

Aeration for increasing the bioactivators efficiency in treating household wastewater containing synthetic detergents

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ABSTRACT

The paper presents the research results of synthetic detergents influence on various bioactivators efficiency in household wastewater treatment. The research has been carried out using model solutions simulating domestic wastewater, where organic pollutants were represented by the solutions of sucrose, starch and milk powder, and synthetic detergent was used as toxicant-pollutant. The bioactivators effectiveness in the presence of synthetic detergent in model solutions treatment was assessed according to the changes of chemical oxygen consumption during static experimental studies. The study shows that bioactivators effectiveness in the treatment of household waste water containing synthetic detergents increases from 7 to 31% when aeration is applied. The recommendations are given for the considered bioactivators application in household waste water treatment under various operating conditions.

Key words: household waste water, synthetic detergents, biological treatment, bioactivators, aerobic microorganisms, chemical oxygen consumption, aeration

1. INTRODUCTION

Nowadays all over the world much attention has been paid to the problem of environment protection against anthropogenic pollution. Household waste water is one of such pollution sources. It is formed in the result of human economic and household activities and therefore contains organic substances and biogenic elements as basic pollutants. In this regard, mechanical, sorption, and biological treatment methods are used for household wastewater treatment at local and centralized treatment facilities [1-4].

Biological treatment of domestic wastewater is carried out under the impact of microorganisms activity, which mineralize organic compounds - their food sources, dissolved in waste water. Under natural conditions, the process of biological treatment proceeds very slowly as bacteria amount in wastewater is not enough for active fermentation of the household waste. Thus, the degree of biological purification intensity of household wastewater depends on the organic substances composition and

concentration, on waste treatment duration, on treatment equipment and facilities design, temperature, aeration conditions, microorganisms species composition, their adaptive capacity and resilience to the toxic pollutants effects, etc. [5-9].

Currently, bioactivators – compositions of highly active bacteria effectively decomposing organic substances, and enzymes in wastewater such as amylase peptidase, lipase, and lactase which facilitate breakdown of proteins, fats, and carbohydrates contained in household wastewater, are actively used to intensify the household wastewater biological treatment processes.

The bioactivator effectiveness largely depends on toxicants contained in household wastewater, and primarily synthetic detergents that are not digested by microorganisms which are harmful for them, and besides, synthetic detergents are very difficult to be removed from water [10, 11].

The synthetic detergents are based on surface-active substances – various salts of sulfonic acids or polyethylene glycols ethers, as well as various auxiliary substances improving the washing ability, enzymes for stains removal, bleaching agents, flavorings, etc. Synthetic detergents include washing powders, shampoos, gels, detergents for washing dishes, care for the kitchen and bathroom glass-ceramic surfaces, etc. The widespread application of synthetic surfactants in detergents causes their high content in domestic wastewater.

In this respect, the research urgent task is to study the synthetic detergents influence on household wastewater treatment using bioactivators and to search for the ways of intensifying bacteria activity in synthetic detergents media.

2. RESEARCH OBJECTS AND METHODS

To assess the microorganisms efficiency in the household wastewater treatment containing synthetic detergents, three bioactivators have been selected: "Doctor Robic" brand 109, "Biobac" brand BB-YS 060 and "Sanex".

The following components were used to prepare model solutions containing organic compounds and simulating domestic wastewater:

- starch ($C_6H_{10}O_5$)_n, which is amylose and amylopectin polysaccharides mixture, their monomer alpha-glucose was used to simulate complex carbohydrates in household wastewater;
- sucrose ($C_{12}H_{22}O_{11}$), which is disaccharide from oligosaccharides group consisting of two monosaccharides: α -glucose and β -fructose, was used to simulate simple carbohydrates in domestic wastewater;
- whole milk powder was used for simulating proteins, fats and simple carbohydrates in household waste water.

All of the above mentioned organic compounds are nutrients for microorganisms present in bioactivators, and, consequently, they can be removed from model solutions with their help.

