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# Wastewater Treatment in Anaerobic Bioreactors - Main Components

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**ABSTRACT**

This article is about the main directions of investigations of anaerobic processes in the wastewater treatment digester. In addition, an anaerobic filter pilot plant is proposed. Keywords: wastewater treatment, bioreactor, methane digestion, anaerobic biofilter, media, immobilized microflora, pilot plant, plant layout.

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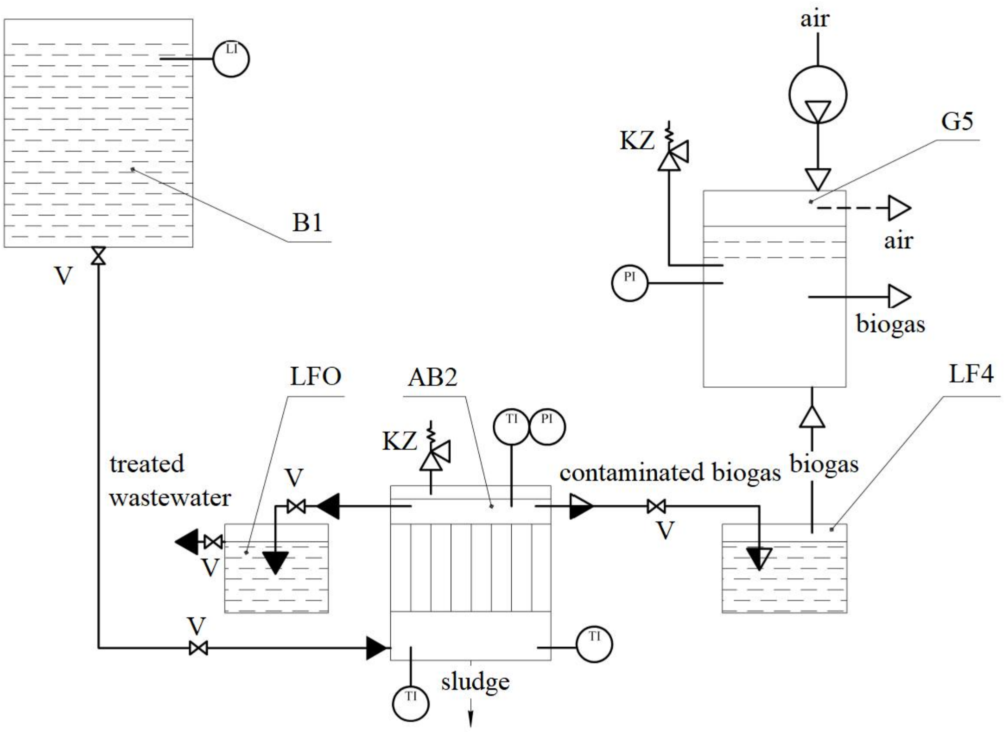
## Introduction.

Wastewater treatment has been and remains one of the main problems of a metropolis from both an environmental and economic point of view. The most common and effective anaerobic treatment is associated with significant costs. At the same time, anaerobic wastewater treatment allows the process to be carried out using one of its products, biogas, as an energy carrier. However, despite a number of additional advantages of anaerobic technology, such as the absence of odor and the possibility of using stabilized sludge as fertilizer, it is characterized by low productivity. This problem was solved by the introduction of anaerobic bioreactors with immobilized microflora. Developments in this area are being actively pursued in many countries, but their results are difficult to systematize. The anaerobic wastewater treatment process largely depends on the characteristics of the wastewater and the design of the bioreactor, so to confirm the theoretical studies of the process, it is necessary to experimentally verify them. The analysis of published works related to the study of the process of anaerobic wastewater treatment on inert media allows us to identify the main areas of development: - the use of substrates and certain types of microorganisms; - conducting the process in one or more anaerobic bioreactors; - the use of various media; - studying the effect of temperature One of the important areas in the treatment technology is the modification of the substrate itself by adding chemical compounds to the wastewater to improve the quality of treatment [1-3].

The process can be carried out in several bioreactors in parallel or in series, and the authors of [4] note significantly better results when using bioreactors installed in series. An important technique for improving the quality of treatment is partial or complete recirculation of treated water, which allows to increase the concentration of biomass in the reactor and, consequently, the treatment rate [5-7]. While the factors mentioned above mainly affect the quality of treatment, the choice of the type of feed determines, first and foremost, the performance of the plant. There are three main designs of anaerobic bioreactors with inert media: fluidized, fixed, and moving nozzles. The least interest has been shown in moving media, which is explained by the complexity of the design and the difficulty of its implementation in airless conditions. The design of a rotating anaerobic biofilter is presented in [8]. The most common are reactors with a nozzle in the form of a bulk porous material, the advantages of which have been proven by many studies [9-11]. In [4], the results of a study of bulk media from different materials were published, and the authors concluded that the most favorable conditions for acetogenic and methanogenic microorganisms are provided by media of different origin. A similar approach has been applied in practice by the authors of [12], where the results of simultaneous loading of media of different specific gravity into the bioreactor are presented in order to increase the processing rate.

