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SLUDGE STABILIZATION OF SEWAGE TREATMENT FACILITIES WITH WASTE FROM PRODUCTION AND APPLICATION OF UREA-FORMALDEHYDE RESINS

The article describes the variants of reagent stabilization, which is an essential stage of sludge treatment of sewage treatment facilities There are many variants of stabilization, which are based on the mineralization of organic matter, the impact on microorganisms (heating, treatment with chemicals, which have a bactericidal effect, adjustment of pH and humidity) to suppress their activity.

In comparison with biological methods reagent stabilization requires minimal capital costs and provides carrying out the process in a short time. Promising method is to be used while stabilizing of waste containing organic substances with microstatic and microbocide action, and which do not change the composition of sediments.

In this paper as reagents to stabilize was used the liquid waste and wastewater generated in the production and application of urea-formaldehyde resins (UFR), which are characterized by high levels of formaldehyde. Flow rate of liquid waste (formaldehyde content of 14.2 g/dm^3) was changed in the ranges from 1 : 100 to 20 : 100, the flow of wastewater (formaldehyde content of 0.5–7.0 g/dm^3) in the varies from 1 : 10 to 1 : 2. Investigations were carried out on the excess activated sludge (solids content 18.1–27.7 g/dm^3).

In the investigated ranges the flow of stabilizing agent, that provides long-term stability, depends linearly on both the solids content of the excess activated sludge, as well as on the content of formaldehyde in the stabilizing agent.

Processing of excess activated sludge with waste from production and use of urea-formaldehyde resins reduces the resistivity to filtering more than 7 times.

Key words: sewage sludge, reagent stabilization, wastes from the production of urea-formaldehyde resins.

Introduction. This primarily refers to the precipitation of sewage treatment facilities, which are most susceptible to decay, accompanied by the release of unpleasantly smelling substances and an increase in the pathogen microorganisms. Among the precipitation formed during the biological treatment, the surplus activated sludge (SAS) gives the largest amount [1, 2].

Main part. In the process of precipitation stabilizing, the vital activity of putrefactive and fermentation bacteria is inhibited, their physical and chemical characteristics changing. There are many variants of stabilization, based on the mineralization of organic matter, the impact on microorganisms (heating, chemical treatment by substances having a bactericidal action, regulation of their pH and moisture) to suppress their activity. Mineralization of organic matter is carried out by biological methods (aerobic, anaerobic stabilization, biocomposting). Anaerobic fermentation and aerobic stabilization are widely used for compacted precipitation while reagent stabilization is much more seldom. Biocomposting and reagent processing are used for dehydrated precipitation.

Biological methods of stabilization allow to process large amounts of precipitation and to obtain products that meet the strict requirements for the content of pathogenic microorganisms. However, substantial capital and operating costs are needed. Reagent treatment requires minimal capital costs, and can be a supplement to the biological stabilization as well as the main process that ensures achievement of the desired effect.

For sealed precipitation, the use of reagents is reasonable only when, alongside with the stabilization, they act as conditioning additives accelerating subsequent mechanical dewatering.

The most widespread, among the stabilizing reagents, is quicklime, the action of which is based on increasing the pH (up to 12) and the temperature (up to 60°C) achieved at lime content 12–30% by weight of dry matter depending on the composition of precipitation.

As stabilizing reagents are also known to be used ammonia, chlorine and chlorine-containing agents, ozone and others [1, 2].

Safe stabilization and disinfection is provided by pesticide treatment precipitation. Thus, it is given the possibility of using karbation, thiasone and calcium salt of dithiocarbamic acid (CSDA) for disinfection of presipitation. At the same time, their flow rate is changed from 0.25 to 5.00% depending on the type of disinfectant [3].

As stabilizing reagents, metallurgical wastes were tested as well as other wastes of mineral composition. However, in this case, along with the stabilization, the composition of the mineral deposits significantly changes, which makes it difficult or impossible their subsequent use [4].

Influence of flow of stabilizing reagent on specific sediment filtration resistance

	Nontreated sludge	Sludge treatment of WW and LW in a volume ratio			
		Sludge : WW			Sludge : LW
		1 : 10	1 : 5	1 : 2	12 : 100
Flow of stabilizing agent (as formaldehyde), mg/g, dry substance sludge	–	2.5	5.0	12.5	60.0
Resistivity of filtration, m/kg	$2.73 \cdot 10^{13}$	$2.41 \cdot 10^{13}$	$1.36 \cdot 10^{13}$	$9.71 \cdot 10^{12}$	$3.91 \cdot 10^{12}$

At precipitation reagent stabilization, the promising direction is to use waste containing organic substances possessing microbostatic and microbicidial action, and do not change the composition of precipitation. Liquid wastes and waste water are the example of such wastes mostly formed at production and using of urea-formaldehyde resins (UFR), which are characterized by a high content of formaldehyde having a strong antimicrobial activity and a number of other properties.

