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# POSSIBILITY OF USING EXCESSIVE ACTIVE SLUDGE AS ORGANOMINERAL FERTILIZER

**Abstract.** The article discusses the existing approaches to the separation of heavy metal ions from excess activated sludge for its further use as an organic fertilizer. Research has been carried out to determine the content of heavy metal ions in the formed excess activated sludge from the Makeevka treatment facilities. There is no data on the migration of metal ions from precipitates treated with calcium oxide under the influence of rain and melt waters. Therefore, studies of the migration of ions of heavy metals, were carried out using the example of zinc, cuprum and iron, from untreated activated sludge, and treated with quicklime.

**Key words:** heavy metal ions, quicklime, migration, activated sludge, leaching.

## STATEMENT OF THE PROBLEM

Activated sludge plays the main role in the process of biological treatment of municipal wastewater. Activated sludge is a biomass, which includes the following types of organisms: bacteria, microscopic fungi, ciliates, amoeba, worms, rotifers, etc. The formation of activated sludge is influenced by the presence of organic contaminants, temperature, pH, redox potential of the environment. Upon completion of purification with the participation of activated sludge, the sludge suspension is divided into two streams, the first of which is return sludge, which again enters the aeration treatment system, the second is excess activated sludge sent for disposal [1]. At many treatment plants, in general, excess activated sludge is not disposed for it's reuse, but is stored at sludge sites. Every year this storage becomes a problem, in connection with which an unfavorable environmental situation arises, large areas of land are required for sludge pads. Storing these types of sludge without pretreatment can lead to pollution of the atmosphere, ground and surface water, and soil. The introduction and development of methods for the disinfection and disposal of the resulting excess activated sludge is an urgent task today.

## ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

For disinfection and binding of metal ions, the authors of [4] recommend treating the sediment with calcium oxide (quicklime). When calcium oxide and sediment interact, calcium hydroxide is formed and heat is released, which contributes to deforming due to temperature treatment of the sediment and increasing the alkalinity of the medium [4]. However, there are no data on the migration of metal ions from precipitates treated with calcium oxide under the influence of rain and melt waters.

**The aim** of this work is to experimentally determine the migration of metal ions into an aqueous solution the from untreated activated sludge and treated with quicklime.

## MAIN MATERIAL

The most rational option for the disposal of treated sediments is their use as organomineral fertilizers, since in their composition they contain biogenic elements: nitrogen, phosphorus and potassium [2]. However, disposal can be hindered by the presence of harmful impurities in the sediments, including heavy metal ions [3]. One of the directions of preparing sediments for disposal is the removal of such impurities from the sediments. The existing methods for removing heavy metal ions can be subdivided into reagent, physicochemical, and reagent-biological. Reagent methods are based on the treatment of wet sediments with acid solutions, while as a result of chemical reactions with heavy metal ions, soluble salts are formed, which are removed during dehydration.

Physicochemical methods include the extraction of heavy metal compounds with organic acids, treatment of the sediment with calcium-containing materials [5]. The reagent-biological method is based on a combination of biological processes and reagent sludge treatment. Biological processes contribute to the conversion of insoluble compounds of heavy metals into soluble forms; reagents are involved both in biological processes and in the subsequent extraction of these compounds from sludge water. Analysis of the methods shows that they all have various kinds of disadvantages that complicate their application. Such disadvantages include the complexity of technological schemes, high consumption of reagents. For two years, industrial research was carried out on the use of sediments from sludge areas as organomineral additives for the cultivation of agricultural crops [6]. It has been shown experimentally that the introduction of urban wastewater sediments into the soil for crops leads to a partial accumulation of metals in vegetable and fodder crops, and also due to atmospheric precipitation, there is a gradual penetration of metals into the lower layers of the soil. The authors [7-8] presented a model of the distribution of heavy metal ions in the soil over time. Due to melt and rainwater, the migration of metal ions into the soil reaches 20...40 cm per year.

Initially, the research was aimed at determining the content of metals in the activated sludge of the industrial aeration tank of Makeyevka treatment facilities and results are compared with previous years.

The method for determining metal ions in activated sludge included the following operations. The dewatered sludge was dried in a drying oven at a temperature of 105 ° C. Then, hydrochloric acid was added to 10 g of the sediment and pH was adjusted to 2, the mixture was kept for 30 minutes with periodic stirring. At the end of the experiment, the content of metals in the aqueous phase was determined using an atomic absorption spectrometer according to the standard procedure. The concentration of metal ions on the absolutely dry matter of the sludge was determined by calculation. The concentration of metals in the activated sludge samples in 2011 and 2018 years and the permissible concentrations of heavy metal ions in the sediment used in agriculture as fertilizers are shown in Table 1.

