of solids and liquids and increases the resistance to environmental influences. Studies have been conducted to establish the effectiveness of immobilized cells for biodegradation of various types of wastewater pollution. It was found that the proposed approach increases the concentration of biomass and prolongs the life of the sorbent.

Pioneering research of (Yang et al., 2015) developed a series of new fullerene-type biocarriers using three-dimensional printing techniques. The biofilm on 3DP biocarriers showed higher microbial activity and stronger adhesion, which the researchers explained as close to ideal mass transfer conditions in the gas-liquid-solid system and surface characteristics.

A significant amount of research is devoted to establishing the activity of immobilized microbiota for purification of aquatic environments from organic pollutants. The results of studies (Zdarta et al., 2021) indicate immobilized oxidoreductases as an effective biocatalytic tool for the removal of hazardous phenolic compounds, which makes them a promising option for water purification. It is established that the conditions of

immobilization and biodegradation affect the efficiency of transformation; therefore, process optimization is required to achieve high removal rates.

A significant number of researchers offer fibrous materials as carrier. Studies (Dombrovskiy et al., 2020) are devoted to the treatment of wastewater from petroleum products by a microbiota grown on fibrous media of the Via type. Studies have confirmed the feasibility of using a fibrous carrier to immobilize the microbiota. The authors (Makarevich et al., 2000) used fibrous materials made of thermoplastics (polyethylene, polypropylene, polyamide) as biomass carrier by melting them. It was established that such carriers of optimized composition, structure and shape are superior to conventional carriers (expanded clay, porous ceramics, foamed polyurethane) in terms of specific sorption capacity to complex associations of microorganisms. In contrast to the biofilters based on expanded clay, the structures with fibrous carrier are characterized by the accelerated achievement of a stationary mode of operation in the process of industrial wastewater treatment. At the same time, a decrease in the aero- and hydrodynamic resistance of the filtering biolayer is also observed. A number of researchers (Jurecska, et al., 2013) have used and tested three types of polypropylene fibers and polyester fiber as fibrous carrier. The results of comparisons proved the effectiveness of the use of fibrous carrier for the formation of biofilm.

However, researchers paid little attention to the study of the growth kinetics of the biofilm on carriers and the species composition of the biocenosis, which was formed on the carrier in the case of purification of aquatic environments contaminated with different types of pollutants. This publication is devoted to the description of such studies for variants of river system cleaning of Pokutsko-Bukovynian Carpathians and Precarpathians, and filtrates of landfills of solid household waste (SHW) and landfills.

MATERIALS AND METHODS OF RESEARCH

Ensuring sustainable development of the Carpathian region is largely determined by the balanced use of nature, the dominant use of renewable energy (Mandryk et al., 2020), and environmental security of the region (Masikevych et al., 2017). One of the priorities of ecological

safety of the Pokutsko-Bukovynian Carpathians is to ensure the cleanliness of their hydraulic system, and an important role in this is given to the introduction of biological methods of cleaning mountain streams.

The formation of the microbiocenosis was investigated on a fibrous carrier type "Via" (Dombrovskiy et al., 2020). Hydrobiological material (biocenosis of periphyton fouling of fibrous carrier type "Via") was taken from the watercourse of the Pokutsko-Bukovynian Carpathians (Solonets stream, Siret river) and delivered to the laboratory in an open vessel. Infusoria, rotifers and turbellaria of the biocenosis of fouling were studied in live condition under a microscope "Biolam R-14" at a magnification of 150–600 times. Other organisms (amphibiotic insect larvae and nematodes) were fixed with 70° ethanol and species determination was performed. Species of aquatic organisms have been identified by determinants and scientific works (Kutikova et al., 1977, Kovalchuk, 2011). The number of organisms in the biocenosis of fouling was determined from a fibrous carrier with an area of 50 cm², and then counted over an area of 100 cm². It was also determined the linear dimensions of the detected organisms periphyton fouling of the fibrous carrier.