Liquid waste (LW) represent a condensate of gas-vapor mixture removed under vacuum drying in the final stage of obtaining UFR from carbamide and formalin. Wastewater (WW) is formed after the washing process of the equipment used for the preparation of adhesives based on UFR.

The aim of this work was to determine the possibility of using of waste production and applying of UFR to stabilize the precipitation of sewage treatment facilities in Minsk.

Materials and methods. Research was carried out on an excess activated sludge (EAS) of Minsk purification plant selected after sludge densifiers. The dry matter content was 18.1–27.7 g/dm^3, the mineral content in the dry residue was 27.5–28.4%. The following reagents were used for stabilization: liquid waste containing formaldehyde 14.2 g/dm^3 and methanol 40.0 g/dm^3 as well as percolate wastewater with concentration of formaldehyde – 0.5–7.0 g/dm^3 and components CFR – 50–80 g/dm^3.

The efficiency of the waste used we evaluated by the total mikrobial number (TMN), which is defined as the total number of colonies (CFU/cm^3), heterotrophic bacteria grown on nutrient meat infusion agar for 24 h of incubation at (37 ± 0,5)°C [5].

The formaldehyde content was determined by using sulfite method involving BAT-15 [6]. Effect of the tested reagents on water loss ability of precipitation was measured in terms of resistivity of filtration [2].

When used liquid waste, methanol content was found by gas chromatography on a chromatograph HP 4890D with detector of ionization in flame, HP-INNOWAX 30 m capillary column (Polyethylene glycol).

Results and discussion. While investigating liquid waste or waste water were introduced into the sludge by stirring for 5 minutes in a certain ratio to the amount of sludge and were kept for 30 min. The treated samples were used for the determination of specific filtration resistance. After centrifugation of treated sludge (3,000 min^{-1}, 5 min), fugate was used to determine the total microbial number, the content of methanol (for liquid waste) and formaldehyde. For treated sludge, TMN was checked for 110 days after treatment.

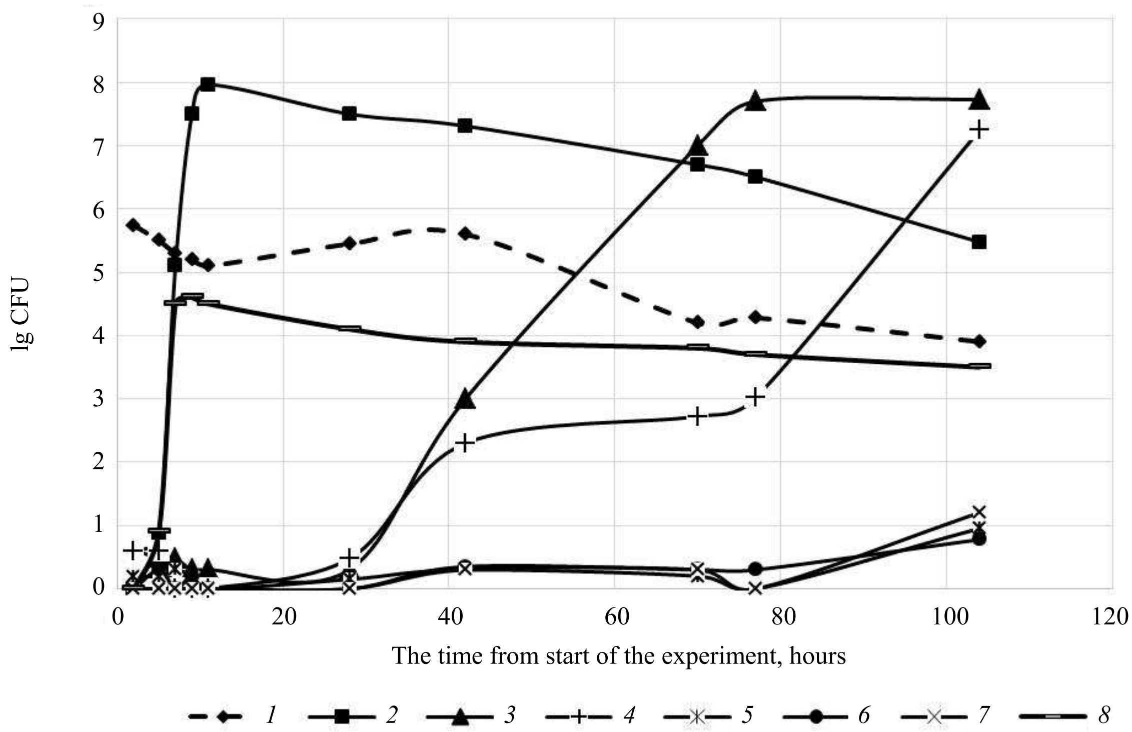
Investigation of the effect of liquid waste on the characteristics of precipitation were performed for relations LW : EAS, which ranges from 1 : 100 to 20 : 100 by volume. Wastewater were introduced in amounts ranging from 1 : 10 to 1 : 2 by volume. The figure shows the dependence of the colony forming unit (CFU) on the consumption of stabilizing agents and the time delay of treated sediments.

