Improvement of ecologically safe sediment processing technology

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Abstract. The processing of sludge formed in wastewater treatment plants is one of the most urgent tasks in ensuring the ecological safety of cities and has been promoted in recent years as one of the most complex, expensive and poorly studied problems in the field of water treatment. The purpose of the scientific article is to improve and study existing and new technologically feasible, highly efficient, environmentally safe sludge processing methods and technologies. Reinforcement of the process of gravitational density of wastewater sediments was studied. Scientific research was carried out at the first stage with excess activated sil, which is formed during the biochemical treatment process at the station. Ammophos and superphosphate were used as reagents. In order to determine technological and economic feasibility of using iron-containing coagulants in enhancing the process of active silt densification, studies were carried out to study its densification kinetics. As a result of research, superphosphate was found to be the most effective in the density of overactive silt with local reagents.

1 Introduction

In the cities of Uzbekistan, the total volume of sediments separated in the process of wastewater treatment varies in wide ranges and usually makes up 0.5-1.5% of wastewater. For example, at the waste water treatment station in Tashkent, the sediment volume is about 4000 m3 per day. Of them, after the primary softener - 0.1%, humidity 93.8%, after the second softener - 0.91%, humidity 99.37%, excess active il - 0.33%, humidity 97.5%.

In Uzbekistan, more than 80% of sediments are dried in landfills, which are inefficient, ecologically dangerous structures that require large areas of land. Low efficiency, lack of free land, and the use of non-mechanized processes for collecting and transporting sediments make it necessary to replace landfills with high-efficiency mechanical drying systems. The processing of sediments formed in wastewater treatment plants is one of the most urgent tasks in the field of environmental safety of cities, and in recent years it has been promoted as one of the most complex, expensive and understudied problems in the field of water treatment.

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The purpose of the scientific article consists in the improvement and study of existing and new technologically acceptable, highly efficient, environmentally safe sediment processing methods and technologies
Scientific novelty:carrying out complex studies on strengthening the process of gravity concentration of sediments by means of high-performance reagents; to determine the laws of the process of mechanical drying of sediments depending on technological factors.

Practical importance and implementation of scientific work. As a result of the research, superphosphate was the most effective in densification of excess activated sludge with local reagents, when using them, the moisture content of the densified sediment was about 91%. Heating the condensed slurry at a low temperature (about 50-70 °C) made it possible to reduce the time of thickening of the slurry to 2 hours and at the same time reduce the dose of reagents.

2 Materials and methods

Theoretical and experimental studies involving work with models and natural settings were conducted Intensification of the process of gravitational densification of sewage sludge was studied. In the first phase, scientific research was conducted with excess active sludge produced during biochemical treatment at the station. Ammophos and superphosphate were used as reagents.In order to determine the technological and economic expediency of using iron-containing coagulants in enhancing the process of densification of active slag, studies were conducted to study its densification kinetics. The results of these studies are presented in the form of graphical correlations in Figure 1.

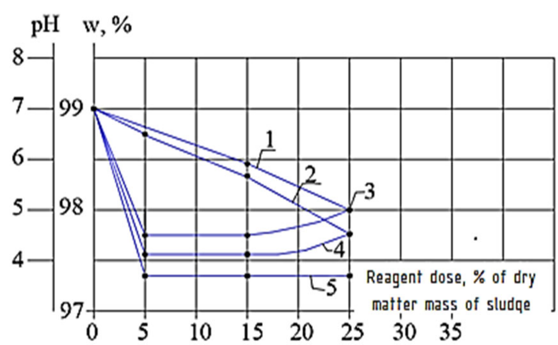

Fig. 1. Changes in humidity and pH of the concentrated solution depending on the reagent dose.

1 - pH of the soil treated with $FeCl_3$, 2 - pH of the soil treated with $Fe_2(SO_4)_3$, 3 - humidity of the soil treated with Fe_2(SO4)3, 4 - humidity of the soil treated with $FeCl_3$, 5 - humidity of the control soil. Concentration time: in the experiment - 4 hours, in the control - 9 hours [1-2].