**Table 1** – Content of ions of heavy metals in activated sludge of sewage treatment facilities of the town of Makeevka

| Metal ions | Concentration of metal ions in activated sludge, mg / kg | | Norm for groups of fertilizers, mg / kg | |
|---|---|---|---|---|
| | 2011 year | 2020 year | I* | II** |
| Cuprum | 17,9 | 85,7 | 132 | 750 |
| Chromium | 31,6 | 0,94 | 90 | 500 |
| Zinc | 406,8 | 58,74 | 220 | 1 750 |
| Plumbum | 47,5 | 12,50 | 130 | 250 |
| Nickel | 272,4 | 16,4 | 80 | 200 |
| Cadmium | 27,8 | 1,26 | 2,0 | 15 |

* Fertilizers of group I: fertilizers based on sewage sludge used for the cultivation of industrial, fodder, grain and green manure crops, in personal subsidiary plots when growing seedlings of vegetable and flower crops. ** Fertilizers of group II: fertilizers based on sewage sludge, used for planting forestry crops along roads, in nurseries of forest and ornamental crops, floriculture, for cultivating depleted soils, reclamation of disturbed lands and slopes of roads, reclamation of solid waste dumps.

From the data obtained in Table 1, it can be seen that the concentration of heavy metal ions contained in the activated sludge has significantly decreased over the past years. This is probably due to the decrease in wastewater discharges by industrial enterprises. At the moment the concentration of metal ions is in the permissible norms, when using sludge as a fertilizer, for different types of crops. It also allows the use of excess silt for biological land reclamation.

The second stage of research was the experimental determination of the migration of metal ions from the untreated activated sludge and the one treated with quicklime. The behavior of ions of copper, zinc and iron was studied. Experiments on leaching sludge untreated with calcium oxide were carried out according to the following procedure. Samples of the dried sediment were mixed with distilled water and kept with periodic stirring for four hours. After that, water was removed from the mixture by filtration, and the content of metal ions in the water was analyzed, the active reaction of the medium was 7.8. To assess the degree of leaching of metal ions depending on the duration of contact of sludge with distilled water, this contact was carried out in parallel experiments for two and four hours.

Experiments on the leaching of sludge treated with calcium oxide were carried out in a similar way, only the sample of sludge was pre-mixed with a dose of calcium oxide equal to 20% of the sludge dry matter weight, while pH value was 11.

For example, Figures 1 and 2 show the results of experiments with the determination of the migration of zinc and copper ions.