Cleaning of landfill filtrates was investigated in the laboratory at an installation that simulated the conditions of an aerated lagoon. The flask was filled with the filtrate of the Hrybovytsia landfill SHW, selected from the storage pond No. 5 in the amount of 4 liters. Air with a flow rate of $4.2 \cdot 10^{-5}$ m³/s was supplied to the lower part of the flask through the laboratory aerator. In the process of aeration, a microbiocenosis was formed on the surface of the flask, which participated in the purification of the filtrate. The samples of the increased biomass were taken from the laboratory on the 15th day after the start of aeration. At the same time, the samples were taken from the storage tank of leachate No. 5 at the Hrybovytsia landfill SHW. The count of the number of microorganisms of different physiological groups was performed by superficial inoculation of suspensions from the filtrate from the appropriate dilutions on agar nutrient media by using the direct cell count method.

The direction of microbiological processes in the filtrates was determined by (Andreiuk et al., 2001) and by the methods described in (Volkohon et al., 2010).

The coefficient of mineralization-immobilization ($k_{min.im}$) was calculated by the formula:

$$k_{min.im} = \frac{C_1}{C_2} + C_3 \quad (1)$$

where: C_1, C_2, C_3 – the number of colony-forming units (CFU) in 1 ml of filtrate on starch-ammonia medium, meat-peptone agar and wort agar, respectively.

The oligotrophic coefficient (k_{ol}) was calculated by the formula:

$$k_{ol} = \frac{C_4}{C_1 + C_2 + C_3} \quad (2)$$

where: C_4 is the amount of CFU / ml of filtrate grown on starvation agar.

The coefficient of pedotrophic (k_p) was calculated by the formula:

$$k_p = \frac{C_5}{C_2 + C_3} \quad (3)$$

where: C_5 is the amount of CFU / ml of filtrate grown on the agar filtrate.

Samples were taken from the walls of the flask, which under laboratory conditions simulated cleaning in an aerated lagoon, from the surface of the pond-storage filtrate No. 5, as well as from a depth of 0.5 m and 1.0 m by using the method of surface sowing of suspensions from filtrates from the appropriate dilutions on agar nutrient media through direct calculation of CFU. At meat-peptone agar, the number of bacteria that absorb nitrogen from organic compounds was taken into account; on starch-ammonia medium – the number of microorganisms that absorb mineral forms of nitrogen; on the medium of Chapek and wort agar – micromycetes; on Ashby medium – oligonitrophilic microorganisms; on the environment of Menkina – phosphate-mobilizing bacteria; on agar infiltrate – pedotrophs; on starvation agar – oligotrophs, on Hiltai medium – denitrifying microorganisms.

Preparation of the filtrate for the cultivation of pedotrophic microorganisms was performed in the following sequence. The 500 ml of filtrate was poured into 1.5 ml of tap water and kept in an autoclave for 30 minutes at 1 atm. The resulting extract was filtered through a paper filter, 0.5 g of CaCO_3 was added to the hot filtrate, mixed thoroughly and filtered again after 5–7 minutes.

Then, 0.2 g of K_2HPO_4 was added to the extract and the volume was adjusted to 1 L and the hydrogen pH was adjusted to 6.8–7.0. Sterilized for 30 minutes at 1.5 ATM.

The calculation of the amount of CFU in 1 ml of filtrate was performed, considering the dilution of samples, according to conventional methods (Tepper et al., 1987).

RESULTS AND DISCUSSION

Investigation of the formation of microbiocenters on the "VIIA" fibrous carrier in the conditions of purification of mountain watercourses

In order to improve the quality of surface waters watercourses of the Pokutsko-Bukovynian Carpathians, a fibrous carrier of the VIIA type (Dombrovskiy et al., 2020) made of textured plait thread was used. Previously, in the works (Hvozdiak, 2003, Rylskiy et al., 2012) the prospects of using the "Via" fibrous carrier in bioreactors for the purpose of wastewater and surface water treatment were established. The "Via" carrier was attached in the watercourse to specially installed wooden structures "kashytsya", which are traditionally used by locals to oxygenate mountain rivers. Schematic representation of the process of river water purification on the "Via" carrier is shown in Figure 1.