The analysis of graphical relationships shows that the use of iron-containing coagulants in a dose of 5-25% compared to the dry matter of the il is ineffective. This cycle of research shows the need for additional weighting of the il fragments. This assumption is confirmed by experimental data on additional charging of sulfuric acid. Loading the solution with sulfuric acid does not reduce the moisture content of the condensed part, but increases the rate of initial separation of the liquid and solid phases with a decrease in rN. The highest densification rate is reached at ρN ~2.0, which is probably explained by the intensive

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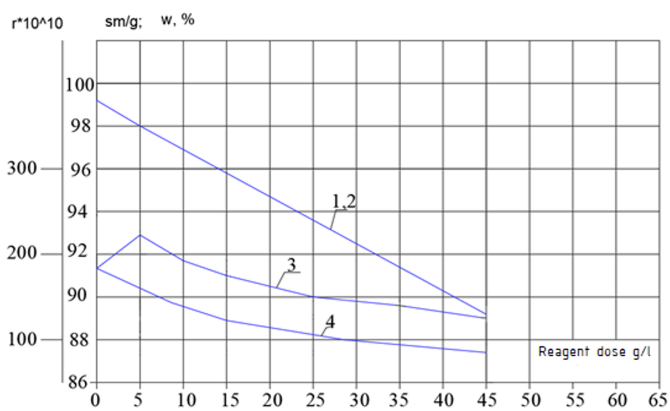
separation of free water. Reinforced wire has a higher density, which means it can resist 1.5 times more than untreated wire.

The possibility of using lime in gravity compaction of silt was also studied. Experiments showed that as a result of lime treatment of silt (-36% CaO) (after 4 hours of compaction), the moisture content of the silt decreased to 95.4-96.2%. At the same time, the pH level of the environment increased to a level that ensured silt stabilization, which indicates the advantage of lime treatment.

Treatment of the clay with lime and iron salts in different proportions (for the purpose of densification) gave almost the same results. The highest efficiency was achieved with doses of 16.7% $Fe_2(SO_4)_3$ and 25.2% CaO, the moisture content of the clay compacted to 95.2%. At this time, the volume of the solid phase decreased by 2.8 times compared to the initial state [3-4].

A special series of studies was conducted to determine the change in the density and moisture content of the silt. The silt was treated with ammophos and superphosphate reagents. Studies have shown that an increase in the dose of reagents (superphosphate) reduces the density of the silt. For example, the density of the silt treated with superphosphate at a dose of 25 g/l decreases by 1.8 times. (Figure 2).



1 - the moisture of the soil treated with superphosphate, 2 - the moisture of the soil treated with amphos, 3 - the density of the soil treated with ammophos, 4 - the density of the soil treated with superphosphate.

Fig. 2. Moisture content and density of superphosphate-treated soil.

3 Results and discussion

The analysis of experimental data shows that the optimal dosage for Ammophos and superphosphate is 25 g/l, which corresponds to the ratio of 5 g of reagent to 1 kg of dried il. The same results for residual moisture and the difference in the initial rates of densification indicate the advantage of using ammophos.

The effect of low-temperature heating on the rate of densification of clay and its characteristics was studied with amphos and superphosphate reagents. A series of studies showed that heating at a low temperature significantly increases the rate of densification, at doses of 5 and 15 g/l, the rate of densification increases by 1.5-1.8 times. This makes it possible to reduce the duration of densification to 1.5-2 hours, which is very important for production conditions, because it becomes possible to reduce the volume of the densifier by 5-6 times (Figure 3).

At 50-70°C, stable moisture results were recorded in ammophos-treated soil, while for superphosphate, uniform moisture was achieved only at 70°C, heating at 50°C did not give good results.
Analysis of the effect of heating at low temperature on the ability of water to release water showed that the reagents at a dose of 5 g/l did not reduce the density of water. However, doses of 15 g/l and higher had a positive effect on the water release capacity of the il, after 4 hours of il concentration, the il density decreased significantly. The lowest values were obtained for the ammophos variant at 70°C and were stable at ammophos doses of 15-45 g/l. According to the results of the conducted research, special studies were conducted to study the effect of the magnetic field on the dehydration of sediments. Magnetization was carried out on AMO-25U equipment with a production capacity of 25 m³/h. In all experiments, the current was set to 10A. Experiments were performed without and with reagents. Sediment magnetization treatment was performed once, three times and five times. Studies have shown that: magnetic treatment slightly worsens the properties of non-dewatered slurry and slightly reduces its compaction resistance; it does not have a negative effect on the density resistance of the sediment that has been compacted by magnetic treatment without a reagent, and it is not advisable to use it in the technology of dewatering.

