pollutants usually present as suspended solids, as well as heavy metals, petroleum compounds, and nutrients. Although stormwater drainage systems are not intended for the discharge of domestic wastewater, they are an important source of pollutants entering rivers, lakes, and retention reservoirs. Rainwater washes various organic substances and pathogens from urban surfaces.

Therefore, monitoring the quality of stormwater is becoming increasingly important-both from an environmental protection perspective and in terms of compliance with water legislation. Regular testing of stormwater quality makes it possible to identify pollution sources, assess the efficiency of treatment devices (e.g., sedimentation tanks, separators), and adjust stormwater management strategies. Monitoring is also essential for the protection of surface and groundwater and for preventing eutrophication. Currently, a variety of analytical techniques are used in research-ranging from classical gravimetric and spectrophotometric methods to advanced instrumental analyses. The most commonly used include measurements of total suspended solids, determination of heavy metals (AAS, ICP), and photometric and conductometric analyses for nutrients, pH, and conductivity.

Although these methods are highly accurate, stormwater monitoring is challenging due to the irregularity of precipitation and the dynamic nature of the “first flush,” in which pollutant concentrations are the highest. For this reason, new automated solutions for remote monitoring of stormwater quality are being sought. A promising direction involves so-called **electronic senses**-such as the *“electronic tongue”* and *“electronic eye.”* Their advantages include the absence of chemical reagents and the ability to perform real-time measurements at low operational costs compared to traditional laboratory methods. Preliminary research was conducted on the campus of Lublin University of Technology, where the stormwater drainage system has a total length of 2,501.70 meters. Rainwater is discharged into the Bystrzyca River through pipes with diameters ranging from 0.16 m to 0.5 m. The network includes 144 inspection manholes and 73 storm inlets. Samples for analysis were collected from six points: three inlets (W14, W43, W51) and three manholes (D41, D79, D82), located near campus roads and parking areas. The obtained results will serve as reference data for the development of laboratory prototypes of an electronic tongue, enabling the detection of water pollution indicators based on signal analysis from multisensor arrays.

APPLICATION OF IMMOBILIZED MICROORGANISMS FOR RESTORATION OF BIOLOGICAL WASTEWATER TREATMENT

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Modern technologies for biological wastewater treatment are based on the use of microorganisms capable of biochemical decomposition of organic substances and nitrogen compounds. Activated sludge systems remain the most common, but they have several significant limitations, including the sensitivity of microbial communities to hydraulic and temperature fluctuations, instability to toxic impurities and the need for continuous energy supply. These disadvantages are especially critical for small treatment plants operating in seasonal or intermittent mode, when long shutdowns lead to loss of biological activity and the need to re-form the biocenosis after start-up, which can take from 2 to 4 weeks, requiring significant costs to provide the biological process with “fresh” activated sludge or restore the efficiency of activated sludge by long-term feeding [1].

Significant progress in water treatment biotechnology is associated with the development of systems in which microorganisms are immobilized on artificial carriers, forming a stable biofilm. Unlike free-floating activated sludge, immobilized consortia have increased resistance to stress conditions, and their biochemical activity can be maintained even during interruptions in wastewater supply [2].

Anhydrobiosis is the ability of some organisms to survive almost completely loss of water. Important biological agents of activated sludge are the nitrifying bacteria *Nitrosomonas* and *Nitrobacter*. Nitrifying bacteria are autotrophs and sensitive to environmental changes, including temperature, pH, oxygen, and water availability, unlike the spore-forming bacteria *Bacillus*. *Bacillus* spores are among the most resistant to desiccation, high temperatures, radiation, and chemicals of biological objects. They can remain viable for decades in a completely dried state, which is a classic example of anhydrobiosis. Nitrifying bacteria do not have natural mechanisms for surviving complete natural desiccation. However, they can tolerate moderate dehydration as part of a biofilm, where they are partially protected by a polysaccharide matrix that can hold small amounts of water, providing a buffer against complete dehydration. This allows them to survive at moderate humidity levels for a certain period [3].

The aim was to experimentally study the rate of biofilm recovery on a polymer carrier after a period of downtime. The main idea was to create a stable biofilm system that can maintain viability and functional activity during periods without load, which allows to reduce the reactivation time after restarting the treatment plants. Achieving this goal involves studying the processes of biofilm formation, preservation and recovery in laboratory conditions using consortia of microorganisms obtained from activated sludge of operating treatment plants.

