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## REDUCTION OF HEAVY METALS CONTENT IN WASTEWATERS DURING TREATMENT PROCESS

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**Abstract.** *This article is devoted to the problem of wastewaters treatment and wastewater sludge utilization. Attention is paid to the problem of high content of heavy metals in wastewater sludge and inability of its further use. An alternative method for reduction of heavy metals content in wastewaters and sludge is proposed. The experiments with EM treatment of wastewater sludge in order to control heavy metals among other harmful substances are presented in the article.*

**Keywords:** effective microorganisms, EM-technology, heavy metals, wastewaters, wastewater sludge, wastewater treatment, water quality.

### Introduction

As it is known, the process of wastewaters treatment leads to formation of great amounts of sludge. However, all sewage treatment plants in Ukraine have the similar problem connected with utilization of sludge, which forms in a result of the wastewaters treatment process.

The most common and popular method for wastewater sludge utilization during long years was drying at sludge fields and further use as organic soil nutrient. However, during last 20 – 30 years this method has not being used, because of the high concentrations of various toxic substances in sludge, mainly heavy metals.

The presence of heavy metals in sludge is stipulated by activity of industrial enterprises. Their wastewaters come to canalization system insufficiently purified or without any purification. Moreover, sludge content is not homogeneous, bacterially infected, and there are organic substances, which decay easily causing unpleasant smells. So, the presence of high concentrations of heavy metals and other toxic substances in wastewaters sludge made it impossible to use in agriculture or other spheres of human activity [1].

Nowadays most of all sewage treatment plants in Ukraine just pump wastewater sludge to sludge composting fields, where it is stored. So, development of ecologically safe technologies for wastewaters sludge utilization is of high importance.

### Analysis of researches and publications

Today one of the most effective technologies for wastewater sludge utilization is dewatering and thermal processing. During the combusting process heavy metals are removed as ash. However, projecting and implementation of thermal processing complexes requires significant capital investments, which are usually absent in such countries as Ukraine. So, there is a need in search for new alternative technologies for wastewater sludge utilization.

During sewage processing the equipment in which both natural and physical methods are used; biological activity of microorganisms is also applied. The microbial communities used in the cleaning equipment consist of the cultures living in sewage. However, microorganisms naturally living in drains are not necessarily the most effective microbial communities, which can provide necessary quality of processing of these drains. Therefore it is possible to assume, that the method of specific microbial cultures introduction into sewage waters can increase efficiency and productivity of existing treatment systems.

These groups of organisms were found in 1980's in Riucus University, Japan and they are known as effective microorganisms (EM). Nowadays they have become popular in numerous countries all over the world and cause positive influence on Earth's environment. EM-technology has being successfully applied in numerous countries for about 20 years.

Analysis of this experience shows that introduction of effective microorganisms into sewage treatment process reduces unpleasant smells, improves quality of treated waters and waste water sludge, significantly reduces amount of sludge formation, increases the level of coli bacillus suppression, and decreases sulfides content [2].

As a whole EM represents a liquid with pH = 3,5 or lower. They are created by mixing various groups of naturally living, useful, not pathogenic, aerobic and facultative anaerobic microorganisms. EM contains a plenty of lactic bacteria (*Lactobacillus* and *Pedococcus*), yeast (*Sacharomyces*) and a small amount of photosynthesizing bacteria, actinomycetes and other microorganic cultures [3].

### Purpose

Existing methods of sewage treatment at industrial enterprises are not enough effective. Different types of microorganisms, which are used for this purpose have not shown yet a significant practical effect. That's why the aim of this work is to analyze the existing experience in EM application for the content of heavy metals reduction. It is necessary to study the ability of microorganisms to change the ionization of heavy metals. The task is to develop a technology with introduction of EM into the process of wastewater sludge treatment.

### Application of effective microorganisms for heavy metals content reduction

Today, the ability of EM to adsorb  $\text{Fe}^{+3}$  ions and  $\text{Cu}^{+2}$  ions in model solutions and wastewater flows on industrial enterprises is being studied.

Since biochemical processes are usually prolonged in time and also depend on the concentrations of the components of the wastewater. The interest of the study is how the concentration limits of the interacting substances and the dynamics change in the ongoing process.