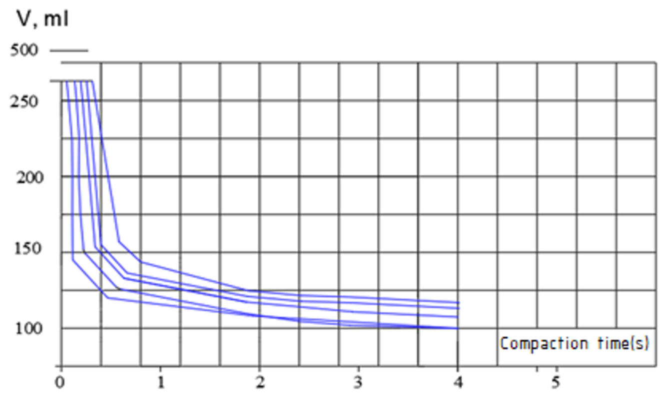


Fig. 3. Effect on the densification of il during heating at low temperature.

Studies have shown that magnetic treatment slightly deteriorates the properties of non-dewatered slurry and slightly reduces its resistance to compaction; magnetic treatment without reagents does not negatively affect the compaction resistance of digested slurry and is not advisable to use in dewatering technology.

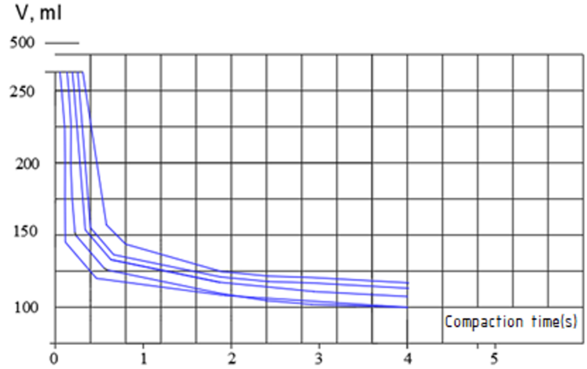


Fig. 4. The effect of various doses of ammonium phosphate on the compaction of clay under low-temperature heating.

The results of the experiments to determine the optimal concentration of the reagent solution are presented in Table 1 [5-6]

Table 1. Reagent concentration.

Experiment number	**The performance capacity of the equipment at different reagent concentration m3/hour**			
	0.07	0.1	0.15	0.2
1	32.8	34.2	32.1	30
2	33.2	34.4	32.4	30.2
3	33.4	34.7	32.3	30.2
4	33	34	32	29
5	33.2	34	32.4	30.3
6	32.8	33.8	31.8	29.9
7	33.1	34.2	32	30

According to the table data, the optimal concentration for the working reagent solution is 0.1%

The research on selecting the optimal speed of the belts was conducted with a belt pressure of 5.0 kgc/cm². The results of the experiments are presented in Table 2.

Table 2. Moisture content of the sludge relative to the speed of the filter tapes.

Experiment number	**The moisture content of the sludge (%) in relation to the speed of the filter belts (m/min)**			
	2.25	2.5	2.75	3
1	76	76	77.2	79.8
2	75.2	75.8	76.9	80.2
3	76	76.2	77.1	81
4	77	77.8	78.8	81.1
5	76.4	76.8	78.2	81
6	76.2	76.4	78	80.8
7	75.8	76.2	78	80.2

"When the belt speed is below 2.25 m/min, sediment escapes from the roller zone of the filter press. Research has shown that reducing the belt speed to 2.5 m/min does not produce any effect, as the sediment escape increases. The optimal belt speed is 2.5 m/min." [7-8]

4 Conclusion

Sediments collected in rural areas and formed in the treatment facilities of the city sewage treatment plant pose a serious ecological, epidemiological and sanitary-hygienic risk. One of the most urgent problems is the processing and disposal of sludge generated in wastewater treatment plants in large cities. Superphosphate and ammophos are the most effective local reagents tested at the station for compaction of excess soot. The optimal dose of reagents for compaction of sludge is 10-15 g/l (1.50-2 g/kg of dry matter), which ensures moisture of compacted sludge.

The composition and properties of the sludge, methods of its drying (gravitational, mechanical, thermal, reagent-based, and biochemical), methods aimed at future use or storage, preparation techniques, as well as potential directions for its utilization and disposal, have been analyzed.

The implementation of mechanical drying of the sludge has allowed for a reduction in the load on the field areas and enabled the use of the sludge without exceeding the regulated amount. Mechanical drying also eliminates the long-term drying of the sludge on the field (3-5 years), which is an important factor for environmental protection.

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