To simulate the presence of synthetic detergents (SD) in the household wastewater, the dish washing agent "Fairy" was added, which played the role of a toxicant in relation to the microorganisms vital activity. This product contains the following components: sodium Laureth sulfate (anionic surfactant), lauramine oxide (nonionic surfactant), polypropylene glycol, sodium chloride, ethoxylate-propoxylate of polyethylenimine, Phenoxyethanol, 1,3-cyclohexandimethylamine, sodium hydroxide, methylisothiazolinone, limonene, linalool, water. The efficiency of organic compounds removal from model solutions purification was assessed by the decrease of chemical oxygen consumption (COD) during the experimental studies. The measurements were carried out using COD photometric analyzer "Expert-003-COD".

To study the aeration effect on the biological purification process intensification in model solutions, air oxygen was supplied by the compressor with the capacity of 0.12 m³/h.

All experiments were performed under static conditions at ambient temperature of 22±2°C. Sampling was performed in 3 repetitions on the fourth, eighth and twelfth day with the determination of the initial COD before introducing bioactivators to the model solutions.

3. EXPERIMENTAL RESULTS AND DISCUSSION

In the previous researches, the authors showed that all three considered bioactivators contain viable and highly active bacteria, which as a result of the consumption of organic pollutants, are forming the large number of bacterial communities and are effectively purifying the model solutions from the pollutants used in this work. It has also been stated that aeration causes the increase in bacteria efficiency, and therefore they are aerobic [12]. In this regard, the research was carried out including two parallel experiments: for processing model solutions without aeration and with aeration.

Figure 1 shows the results of treating model solution containing the mixture of organic compounds and

toxicant-pollutant "Fairy", using the bioactivator "Doctor Robic" without aeration and with aeration.

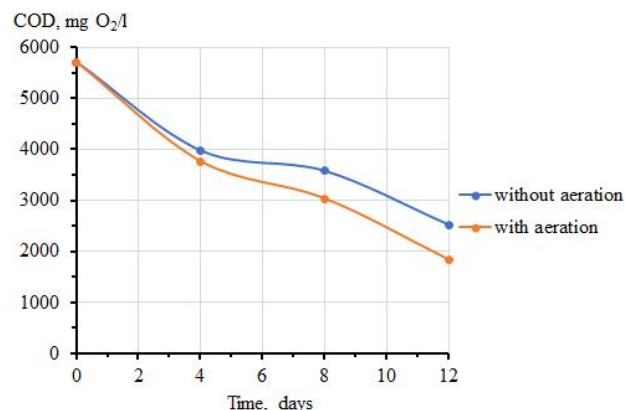


Figure 1: Treatment efficiency of model solution containing the mixture of organic compounds and toxicant-pollutant Fairy, using "Doctor Robic" bioactivator

As the received data shows, the synthetic detergent "Fairy" significantly reduces this bioactivator effectiveness. This can be explained by the fact that the synthetic detergent "Fairy" introduction into the model solutions, simulating household waste water, restricts the bacteria access to the air oxygen and toxically affects them directly causing the decrease of viability and activity of bioactivators microbial communities and, as a result, the effectiveness is inevitably reduced. The best bioactivator performance under the conditions of applying aeration depends on the fact that surfactants partial decomposition occurs under the aerobic conditions. Moreover, additional oxygen in the air increases bacteria resistance to the toxic effects of synthetic detergents.

The treatment results of the model solution containing the mixture of organic pollutants in the presence of Fairy toxicant, using "Biobac" bioactivator without the aeration and with aeration are shown in figure 2.

