THE RESEARCH OF ACTIVATED SLUDGE DEWATERING PROCESSES.

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ABSTRACT.
The efficiency of different activated sludge dewatering processes was investigated. The activated sludge for researches was taken from biological processes of public wastewater treatment. Was found that neither pH adjustment no addition of different flocculants can significantly reduce the volume of sludge. The settling failed to provide the required efficiency too. The optimal results were obtained by using filtration for activated sludge dewatering processes. At the same time there was no significant efficiency of dewatering processes that could be compared with the cost of reagents and chemicals. New method of water separation from activated sludge was used. This method involved the use of materials with capillary properties. The laboratory plant with continuous action for activated sludge dewatering processes was developed during researches. Also the efficiency of activated sludge dewatering, the influence of various factors on the parameters of dewatering processes and the working features of the laboratory plant were studied.

KEYWORDS: activated sludge, filtration, capillary materials, dewatering.

INTRODUCTION

Today the process of wastewater treatment the biological methods are being used most widely. These methods allow removing a big range of harmful substances from the liquid phase. The activated sludge is the basis of the biological methods [1]. The activated sludge is the amorphous mass which is densely inhabited by aerobic bacteria and other aquatic organisms who can use waste water pollutants in the own life processes. A characteristic feature of biological wastewater treatment is the formation of a large quantity of wet sludge which is difficult to dewater.

Considering the high humidity of this sludge (85 - 99.7%) [2], in most cases it is dumped on the sludge beds. The water from sludge is filtering and evaporating to the environment. These processes take a lot of time. Recently, under the pressure of some circumstances, Kiev City Administration paid attention on the problem of activated sludge storage. However, the modern technologies for activated sludge dewatering are low-yield and high cost [3]. For example, centrifugation or filtering can not provide dewatering for huge amounts of sludge. Only in Kiev daily more than 6.000 m^3 of sludge formed. Therefore, the problem is quite acute and urgent for most cities. The use of variety complex and expensive processes for treatment of big sludge volumes always requires considerable resources, complicated service and qualified personnel. In that reasons every new ideas and decisions in this field are very relevant and important.

METHODOLOGY

The researches of activated sludge dewatering processes included three stages. On the first stage of research the efficiency of solid phase settling processes was investigated. Also we studied the possibility of using the settling as a preparatory process for decreasing of activated sludge volume. 100 ml of activated sludge was processed by relevant reagents. Than it was merged to graduated cylinder. The settling curves were obtained from data which was recorded during process of solid phase sedimentation in graduated cylinder.

The efficiency of activated sludge filtration thru the filtering paper "Blue tape" (diameter - 150 mm) was researched on the second stage. The changing of filtrate volume depending on time was recorded during experiment.

The use of materials with capillary properties (so-called capillary filtration) for activated sludge dewatering processes was explored on third stage of our researches. The scheme of laboratory plant is shown in Figure 1.

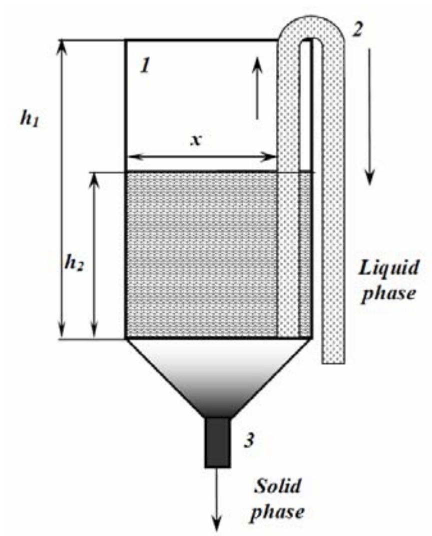

Figure 1. The laboratory plant for capillary filtration studying.

