на вираженість специфічної дії ципрофлоксацину та цефтзидиму, підвищуючи активність антимікробних препаратів відносно біоплівок *E. coli*.

Отриманні дані свідчать про доцільність проведення подальших досліджень та вивчення механізму дії комбінацій антимікробних препаратів та нестероїдних протизапальних препаратів по відношенню до мікроорганізмів у біоплівковій формі.

Список використаних джерел:

1. Маянський А.Н. *Pseudomonas aeruginosa*: характеристика утворення біоплівки / Маянський А.Н., Чеботарь І.В. // Молекулярна генетика, мікробіологія та вірусологія. – 2012, № 1.

2. Afeltra J., Verweij P. E. Antifungal activity of nonantifungal drugs // Eur. J. Clin. Microbiol. Infect. Dis.

3. Mohsen A., Gomaa A. Antibacterial, Anti-biofilm Activity of Some Non-steroidal Anti-Inflammatory Drugs and N-acetyl Cysteine against Some Biofilm Producing Uropatogens // American Journal of Epidemiology and Infectious Disease – 2015 – Vol. 3, № 1, p. 1-9.

4. Определение чувствительности микроорганизмов к антибактериальным препаратам: Методические указания МУК 4.2.1890-04 // Клин. микробиол. и антимикроб. химиотерап. – 2004. – Т. 6, № 4. – С. 306–359.

5. O'Toole G. A. Microtiter Dish Biofilm Formation Assay / G. A. O'Toole // J. Vis. Exp. – 2011. – № 47. – pii: 2437.

6. Лапач С. Н. Статистические методы в медико-биологических исследованиях с использованием Excel / С. Н. Лапач, А. В. Чубенко, П. Н. Бабич. – Киев: Морион, 2001. – 408 с.

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MATHEMATICAL MODEL OF BIOLOGICAL TREATMENT OF HARMFUL GAS-EMISSIONS

Chemicals are an integral part of everyday life. There are over 100,000 different substances in use today. They play a role in every industry, and many are critical to human wellbeing and sustainable development. Yet chemicals can also endanger human health and the environment if not managed properly.

Much work remains to be done to understand and mitigate these negative impacts, such as widespread contamination of land, water and air. This work is especially critical today as new and potentially hazardous substances continue to emerge.

There is only one way to halt environmental pollution – is the cleaning of emissions entering the air, because the atmosphere is the initial «reservoir» from which harmful chemicals are distributed throughout the ecological environment. Actions in this field should be targeted and supported by effective technical solutions.

Based on the literature review was considered the current state and prospects of development of gas-emission control technologies using biological systems.

Traditional physical-chemical methods of cleaning gaseous emissions will not solve the problem of environmental safety of these compounds to the environment. Now, for the removal of a number of industrial emissions of gaseous pollutants are rather promising biological treatment installations of air.

The process of biodegradation of gaseous pollutants investigated a number of domestic and foreign scientists – was investigated the analysis and synthesis of available technical solutions and also classification processes and biological purification of gas emissions of industrial origin [1, p. 1419-1436]. Modern devices of biological treatment gas emissions can be classified by structural features (filters, scrubbers), processes that occur in them (adsorption, absorption) and types of microorganisms (aerobic, anaerobic, thermophilic, etc.).

Today we know two microbiological methods of cleaning gas-flow: biofiltration and bioadsorption. During bioadsorption of emissions, harmful components selectively utilized by different strains of microorganisms that can be dispersed in the washing liquid (absorbent) or immobilized on the surface of orifice in the form of biofilms. During biofiltration, polluting components initially adsorbed in layer filtering, and then oxidized by microorganisms contained therein. The most commonly used is adapted activated sludge or cultures of microorganisms, for example, genus Pseudomonas, and mold fungi.

The comparative economic analysis of of different ways of treating gaseous emissions shows that biological air purification methods are cheaper, than traditional physical and chemical methods of removing contaminants, such as a catalytic afterburning or absorption on activated carbon, and no harmful effects on the environment [2, p. 309-318]. Biological air purification methods are based on the ability to destroy certain microorganisms under aerobic conditions present in its organic and inorganic substances to form harmless products of microbial metabolism. Pre-selection of specially adapted monocultures or mixed cultures of microorganisms providing for more efficient cleaning of air from the relevant pollutants and reduction of terms input of the installations into operation. Currently there are three basic types of installations for biological air cleaning: biofilters, bioreactors and bioskrubbery (biological tricking layer filter). The basic element of the biofilter is a filter bed which is providing of sorption components of purified air environment and subsequent destruction their by microorganisms which were in thise layer. As filter layer use a compost, peat, sawdust, vegetable waste and other materials of natural origin containing minerals required for nutrition of microorganisms. At this optimum moisture content in the filter layer is from 40 to 60% by weight of carrier material. The filter layer may also contain various additives which improve its porosity (glass, porcelain or plastic pellets) and sorption properties (absorbent carbon) or ensuring the maintenance of constant pH in the filter layer (limestone, chalk) [3, p.1-25].