"Via" fibrous carrier forms a kind of biofilter, which creates and operates an artificial microecosystem. In this microecosystem, microorganisms, algae and invertebrates accumulate and coexist, which absorb pollutants in trophic chains. Thus, the purification of the reservoir is realized in two stages: at the first stage – by adsorption on the "Via" carrier, and at the second – by utilization in the trophic chain. This principle of river flow treatment can be interpreted according to the concept (Hvozdiak, 2003) as a biological conveyor. Bioconveyor based on the "Via" carrier accumulates a significant number of bacteria of the *Escherichia coli* group (BECG), forming a spatial succession of microorganisms, as well as a trophic chain of aquatic organisms, which includes representatives of eight systematic groups: diurnals, freckles, volokhokryltsy, dipterous, turbellaria, nematodes, rotifers, infusorium.

The identification of the species composition of microorganisms in the microperiphyton, which

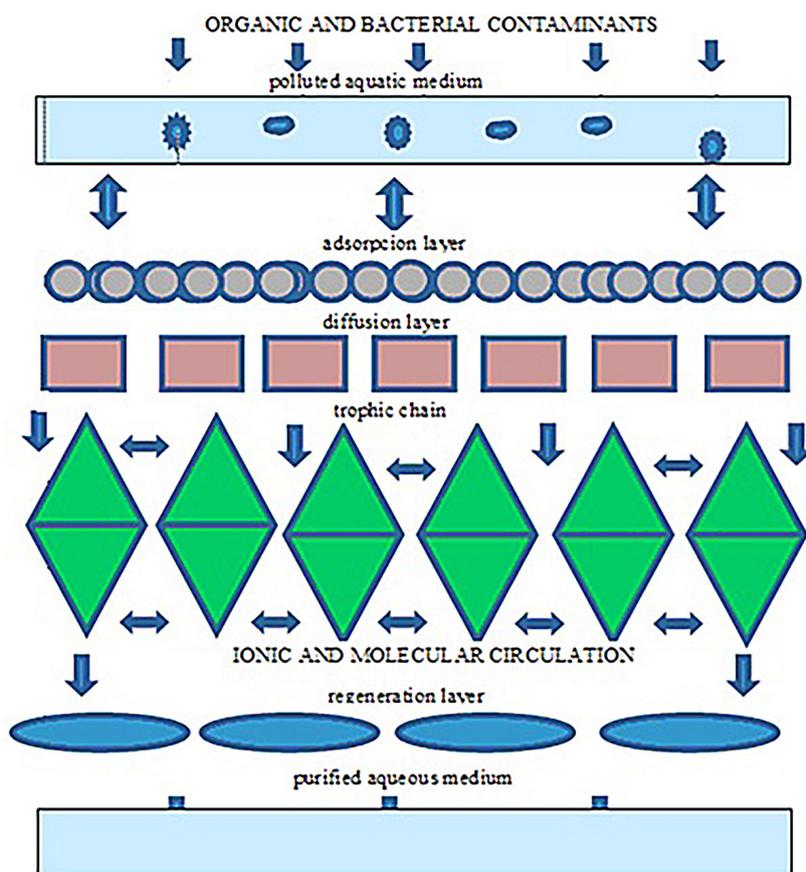


Figure 1. Schematic representation of the treatment process on the "Via" carrier

was formed on "Via" was performed, the results of identification are shown in Table 1.

In the microperiphyton of the "Via" fibrous carrier of the Solonets stream, 7 species of fouling organisms were found: 3 species of day-old larvae, other aquatic organisms (larvae of freckles, volohokrilts, chironomids and turbellaria) were represented by one taxon, respectively. In the studied biocenosis of periphyton, only the larvae of amphibiotic insects predominated in number, mainly due to the larvae of *Leuctra digitata*. According to the current classification, this species of spring larvae belongs to the class of bryophiles, in which the life of aquatic organisms is associated with the presence of moss. Thus, it can be assumed that the "Via" fibrous carrier (which is similar in structure to artificial fibers to the structure of moss) is also a source of food, as it traps particles of coarse detritus and at the same time serves as a hiding place from predators. During the study, 5 fouling taxa belonging to three systematic groups were found in the microperiphyton of the fibrous carrier of the Solonets stream. Infusoria and rotifers were represented by two taxa, respectively, and nematodes – one species.