The laboratory plant consisted of plastic tank *1* (vol. 1.5 dm^3) with pipe *3* for pressed activated sludge sampling. The capillary filter was made from 120 layers of medical bandage and used for water separation. For experiment 1 dm^3 of activated sludge was placed to plastic tank to the level of h_2. Under the action of surface tension the water was rising through the capillary filter pores and removing from the tank. During the experiment the level of activated sludge in tank constantly was kept at h_2 point. After ending the experiment (the moment when capillary filter stopped transporting water) the test sample of pressed activated sludge was taken from pipe *3* for humidity measuring. Further experiments were to change the parameter x (Fig.1). All activated sludge in our researches was taken from Bortnichi aeration station (Kiev). The solid phase concentration in activated sludge was 16 g/dm^3.

In our researches we used flocculants Zetag 7648 with cationic charge and molecular weight up to 20 million and Magnafloc 156 with anionic charge and molecular weight up to 20 million and polyacrylamide solutions (PAA) as a non-ionic flocculants. All experiments were replicated 5 - 6 times and obtained results were processed with using of mathematical methods. The reiteration and reliability had satisfactory values.

RESULTS

On the first stage we analyzed the possibility of use the settling processes for activated sludge dewatering. Considering that 98% of activated sludge solids had size less than 1 mm [4], the settlement in this case was not applicable because it could not concentrate the solid phase and clarify treated liquid. Thereby, the activated sludge without any pretreatment during 2 hours settlement had clarified only for 2%. The pH adjustment allowed to obtain clarify degree at the level of 7% (at pH 2.9). After pH adjustment and using flocculants (during 2 hours settlement) the clarify degree of activated sludge suspension did not exceed 10%. So, it was clear that the efficiency of settling in activated sludge dewatering processes was very small and had very high costs. Better results were obtained by applying the filtering (Fig. 2). The activated sludge (pH 6.8), picked directly from the processing, could be filtered almost completely for 14 minutes. The maximum filtration velocity was only 0.086 m/ hr and the humidity of obtained solid phase was 95.1%.

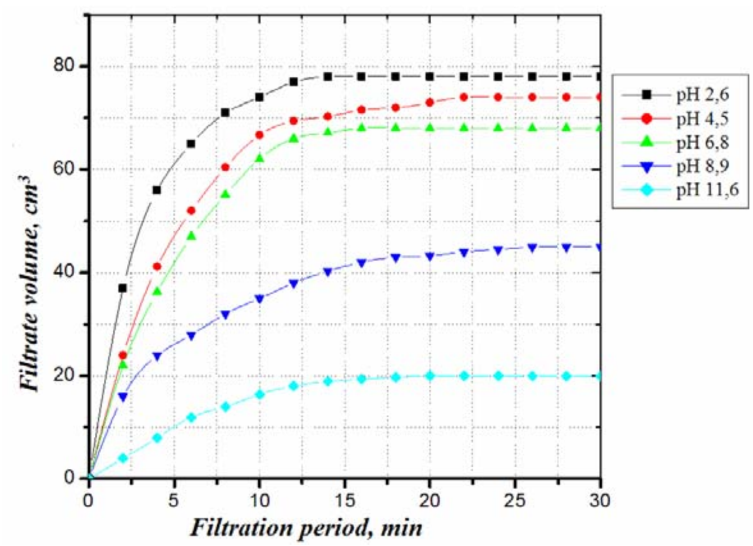

Figure 2. Activated sludge filtration thru the filtering paper "Blue tape" for different pH values (solid phase concentration - C_{sf} =16 g/dm^3)

Reduction of pH allowed to decrease the humidity (about to 93% at pH 2.6) while maintaining a constant speed of filtering. The pH increasing was accompanied by significant degradation of filtering processes. Humidity of obtained solid phase at pH 8.9 was 96% and at pH 11.6 it increased up to 98%.

So, in this case, pH adjustment could not use as the primary technological process, because further treatment or disposal of acid sludge would be associated with considerable difficulties such as significant usage of additional reagents and high cost of the dewatering processes.

The flocculants are traditional reagents for solid particles separation in water purification processes [5]. These reagents allow accelerating water clarification processes, decreasing the sludge humidity and significantly improve dewatering processes efficiency. So, next stage of our researches was to study the different flocculants types and the flocculants efficiency for activated sludge dewatering in the systems of biological sewage treatment.