In experiments conducted with municipal waste waters, cations concentrations of  $\text{Fe}^{+3}$  and  $\text{Cu}^{+2}$  have been set in accordance with the state standard methodology for their determination. During experiment EM preparation was added to wastewater samples in different concentrations. It was determined the minimum current concentration of EM preparation, that is equal to 0,065 ml/l. A further increase in the concentration of EM had no effect on the concentration of metals in testing samples. The initial concentrations of  $\text{Fe}^{+3}$  and  $\text{Cu}^{+2}$  in model solutions were respectively 0,40, 1,00,

2,00, 3,00, 4,00 mg/ml, and 0,06; 0,10; 0,20; 0,30; 0,50 mg/ml. These solutions were exposed to the EM-preparation during 1, 2, 3 hours. After the experiment, the iron content decreased respectively by 32,3%, 55,5% and 63,3%. As for the sorption of copper ions during the similar time periods (1-3 h), the concentration in model solutions has decreased respectively by 15,4%, 26,7% and 37,4%. Longer incubation of EM (24 h) did not change the concentration of metal ions.

In subsequent experiments sorption capacity was determined by effective microorganisms immobilized in mold. It was determined previously that concentration of  $\text{Fe}^{+3}$  ions in industrial wastewater used for experiment exceeds the limit acceptable concentration (LAC) in three times. Under the influence of the EM the level has decreased in 11.2 times.  $\text{Cu}^{+2}$  ions in these waste waters were absent. The methodology of experiment looks as the following. A column of 10 mm diameter and 150 mm high was filled with milled mold (3 mm). The first sample of the waste water was passed through the column with mold. Second sample of waste water was passed through the column with mold and immobilized EM (physical immobilization of microorganisms was 80%). The content of  $\text{Fe}^{+3}$  ions in the control sample (initial waste water) was equal to 1,119 mg/l. The content of  $\text{Fe}^{+3}$  ions in the first sample (waste water passed through the mold) decreased to 10.2 times, and it was equal to  $0,19 \pm 0,01$  mg/liter. In second sample with wastewater passed through the mold and immobilized EM it was achieved almost complete purification of sewage from iron ions. The content of  $\text{Fe}^{+3}$  ions was equal to 0,001 mg/l. The data obtained during these experiments are of great practical interest and require further extensive study [4].

As it was mentioned earlier, high concentrations of heavy metals in wastewater sludge make impossible the further use of this sludge in agriculture or other spheres. Having some theoretical data about EM ability to decrease the content of heavy metals ions it was decided to execute the series of experiments with introduction of EM into wastewater sludge. The goal of this investigation was to study the feature of EM to absorb heavy metals ions therefore making them not harmful [5].

Samples of sludge from wastewaters were taken for the experiment and then treated with two kinds of preparations:

- 1) EM Bokashi;
- 2) Water Bokashi.

These Bokashi is a special kind of flocks made of wooden chips and mixed with: a) water, molasses and EM (EM Bokashi), b) pure water (Water Bokashi).

The Bokashi were being fermented in anaerobic conditions during over 2 weeks. After this process the Bokashi were mixed into the sludge mass, at a proportion of 1:1. Each sample of mixture contained 12 kg of sludge and 12 kg of Bokashi. The mix of sludge and Bokashi then was being fermented again in anaerobic conditions during over 4 weeks.

After this time the samples of untreated sludge and sludge treated with Bokashi were analyzed for the content of heavy metals. The percent variations between the content of heavy metals by EM treated and "water" treated sludge show a significant difference in table.

**Heavy metals content in untreated and treated sludge**

Heavy metals	Untreated sludge, mg/kg	EM treated sludge, mg/kg	"Water" treated sludge, mg/kg	Content difference between EM and water treated sludge, %
Cadmium Cd	1.7	0.76	0.96	20.8
Chrome Cr	29	14	18	22.2
Copper Cu	360	110	160	31.3
Quicksilver Hg	2.0	1.1	1.5	26.7
Nickel Ni	32	13	16	18.8
Lead Pb	55	27	29	6.9
Zinc Zn	900	360	500	28.0

These differences show that the content of all heavy metals in the EM treated sludge is lower than in the water treated sludge. The gap between these differences is from 6.9 percent to 31.3 percent. Analyzing the total level of heavy metals content in untreated sludge and EM treated sludge, we have got the following results: the contents of Cd reduced on 55,3%, Cr – 51,7%, Co – 69,4%, Hg – 45%, Ni – 59,4%, Pb – 51%, Zn – 60%).

## Conclusions

It was determined that municipal wastewater sludge contains some heavy metals (Cd, Ni, Cr, Co, Hg, Zn, Pb, and others). That is the reason, why it is impossible to use wastewater sludge as a fertilizer (compost) in agriculture. Proposed EM cultures are able to reduce the content of heavy metals in sludge up to 60%.

Taking into account the results of conducted experiments we determined, that the microorganisms in EM have the ability and power to change the ionization of heavy metals, so the heavy metals are not detected by the tests. Non-ionized heavy metals are not taken up by plants, and therefore not harmful. The further experiments will be intended for more detailed investigation of microorganisms property to reduce content of heavy metals in wastewater sludge.

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