At the dose of liquid waste from 2 : 100 and more there was a significant reduction in total count. However, the long-term stabilization of the precipitation is achieved by liquid waste consumption constituting 12 : 100. At lower consumption the initial significant reduction in total microbial number after a holding period of 30 days is replaced by a significant increase in this indicator, which, in our opinion, due to the high content of easily oxidized organic substances (e.g. methanol), introduced together with a stabilizing agent. For wastewater the long-term stabilization failed even at maximum consumption.

It is established that in the investigated range, the consumption of stabilizing agent ensuring long-term stability, linearly depends on the solids content of the EAS as well as formaldehyde content in the stabilizing agent.

Stabilization of precipitation by liquid waste and waste water production and the use of UFR is a complex physical and chemical process, based on interaction of living and nonliving organic matter of EAS, primarily with formaldehyde [7].

Formaldehyde being highly reactive substance, undergo addition and substitution reactions. Its remaining content has microbial static action. It forms strong chemical protein compounds [8] and produce “tanning” effect, which is always due to the appearance of additional inter-molecular bonds in the protein structure.



CFU dependence on the consumption of the stabilizing agent and the delay time of treated sediments:
1 – initial EAS. The dose of the liquid waste by volume ratio LW : sediment:
2 – 2 : 100; *3* – 5 : 100; *4* – 10 : 100; *5* – 12 : 100; *6* – 17 : 100; *7* – 20 : 100.
The dose of wastewater by volume ratio WW : sediment – *8* – 1 : 2

Tanning effect of formaldehyde mainly due to the advent of the bridges –CH_2– by which ammine groups and groups –CO–NH– of polypeptide portions are bound. These processes modify the hydrophilic-lipophilic balance, which affects the ability of precipitation to dehydration.

Study of the formaldehyde content in the liquid phase of precipitation treated with liquid waste and wastewater, has established that the maximum adsorption capacity of solids precipitation on formaldehyde was 0.039 g/g, in terms of organic matter precipitation was 0.052 g/g. With the introduction of the stabilizing agent in amounts, in which these values of capacity, for formaldehyde don't exceed, its content in the liquid phase is below the limit of the sensitivity method (less than 0.5 mg/dm^3). Long term stabilization of the precipitation is provided in the case when the concentration of free formaldehyde in the liquid phase is not less than 500 mg/dm^3.

Methanol contained in LW is also involved in the above processes, and contributes to hydrophobization of proteins. Comparison of the amount of methanol injected with LW and its concentration in the liquid and the gas phase being in equilibrium with the precipitation, treated by LW showed that the sorption capacity of the sediment for methanol was 0.038 g/g.

It was found that the treatment of LW and WW reduces specific resistance of sediment filtration (table). The maximum decrease in specific resistivity (more than 7 times) is reached when dosed in LW precipitation. Change of specific resistance of filtration varies regularly with an increase in the content of formaldehyde in the stabilizing agent.

Reduction of specific filtration resistance provides reagent consumption used for sediment conditioning before dehydration, it also accelerates the drying of precipitation in natural conditions (e.g., on sludge banks).

In consideration of the fact that the waste water used for stabilizing, include components of urea-formaldehyde resins containing more than 30% of nitrogen, stabilized sludge can be considered as a nitrogenous fertilizer on the assumption of satisfying the requirements on the content of heavy metals in it.

Conclusion. The research results indicate the possibility of the use of liquid waste and waste water production as well as the use of carbamide-formaldehyde resins for the stabilization of the sediments of urban sewage treatment plants. At doses of stabilizing agents, in which the formaldehyde consumption does not exceed 0.039 g/g of dry matter precipitation, it is almost completely bound by the solid phase of precipitation. Stabilization is accompanied by a decrease in specific resistance of filtration of surplus sludge.

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