In terms of numbers, the studied microperiphyton was dominated by infusoria (510 specimens/100 cm²), rotifers accounted for 33% of the total number of biocenosis of fouling. It should be noted that two subspecies of rotifers found in the microperiphyton of the fibrous carrier of the Solonets stream were previously indicated for the Carpathian reservoirs (Kovalchuk, 2011), namely *D. aculeate* for r. Tysmenytsia and *C. megaloccephalamegaloccephala* for r. Lukva.

In total, 12 species and subspecies of aquatic organisms were found in the periphyton of the "Via" fibrous carrier of the Solonets stream of the Siret river basin, most of which belong to amphibiotic insects (diurnals, freckles, volochokrilts, dipterous) – 6 taxa, rotifers and ciliates are represented by 2 taxa. Other systematic groups (turbellaria, nematodes) were represented by one species, respectively.

Thus, invertebrates (so-called periphyton), bacteria and algae are concentrated on the "Via" carrier. To establish the quantitative characteristics of concentrated species of aquatic organisms 3 months after the installation of carrier in the watercourse, samples were taken

Table 1. Species composition of periphyton fouling of "Via" fibrous carrier during biological treatment of water of the left tributary (stream Solonets) of the river Siret

Taxatio	Taxatio	Numerus exempl. /100 cm ²	Linearibus magnitudine
Classis <i>Insecta</i> , Ordo <i>Ephemeroptera</i>			
Familia <i>Ephemerellidae</i>	<i>Ephemerella (Serratella) ignita</i> (Poda, 1761)	4	2.65 mm
Familia <i>Heptageniidae</i>	<i>Ecdyonurus venosus</i> (Fabricius, 1775)	2	5.83 mm
Familia <i>Leptophlebiidae</i>	<i>Habroleptoides caucasicus</i> (Tshernova, 1930)	2	< 100 mm
Ordo <i>Plecoptera</i>			
Familia <i>Leuctridae</i>	<i>Leuctra digitata</i> (Kempny, 1899)	24	3.24-5.08 mm
Ordo <i>Trichoptera</i>			
Familia <i>Hydropsychidae</i>	<i>Hydropsyche angustipennis</i> (Curtis, 1834)	8	3.0-6.3 mm
Ordo <i>Diptera</i> Sub/Ordo <i>Nematocera</i>			
Familia <i>Chironomidae</i>	<i>Micropsectra junci</i> (Meigen, 1818)	4	9.5 mm
Classis <i>Turbellaria</i> Ordo <i>Tricladida</i>			
Familia <i>Dugesiidae</i>	<i>Dugesia gonocephala</i> (Duges, 1830)	10	4.5 mm
Fylum <i>CILIOPHORA</i> Classis <i>Spirotrichea</i> Ordo <i>Euplotida</i>			
Familia <i>Euplotidae</i>	<i>Euplotes sp.</i>	170	90 mm
Ordo <i>Hypotricha</i>			
-	<i>Hypotricha gen. sp.</i>	340	80 mkm
Classis <i>Nematoda</i>			
-	<i>Nematoda sp.</i>	170	0.39 mkm
Fylum <i>ROTIFERA</i> Classis <i>Archiorotatoria</i> Ordo <i>Bdelloida</i>			
Familia <i>Philodinidae</i>	<i>Dissotrocha aculeate</i> (Ehrenberg, 1832)	170	100 mkm
Classis <i>Eurotatoria</i> Ordo <i>Saeptiramida</i>			
Familia <i>Notommatidae</i>	<i>Cephalodella megaloccephala</i> (Glasscott, 1893)	170	235 mkm

from 6 points of installation of "Via" in the summer (average temperature 23 °C) and autumn (average temperature 6 °C) periods located in different parts of the watercourse with different hydrodynamic conditions. The multiplicity of concentration of aquatic organisms in comparison with the aquatic environment, where "Multiplicity of concentration" was not established, was established by direct calculations. The calculation data are presented in Figure 2. As shown in Figure 2, "Via" is capable of almost 15-fold accumulation of bacteria and aquatic organisms. The multiplicity of microbiocenosis accumulation practically does not depend on the season and the average ambient temperature, but is largely determined by hydrodynamic flow conditions (as evidenced by different indicators of biomass accumulation at different observation points).