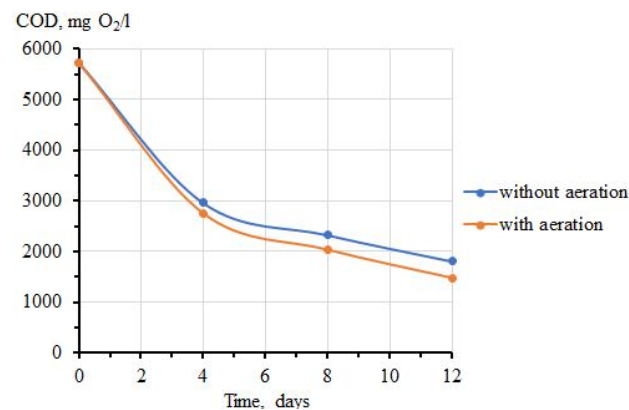


Figure 2: Purification efficiency of model solution containing the mixture of organic compounds and contaminant-toxicant Fairy, using "Biobac" bioactivator

As the figure shows the dependencies for solutions without aeration and with aeration are similar, but more COD intense decrease is detected in the first four days. Thus, the bacteria from this bioactivator are less dependent on oxygen.

The treatment results of the model solution containing organic compounds mixture and toxicant "Fairy", using "Sanex" bioactivator without aeration and with the aeration are shown in figure 3.

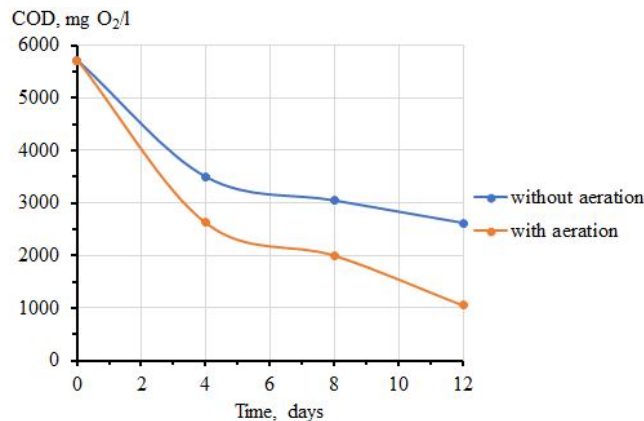


Figure 3: Treatment efficiency of the model solution containing the mixture of organic compounds and toxicant Fairy using "Sanex" bioactivator

In this case, the similar nature of dependencies is observed, but COD reduction without aeration is less effective, but with aeration, the purification rate exceeds the experiments results with bioactivators "Doctor Robic" and "Biobac".

Table 1 presents the comparative characteristics of the considered bioactivators effectiveness under different treatment conditions basing on the previously obtained data [12] and on the current research results.

Table 1: Comparative assessment of the bioactivators effectiveness

Parameter	Bioactivator		
	«Doctor Robic»	«Biobac»	«Sanex»
COD total reduction without aeration, %:			
- without SD	90.8	69.0	54.7
- with SD	50.5	64.4	48.8
COD total reduction with aeration, %:			
- without SD	95.6	77.9	71.2
- with SD	60.4	65.0	69.2

When comparing bioactivators, it can be noted that "Doctor Robic" bioactivator was the most sensitive to synthetic detergents and its effectiveness in this case was the lowest. "Biobac" bioactivator revealed average results in treating model solutions with synthetic detergents, the aeration effect on the result is insignificant, and it is inferior to "Sanex" bioactivator in treating model solutions in the presence of synthetic detergents. "Sanex" bioactivator proved to be the most effective for the model solutions treatment in the presence of synthetic detergents with the aeration.

The research has shown that aeration can reduce the negative effect of synthetic detergents at the example of toxicant-pollutant Fairy for all considered bioactivators. According to the research results the highest treatment efficiency with aeration and synthetic detergent has been observed for "Sanex" bioactivator.

4. CONCLUSION

The research results concerning model solutions simulating household wastewater has revealed that synthetic detergents cause efficiency decrease of the bioactivators "Doctor Robic", "Biobac" and "Sanex". To reduce the negative impact of synthetic detergents on biological treatment processes using aerobic bacteria, it is recommended to apply aeration, which, as research results show, allows to increase the treatment efficiency of the model solutions, containing synthetic detergents. Besides it was detected that "Sanex" bioactivator with the aeration revealed the best microorganisms resistance to synthetic detergents, and, as a result, provides the highest purification degree.

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