The use of anionic flocculants Magnafloc 156 showed than this type of flocculants could not significantly influence on the filtering and settling processes efficiency. In the range of concentrations start from 5 mg/dm^3 to 70 mg/dm^3 Magnafloc 156 did not affect on the settling processes efficiency. During filtration of activated sludge the flocculant affect was much more pronounced, especially with pH adjusting. As seen from Fig. 3, in the acid medium the use of flocculants, even in small doses, reduced the humidity of the solid phase from 93% to 84%. In neutral and alkaline medium adding of flocculants leaded to increasing of solid phase humidity.

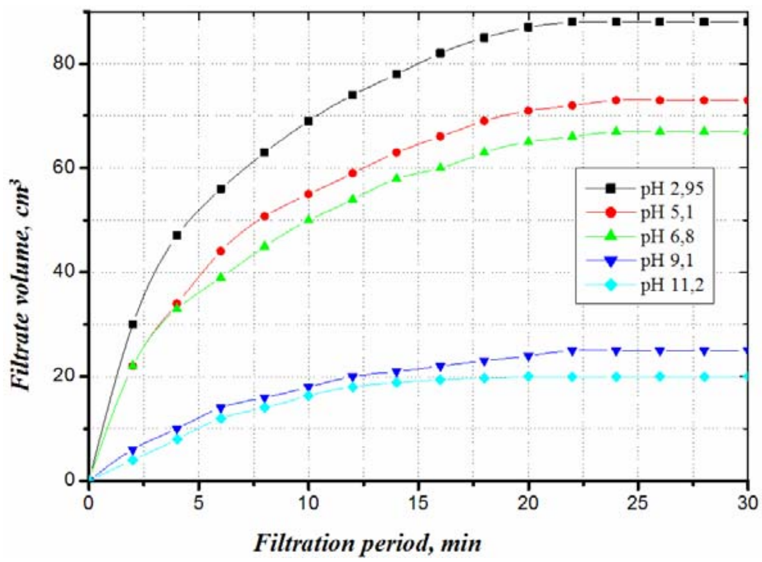

Figure 3. Activated sludge dewatering (treated by Magnafloc 156) on filtering paper "Blue tape" for different pH values (C_{sp} = 16 g/dm^3, $C_{flocculant}$ = 5 mg/dm^3)

It is also important that the maximal filtration velocity decreased. The period of water separation increased almost twice in comparison with filtering of untreated activated sludge. Even a significant increasing of flocculant concentration in a neutral medium did not provide desired effect. At flocculant concentrations equal of 50 - 70 mg/dm^3 activated sludge dewatering conditions became worse in comparison with untreated suspension (Fig. 4). Therefore, the use of anionic flocculants in activated sludge dewatering processes could not be appropriated.

The use of non-ionogenic flocculant Polyacrylamide (PAA) did not show good results too. As seen from Fig. 5, PAA had bed effectiveness in a wide pH range. In acid pH range PAA efficiency was lower than effectiveness of Magnafloc 156 solutions. In the same time, in the alkaline medium PAA efficiency was twice as good in comparison with Magnafloc 156. But, even in this case, the PAA efficiency was very low. Maximum filtration velocity at pH 2.9 was about 0.068 m/hr. The humidity of dewatered solid phase was within 94.5 - 97.2%, which was not enough for such expensive process. Very unexpected was the result of flocculant concentration increasing. The conditions degradation of water separation from the solid phase was detected with increasing of flocculant concentration (Fig. 6). The optimal flocculant concentration was within 20 - 30 mg/dm^3. The major quantity of water was filtered during first 20 minutes. The rest humidity could not be separated by filtration. Therefore, PAA, as Magnafloc 156 too, could not be appropriated reagent for activated sludge dewatering processes.

The flocculant Zetag 7648 was another type of reagent, which was investigated in our researches. This flocculant had cationic charge and molecular weight up to 20 million. The research methodology was the same as methodology that was described above.