The dynamics of the formation of the microbiocenosis on the surface of the "Via" carrier is presented in Figure 3. The data demonstrated in Figure 3 show that during the calendar month on the "Via" carrier is formed periphyton, balanced in composition and quantity, which further serves as an element of the treatment system for water treatment of mountain streams. The obtained data enabled to recommend the "Via" fibrous carrier for installation in watercourses for the purpose of purification of water of watercourses from pollution. The advantages of the proposed scheme of natural water purification are that the microbiocenosis formed on the "Via" carrier consumes and mineralizes pollutants in the trophic chain. It should be noted that in the case of wastewater treatment with activated sludge, only protozoa and bacteria

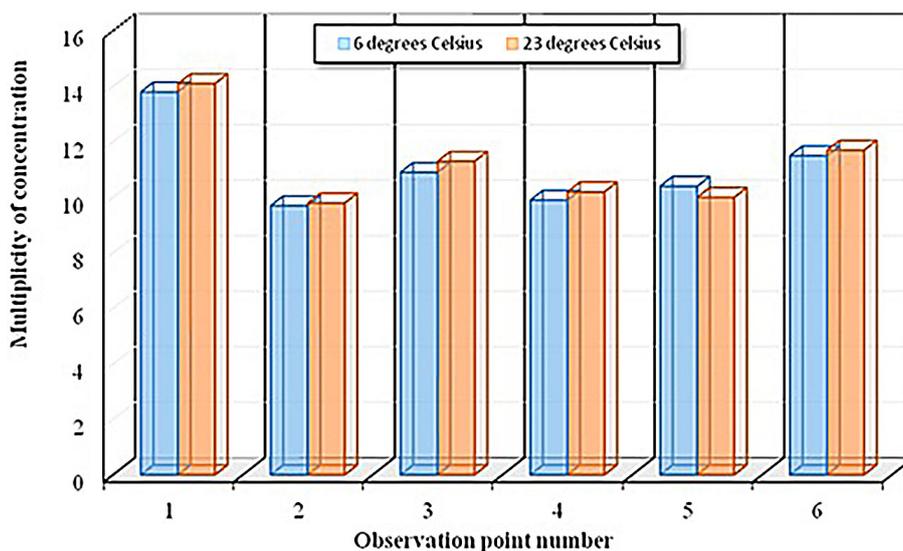


Figure 2. Accumulation of bacteria and aquatic organisms on "Via" fibrous carrier

are involved in the process (others cannot survive in toxic collector fluid), while in the case of the "Via" carrier installation, also more complex aquatic organisms are involved (II and III order consumers), forming a more complete trophic chain. It can be assumed that the "Via" fibrous carrier (which is similar in structure to artificial fibers to the structure of moss) is not only a substrate where BECG and a number of aquatic organisms accumulate, and is both a haven and a source of food, as it traps particles of coarse detritus.

As it is known, in nature a priori there is no organism that could dispose of all types

of pollution. On the contrary, there are many organisms in the biosphere that form complex hydrobiocenoses and that are able to work on the principle of a bioconveyor (Masikevych et al., 2017). The authors are far from idealizing the "Via" carrier and are confident that to some extent, another carrier would work effectively under these conditions. The advantage of using the "Via" carrier in mountain streams was, in addition to its developed mass transfer surface, also the convenience of mounting under research conditions and minimal impact on changing the hydrodynamic characteristics of mountain streams.