Bulk reactors have a number of undoubted advantages, however, they are characterized by siltation of granules, partial removal of the load with the flow of liquid, so it is advisable to limit the nozzle in a certain volume, for example, with a grid, as proposed by the author [13]. Another way to solve this problem is to use fixed media in the form of grids, ruffs, etc. The temperature regime is crucial for the anaerobic digestion process. The most studied are the thermophilic fermentation mode, which is considered more efficient, and the mesophilic mode, which is more resistant to temperature changes and more economical in temperate climates [5, 14].

Least attention has been paid to the psychrophilic fermentation mode, which can be explained by its low productivity. The main objectives of the experimental study described below are: confirmation of the operability, intensity, and efficiency of the proposed design of the anaerobic bioreactor; substantiation of the feasibility and efficiency of the process of destruction of organic pollution by a film of activated sludge immobilized on fixed media; study of the basic laws of bioreactor operation; substantiation of the use of polymeric media; obtaining experimental data for their comparison with the numerical data of mathematical modeling. To solve these problems, a pilot plant was installed at the Department of Biotechnology and Engineering (Figure 1).




(Fig. 1). Schematic of the pilot plant: B1 - pressure tank; AB2 - anaerobic bioreactor; LFO - clarified liquid collector; LF4 - biogas collector; G5 - gas holder; V - shut-off valve; KZ - safety valve.

When studying the process, it will be advisable to use model liquids with a composition similar to wastewater and activated sludge from municipal water treatment plants. The substrate is fed into the bioreactor AB2 from the pressure tank B1, the liquid level in the tank is controlled by a level indicator. The liquid from the tank is transferred to the bioreactor by gravity. A flow meter is installed on the pipeline section between the tank and the bioreactor. The anaerobic bioreactor AB2 is a rectangular tank. The substrate is fed to the bottom of the bioreactor. To maintain proper temperature conditions, the substrate is insulated and preheated, and the temperature of the liquid at the inlet and outlet of the apparatus is monitored. The bioreactor body contains media used to immobilize methanogenic microorganisms. The media is made in the form of sheets of waste plastic. The sheets are fixed on a metal or plastic frame. In order to study and compare the characteristics of different types of media, it is possible to replace the frame with media. The distance between the polymer sheets is chosen so that the substrate flow does not disturb the boundary laminar layers around adjacent sheets, without forming a middle zone of the medium flowing through the channel without contact with microorganisms. On the other hand, the specific surface area of the contact between the substrate and the microorganisms should not be less than 100 m 2 per 1 m 3 of substrate.

During operation, the temperature is controlled and the liquid flow rate is regulated. The water at the outlet of the bioreactor is directed to the liquid collector, from where it is taken for further analysis. The bioreactor is equipped with a safety valve, and the pressure above the liquid surface is periodically monitored by a pressure gauge. The purified water is removed through the side wall of the vessel and enters the liquid collector ZR3. In order to maintain anaerobic conditions in the anaerobic bioreactor, the liquid collector is equipped with a water seal. Biogas with liquid vapors enters the biogas purification collector GC4, where a certain level of liquid is maintained to prevent air from entering the anaerobic bioreactor. In addition, the liquid performs a purification function - passing through the liquid layer, the biogas is purified from liquid vapors and other impurities, in addition, due to the good solubility of carbon dioxide in water, methane is separated from biogas.

It is also possible to reorient the process in such a way as to obtain the maximum amount of biogas. The installation is quite simple and involves the installation of control and safety equipment. It should be noted that anaerobic bioreactors with immobilized media after reaching steady-state are efficient and resistant to fluctuations in environmental conditions.

## Conclusion.

The proposed design of the anaerobic bioreactor AB2 demonstrates efficiency in water purification and biogas production processes due to the introduction of modern solutions for immobilizing methanogenic microorganisms and optimizing thermal and hydrodynamic conditions. The use of polymeric carriers provides a high specific contact area between the substrate and microorganisms, which contributes to the maximum productivity of the methanogenesis process. The bioreactor is equipped with temperature, pressure, and liquid flow control systems, which allows for stable operation of the plant under various conditions. In addition, an efficient biogas purification system ensures the quality of the product, and a gas holder with an elastic partition optimizes the biogas accumulation process. Thus, the plant is energy-efficient, easy to operate and versatile in use, which allows it to be adapted for both water treatment and biogas production, contributing to the development of environmentally sustainable technologies.

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