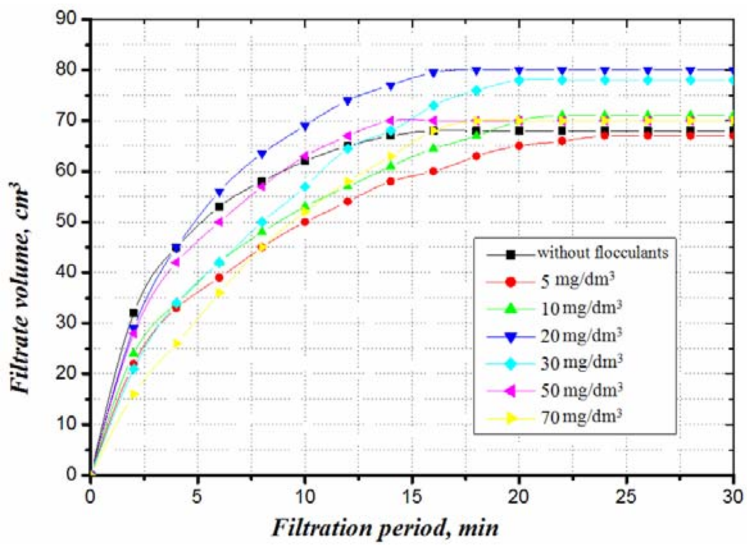

Figure 4. Activated sludge dewatering (treated by Magnafloc 156) on filtering paper "Blue tape" for different flocculant concentrations (C_{sp}=16 g/dm^3, pH=6.8)

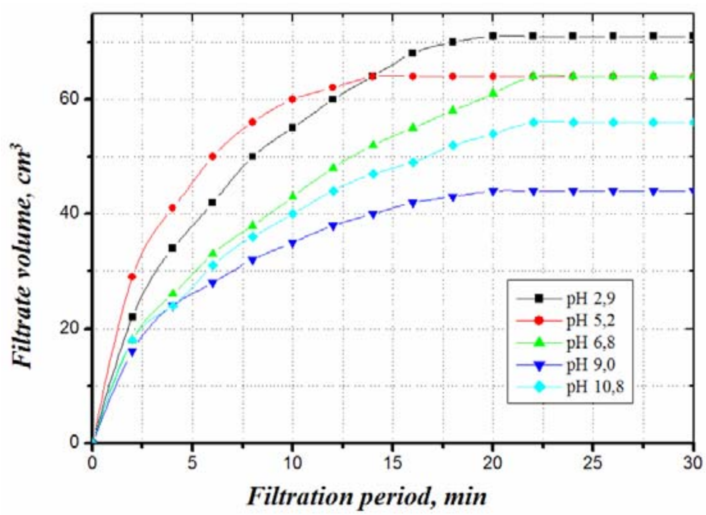

Figure 5. Activated sludge dewatering (treated by PAA) on filtering paper "Blue tape" for different pH values (C_{sp} = 16 g/dm^3, C_f = 5 mg/dm^3)

As shown in Fig. 7, the flocculant effectiveness was significantly higher in comparison with Magnafloc 156 and PAA, even without pH adjusting. At pH 6.8 and flocculant concentration of 0.5 mg/dm^3 for Magnafloc 156 and PAA after filtering the residual humidity was 96.1 and 95.5% respectively. In the same conditions the residual humidity for Zetag 7648 was 94%.

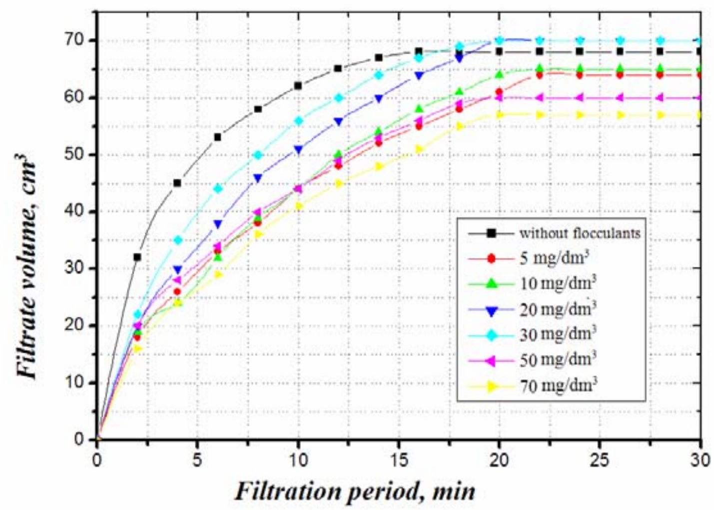

Figure 6. Activated sludge dewatering (treated by PAA) on filtering paper "Blue tape" for different flocculant concentrations (C_{sp} = 16 g/dm^3, pH = 6.8)