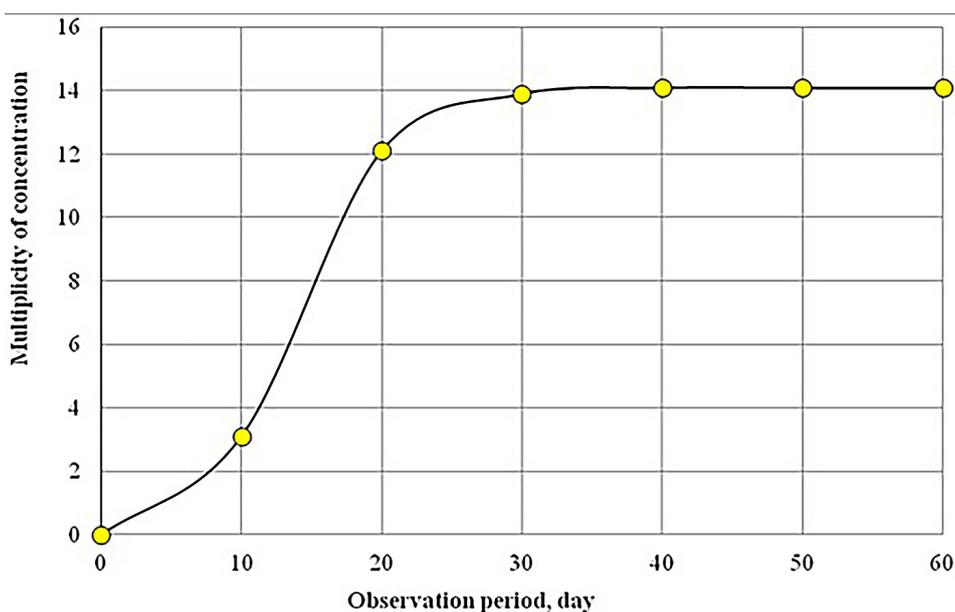


Figure 3. Dynamics of accumulation of microorganisms on "Via" synthetic carrier at observation point 1

Investigation of microbiocenosis formation in the conditions of filtrate treatment of solid waste landfills and landfills in aerated lagoons

Cleaning of leachate storage ponds located on the territory of Hrybovytsia (Lviv) landfill SHW is a necessary condition for the beginning of its reclamation. The microbiocenosis formed in these ponds is involved in the cycle of matter and provides the formation of the basic properties of storage ponds. Therefore, it can be used in remediation technologies in the areas with a similar composition of pollution. The microbiocenosis of the storage ponds of the Hrybovytsia landfill SHW and the microbiocenosis generated in the aerated lagoon under the conditions of active aeration are described in detail in the paper (Malovanyy et al., 2019b); the results of these studies were summarized.

The largest number of CFU was found in the sample taken from the surface of the filtrate storage pond. Pedotrophic microbiota dominated in all selected samples. This is probably due to the resistance of this microbiota to toxic pollutants of the filtrate and trophic specificity. The highest number of pedotrophic microbiota was observed at a depth of 1 m, where it was 94% of all CFU. The most numerous ecological and trophic groups in the filtrate of the storage pond No. 5 are: oligotrophic microorganisms, nitrifying bacteria, phosphate-mobilizing bacteria, and the microorganisms that absorb inorganic nitrogen compounds.

The concentration of microorganisms and micromycetes that are able to absorb nitrogen from organic compounds was lower. Denitrifying

bacteria were detected in the samples taken from the surface of the storage pond. In the samples taken from depths of 0.5 m and 1 m, denitrifying bacteria were absent. It was found that the concentration of CFU for all studied ecological and trophic groups (except for pedotrophic microorganisms) decreased with increasing depth from which the sample was taken. Most likely, this is due to a decrease in the concentration of dissolved oxygen with increasing depth of the storage pond.

The dominance of certain ecological-trophic groups in the biocenosis of the filtrate is an illustration of the physicochemical processes that take place in the filtrate. The increased concentration of pedotrophic microorganisms, which was observed for all selected samples, is the evidence that the storage pond is under conditions of significant man-made load. As a result, the biological group of microbiota, which is not only able to attract toxic organic substances into the food chain, including phenol, but is resistant to the toxic effects of many pollutants, including heavy metal ions, phenol, chlorite, and nitrogen compounds.

Purification of the filtrate, which was taken from the storage pond No. 5, took place in a laboratory installation under the conditions of active aeration, which simulated the conditions of the aerated lagoon. The numerical composition of microorganisms of ecological-trophic filtrate groups of the Hrybovytsia landfill SHW is shown in Table 2.