By biochemical oxidation, in the cells of microorganisms, pollutants of air often decomposed to carbon dioxide and water. But It should be noted that the process of detoxification such emissions is a set of interrelated processes due by the heavy reactions biokinetics, such as, nitrification and denitrification. in connection with the specificity, toxicity and explosiveness many organic hydrocarbons, such as methane, it is necessary to use immobilized bioreactors, and also are adapted to the pollution of microorganisms and their populations.

The complexity of the processes taking place in the bioreactor,. characterized by rigid dynamics (a wide range of time constants), nonlinearity, variable over time parameters and conditions, as well as the formation of cross- compounds etc. Given the above, for calculating the kinetics of complex processes and structural parameters of bioreactors, the obvious need for a comprehensive approach that includes experimental research and development of mathematical models that is an important preparatory step for the implementation of biological treatment of gaseous emissions.

To determine the patterns of the processes occurring in the reservoir as part of the system «collector-bioreactor», it is necessary to consider the balance of mass contamination [4, p. 53-61]:

$$G_{0t} = G_0 + \delta G_{0t} - \delta G_t, \tag{1}$$

where G_{0t} – mass of contamination in the reservoir for a moment in time t, gr;

G_0 – mass of contamination in the reservoir for a moment in time $t = 0$, gr;

δG_{0t} – mass of contamination in the reservoir for a moment in time t due to its coming, gr; δG_t – mass of contamination in the reservoir for a moment in time t due to its transfer to the bioreactor, gr.

Obviously that:

$$\rho_{ot} = \frac{G_{0t}}{K}, \tag{2}$$

$$\rho_{ot} = \frac{G_0}{K}, \tag{3}$$

where ρ_{0t} – concentration of harmful substances in the manifold that changes over time, gr/m^3; ρ_0 – initial concentration of pollutants in the manifold gr/m^3; K – volume of manifold, m^3.

then the integral form of mass balance (1) can be written:

$$\rho_{0t} = \rho_0 + \frac{1}{K}\int_0^t g_{0t}dt - \frac{N}{K}\int_0^t \rho_{0t}dt, \tag{4}$$

where g_{0t} – intensity of the flow of harmful substances in the manifold that changes over time, gr/h; N – performance of bioreactor by volume gas mixture m^3/h.

After differential equation (4) by time, we have next equation:

$$\frac{d\rho_{0t}}{dt} = \frac{g_{0t}}{K} - \frac{N}{K}\rho_{0t} \tag{5}$$

We assume the intensity of the flow of pollution at some time interval is constant:

$$g_{0t} = g_0 \tag{6}$$

and for initial conditions:

$$t = 0 \rightarrow \rho_{0t} = \rho_0 \tag{7}$$

obtain the solution of equation (5):

$$\rho_{0t} = \frac{g_0}{N} + \left(\rho_0 - \frac{g_0}{N}\right) \cdot e^{\frac{N}{K}t} \tag{8}$$

Expression (8) converts, in the case of substitution, into identity not only the differential equation (5), but and the initial integral equation (4). Fractional part of the exponent depending (8) is time, necessary for processing of the total volume of the collector at a given performance bioreactor:

$$T_{П} = \frac{N}{K} \tag{9}$$

Besides, structure of equation (8) allows to introduce the concept of asimptotation concentration:

$$\rho_{0a} = \frac{g_0}{N} \tag{10}$$

We understand the asimptotation concentration as a limit value, to which is approaching concentration of pollution in the collector over time at constant intensity of flow of harmful substances into collector g_0 and continuous productivity of bioreactor N.

Then finally, the dependence of the average concentration of pollution in the reservoir from the time can be written as:

$$\rho_{0t} = \rho_{0a} + (\rho_0 - \rho_{0a}) \cdot e^{\frac{t}{T_{П}}} \tag{11}$$

Mathematical model of biological treatment of emissions allows to calculate changes the average concentrations of harmful compounds in the bioreactor at constant or cyclical the intensity of pollution flow.

References:

1. Kennes C. Bioprocesses for air pollution control // Portland, 2009. – 1537 p.

2. Gabrieland D. Technical and economical analysis of the conversion of a ful-scale scrubber to a biotrickling filter for odour control // Portland, 2004 – 504 p.

3. Perchugov G.Ya., Bobrov O.G. Industrial and sanitary cleaning of gases // Moskov, 1986 – 73 p.

4. Bahareva G.Yu., Shestopalov O.V., Filenko O.M., Tihomirova T.S. Development of a mathematical model of the process of biological treatment of gasous effluents // Kharkov, 2015. – 89 p.