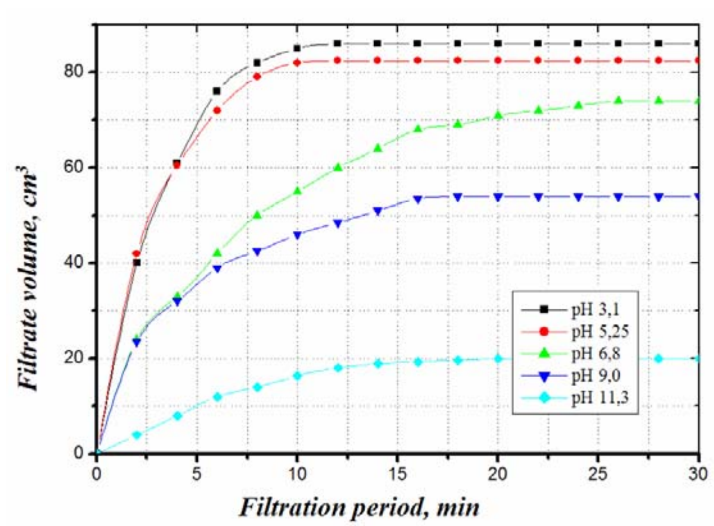

Figure 7. Activated sludge dewatering (treated by Zetag 7648) on filtering paper "Blue tape" for different pH values (C_{sp} = 16 g/dm^3, $C_{flocculant}$ = 5 mg/dm^3)

More significant changes were recorded at pH adjustment. The humidity was being separated better in the acid medium and faster - 10 min. In this case, the humidity was 88.6%. In the alkaline medium flocculants showed worse results. Thus, even for cationic flocculants, pH adjustment did not provide sufficient efficiency that could compensate the cost of additional reagents for this process.

The increasing of flocculants concentration (Fig. 8) allowed significantly improving effectiveness of activated sludge dewatering even at neutral pH values. Even the flocculant concentration of 10 mg/dm^3 allowed decreasing the humidity of solid phase to 93.3% only during 14 minutes. The period to reach given humidity reduced to 4 minutes with increasing flocculants concentration. But residual humidity remained stable, which indicated strong connections between water particles and solid phase. This fact made impossible dewatering of such sludge by using a simple filtration.

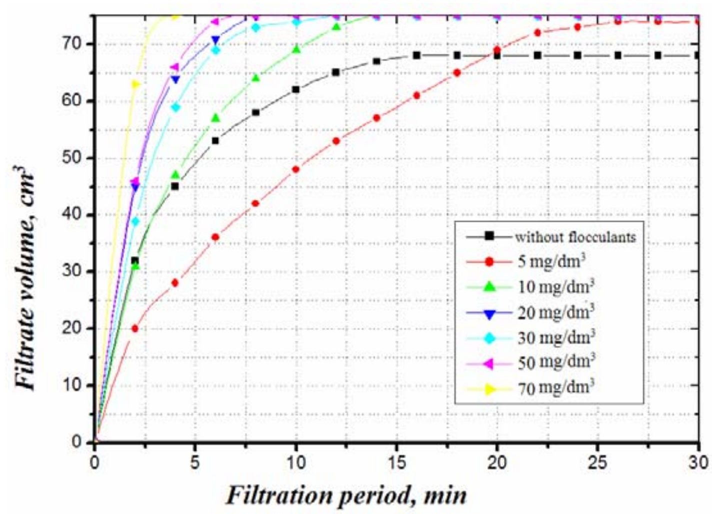

Figure 8. Activated sludge dewatering (treated by Zetag 7648) on filtering paper "Blue tape" for different flocculant concentrations (C_{sp} = 16 g/dm^3, pH = 6.8)