It was found that in the process of purification on the walls of the laboratory bioreactor accumulates the microbiota capable of assimilating organic and inorganic nitrogen compounds, as well as oligotrophic, nitrifying and pedotrophic microorganisms. Their number

Table 2. Numerical composition of microorganisms of ecological-trophic groups of the Hrybovytsia landfill SHW filtrate (Malovanyy et al., 2019b)

Sample	The number of microorganisms (CFU / ml of filtrate)									
	1	2	3	4	5	6	7	8	9	10
0 m	$7 \cdot 10^5$	$4 \cdot 10^6$	$1 \cdot 10^6$	$2 \cdot 10^6$	$7 \cdot 10^4$	$2 \cdot 10^6$	+	$2 \cdot 10^6$	$7 \cdot 10^6$	$4 \cdot 10^7$
0.5 m	$2 \cdot 10^4$	$4 \cdot 10^4$	$1 \cdot 10^4$	$2 \cdot 10^4$	$1 \cdot 10^5$	$1 \cdot 10^6$	-	$1 \cdot 10^4$	$1 \cdot 10^6$	$8 \cdot 10^6$
1.0 m	$2 \cdot 10^3$	$2 \cdot 10^2$	$1 \cdot 10^5$	$9 \cdot 10^4$	$1 \cdot 10^4$	$1 \cdot 10^5$	-	$7 \cdot 10^3$	$9 \cdot 10^6$	$2 \cdot 10^7$
Bioreactor filtrate	$2 \cdot 10^4$	$1 \cdot 10^2$	$1 \cdot 10^4$	$1 \cdot 10^5$	$6 \cdot 10^2$	$6 \cdot 10^4$	-	$4 \cdot 10^4$	$2 \cdot 10^4$	$1 \cdot 10^7$
Silt	$4 \cdot 10^4$	$3 \cdot 10^4$	$2 \cdot 10^5$	$1 \cdot 10^5$	$2 \cdot 10^5$	$6 \cdot 10^4$	+	$6 \cdot 10^5$	$4 \cdot 10^6$	$1 \cdot 10^7$

Note: 1 – Microorganisms that absorb nitrogen from organic compounds; 2 – Oligotrophic microorganisms; 3 – Microorganisms that absorb inorganic nitrogen compounds; 4 – Oligonitrophilic microorganisms; 5 – Micromycetes; 6 – Nitrifying bacteria; 7 – Denitrifying bacteria; 8 – Phosphate-mobilizing microorganisms; 9 – Pedotrophic microorganisms; 10 – The total number of CFU / ml of filtrate.

"+" – growth of denitrifying bacteria; "-" – there was no growth of denitrifying bacteria.

The error between the two alternative populations did not exceed 15%.

was higher compared to the aeration tank. In authors' opinion, this is due to the formation of a biofilm on the walls of the bioreactor by this microbiocenosis. Another confirmation of the formation of the biofilm is the content of studies in the microbiocenosis of denitrifying bacteria, which are not detected in the filtrate.

Laboratory studies have shown that the formed microbiocenosis can provide a sufficiently effective purification of the filtrate according to the main sanitary and hygienic indicators. The cleaning effect differs significantly for filtrates of different composition from different landfills and landfills: from ammonium nitrogen – by 50–60%; from organic compounds by COC by 30–50%.

CONCLUSIONS

As a result of studies, the prospects of use of fibrous carrier for formation of a microbiocenosis, for biological clearing of watercourses of hydroecosystems from organic and microbiological pollution were proven. The species composition and kinetics of periphyton formation on carrier were established for watercourses of mountain hydraulic systems.

It was found that in the process of active aeration of landfill filtrates on the surfaces of carrier and walls of the bioreactor a microbiocenosis is formed, which provides a regime of biological purification of filtrates. This is confirmed by the increased content of microorganisms that absorb nitrogen of organic and inorganic compounds, as well as oligotrophic, nitrifying and pedotrophic microorganisms in the selected samples (compared to the content in the filtrate). Significantly, no denitrifying bacteria were detected in the filtrate.

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