The research was conducted at the Department of Bioenergy, Bioinformatics and Ecobiotechnology of Igor Sikorsky Kyiv Polytechnic Institute. Immobilization of microorganisms on a polymer carrier was carried out using activated sludge collected at the Bortnytsky aeration station in Kyiv. The formed biofilm provided effective treatment of wastewater from organic matter and ammonium nitrogen. Then, the carrier with a surface area of 5255 cm^2 was moved to an empty bioreactor, where it dried naturally. After 3 months, a nutrient solution was added to the bioreactor with the dried carrier with the biofilm, the composition of which was calculated from the ratio BOD:N:P=100:5:1 to maintain the vital activity of biofilm microorganisms. The composition included glucose as a source of sugar, organic matter, sources of biogenic elements - nitrogen and phosphorus.

At the beginning of the recovery process, before adding the nutrient solution, the number of live cells was $8{,}84 \cdot 10^4$ in 1 cm^3 of biofilm, which was determined using a cell counter Countess. Within a week, the value increased to $3{,}01 \cdot 10^5$ live cells in the biofilm recovered on the carrier. During the studies, the sizes of live cells were within 3,78 – 8,54 μm, for comparison - in the working activated sludge the cell size is 9-12 μm. This indicates the absence of higher trophic levels, such as ciliates, rotifers, that the energy of the biomass is directed exclusively to the division and formation of the primary biocenosis. The percentage of live cells in the total number increases from 4 to 26% during the first week of recovery, which indicates the possibility of recovering naturally dried biofilm in a short period of time.

The number of cells increased 3,4 times in just the first week of recovery. The increase in the percentage of live cells to 26% indicates not only an increase in their number, but also the successful reactivation of a significant part of the population.

The tasks of further research will be to verify the efficiency of the restored biofilm, establish technological modes of operation of structures with immobilized microorganisms during the shutdown, stoppage and restart period, and optimize processes during this period to minimize its duration and save material and financial costs.

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ПОРІВНЯННЯ ФІЗИКО-ХІМІЧНИХ МЕТОДІВ ОЧИСТКИ СТІЧНИХ ВОД МОЛОКОПЕРЕРОБНИХ ПІДПРИЄМСТВ

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Останніми роками в Україні суттєво зросло виробництво молочних і кисломолочних продуктів, а разом із цим — кількість молокопереробних підприємств. У процесі виробництва утворюються значні об'єми стічних вод, що містять органічні (жири, білки, цукри) та неорганічні (солі, кислоти, сода) домішки, залишки молочних продуктів і ПАР. Скидання таких вод без очищення призводить до дефіциту кисню у водоймах і загибелі риби. Фізико-хімічні методи очищення забезпечують ефективне видалення завислих речовин, емульгованих жирів і колоїдних частинок. Їхня основна перевага полягає у високій швидкості процесу та високій ефективності очищення [1].

Метою роботи є порівняння ефективності різних методів фізико-хімічного очищення стічних вод молокопереробних підприємств.

Коагуляція є одним із найважливіших фізико-хімічних методів очищення промислових стічних вод, що забезпечує зменшення вмісту колоїдних, завислих речовин і каламутності води. За оптимальної дози коагулянтів сульфату алюмінію та сульфату заліза 1000 мг/дм³ при pH 5 ефективність видалення ХСК зі стічних вод молокопереробної промисловості становила 68% для сульфату алюмінію і 62% для сульфату заліза. Використання сульфату алюмінію в поєднанні з поліферосульфатом і поліакриламідом як допоміжних реагентів дозволило досягти 82% зниження ХСК за набагато нижчої дози — 100 мг/дм³ [2]. При pH 6 для $FeCl_3$ та pH 7 для $Al_2(SO_4)_3$ оптимальна доза Al^{3+} становила 188,4 мг/дм³, а ефективність видалення ХСК сягала 33%. Для Fe^{3+} оптимальна доза дорівнювала 172,5 мг/дм³, а зниження ХСК — 45%. Таким чином, кращі результати очищення були отримані за використання $FeCl_3$ порівняно з $Al_2(SO_4)_3$ [3].

Метод коагуляції було використано для очищення модельних стічних вод молокопереробних підприємств за допомогою неорганічних коагулянтів, таких як поліалюмінійхлорид (PAC), сульфат заліза ($FeSO_4$) та галун калієво-алюмінієвий ($KAl(SO_4)_2 \cdot 12H_2O$) [4]. Експерименти проводили для оцінки впливу початкового pH (5–10) і дози коагулянту (100–5000 мг/дм³) на ефективність видалення ХСК. Оптимальне значення