The modern devices for solid phase separating have a huge number of designs and include machines of different power and performance, which use pressure or vacuum, have periodic or continuous type of action. They all require significant energy costs, complicated maintenance and skilled personnel. The use of materials with capillary properties as filtering materials can be very interesting and perspective in this field. The balance between the forces of gravity and forces of surface tension can create a vacuum in the capillaries, under influence of which the humidity can be extracted from solid phase more effectively [6]. These filters do not require any energy, they have very simple design and can be made from recycled materials. With the appropriate technological parameters using of such filters can be quite promising and economical.

Researches of effectiveness for filter material with capillary properties were performed using laboratory plant which is presented on Fig. 1. As the results of experiments (Fig. 9), even without using flocculants, the humidity of dewatered activated sludge significantly reduced, especially at small values of parameter *x* (Fig. 1). Obviously, that with further decreasing of parameter *x* (less than 1 cm), we could observe a further reduction of residual humidity, but the movement of dewatered solid phase to the pipe *3* had stopped. The increasing of parameter x was not accompanied by a significant increasing of residual humidity of treated activated sludge. But, in this case, we observed the increasing of humidity transportation period. Therefore, in our experiments we limited the values of parameter *x* in the range of 1 - 6 cm.

As shown in Fig. 9, only use of Zetag 7648 was accompanied by a significant improvement of dewatering results. Using of other flocculants had worsened the results of experiments.

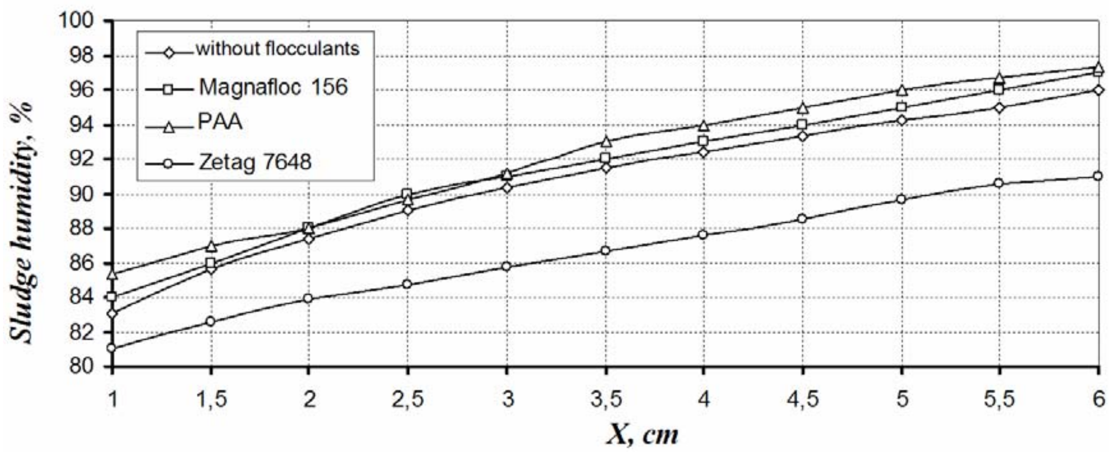

Figure 9. Activated sludge dewatering process using materials with capillary properties (flocculant concentration – 20 mg/ dm^3)

CONCLUSION

Activated sludge is the difficulty dewatering suspension. The settling is ineffective even with pH adjustment and treating by flocculants. The filtering process was more effective. But in this case, even with using of additional reagents, the residual humidity of treated activated sludge had high values. Considering significant amounts of activated sludge and necessity in expensive equipment, the filtering did not become a popular method for activated sludge dewatering. Our proposed method of activated sludge dewatering using the materials with capillary properties has simple design, does not need significant costs for implementation and operation. There is a possibility to develop a mobile plants or autonomous plants for regions without energy. Our method can show much better results than filtering, even without pH adjustment or flocculants using. The encouraging results of previous experiments stimulate further researches in this field.

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