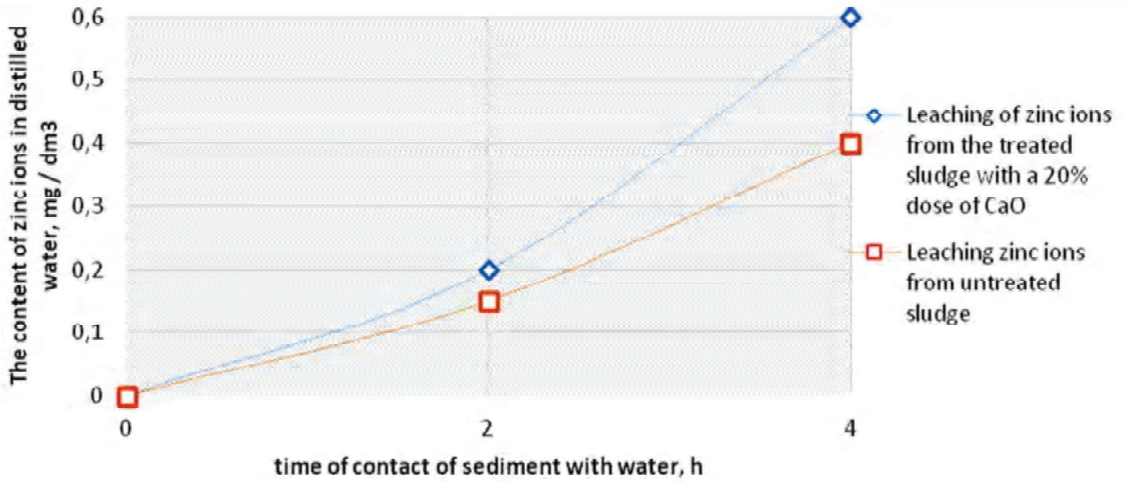


**Figure 1** – Migration of zinc ions into liquid.

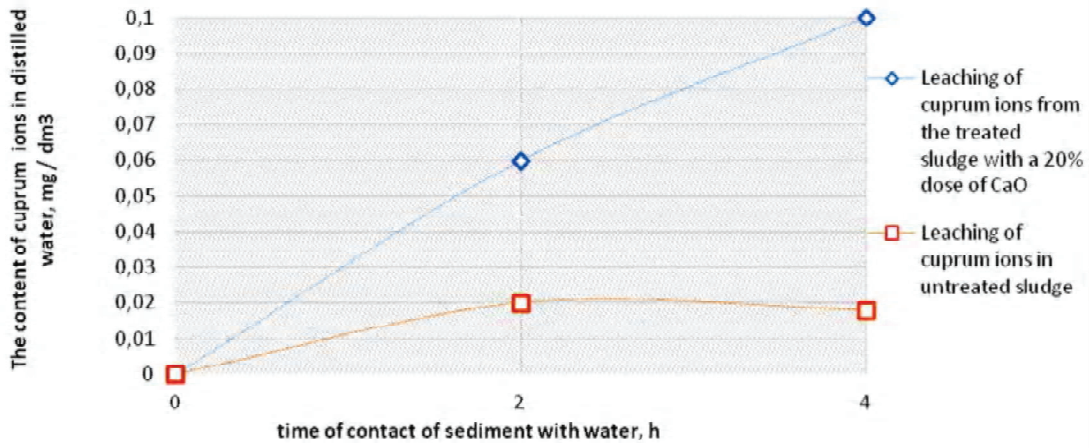


**Figure 2** – Migration of copper ions into liquid.

Table 2 shows the percentage of leaching of heavy metal ions from treated and untreated sludge with calcium oxide, depending on the duration of contact with distilled water.

**Table 2** – Percentage of leaching heavy metal ions from the sediment into an aqueous solution

| Metal ions | Leaching rate of metal ions from untreated sludge | | The degree of leaching of metal ions from the treated sludge with calcium oxide | |
|---|---|---|---|---|
| | with a two-hour contact with water, % | at four-hour contact with water, % | with a two-hour contact with water, % | at four-hour contact with water, % |
| Cu | 15 | 17 | 54 | 80 |
| Zn | 4 | 15 | 7 | 25 |
| Fe | 1,11 | 3 | 2,5 | 3 |

Based on the data obtained, it can be noted that with an increase in the duration of contact of the sediment with water, the migration of metal ions into the liquid increases. In this case, metal ions from the treated sludge


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with calcium oxide undergo the greatest leaching in comparison with the untreated sludge. This indicates that the addition of calcium oxide does not provide the strength of binding of metal ions into insoluble complexes.

## CONCLUSIONS

1) The studies have shown that the excess active sludge of Makeevka wastewater treatment plant, in terms of the concentration of heavy metal ions, is included in the permissible norms for the use of precipitation as a fertilizer.

2) During the treatment of activated sludge with calcium oxide, heavy metal ions are subjected to a greater degree of leaching due to the amphoteric properties of metal hydroxides.

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ВОЗМОЖНОСТЬ ИСПОЛЬЗОВАНИЯ ИЗБЫТОЧНОГО АКТИВНОГО ИЛА В КАЧЕСТВЕ ОРГАНОМИНЕРАЛЬНОГО УДОБРЕНИЯ

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**Аннотация**. В статье рассмотрены существующие подходы к выделению ионов тяжелых металлов из избыточного активного ила для дальнейшего его использования в качестве органического удобрения. Проведены исследования по определению содержания ионов тяжелых металлов в образующемся избыточном активном иле Макеевских очистных сооружений. Отсутствуют данные о миграции ионов металлов из обработанных оксидом кальция осадков под действием дождевых и талых вод. Поэтому были проведены исследования миграции ионов тяжёлых металлов на примере цинка, меди и железа из необработанного активного ила и обработанного негашёной известью.


**Ключевые слова:** ионы тяжелых металлов, негашёная известь, миграция, активный ил, выщелачивание.

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# МОЖЛИВІСТЬ ВИКОРИСТАННЯ НАДЛИШКОВОГО АКТИВНОГО МУЛУ ЯК ОРГАНОМІНЕРАЛЬНОГО ДОБРИВА

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**Анотація**. У статті розглянуті існуючі підходи до виділення іонів важких металів з надлишкового активного мулу для подальшого його використання як органічного добрива. Проведено дослідження з визначення вмісту іонів важких металів, що утворюється в надмірному активному мулі Макіївських очисних споруд. Відсутні дані про міграцію іонів металів з оброблених оксидом кальцію опадів під дією дощових і талих вод. Тому були проведені дослідження міграції іонів важких металів на прикладі цинку, міді і заліза з необробленого активного мулу, і обробленого негашеним вапном.

**Ключові слова:** іони важких металів, негашене вапно, міграція, активний мул, вилуговування.

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