THE INFLUENCE OF DUAL CONDITIONING METHODS ON SLUDGE DEWATERING PROPERTIES

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Abstract

One of the main processes, which facilitates dewatering is conditioning. Although there exist a number of conditioning methods, chemical methods based on the application of polyelectrolytes tend to be used more than any other methods. The following paper contains a discussion of potential applications of fly-ash as well as two selected polyelectrolytes as conditioners. The sludge samples were treated by means of single polyelectrolyte as well as polyelectrolyte in combination with fly-ash. The assessment of conditioning was based on the capillary suction time (CST) as well as the parameters of vacuum filtration process, mainly sludge resistivity. The application of fly-ash turned out to be effective, the best results were achieved for a dose of 8% (by weight). It was established that the application of dual method allowed to reduce polyelectrolyte dose by about 30%.

Streszczenie

Jednym z głównych procesów wpływających na efektywność odwadniania osadów ściekowych jest ich wstępne kondycjonowanie. Chociaż istnieje wiele sposobów prowadzenia tego procesu, obecnie najczęściej stosowana jest metoda chemiczna z zastosowaniem polielektrolitów. W artykule zaprezentowano możliwości zastosowania popiołu lotnego jako środka kondycjonującego. Przebadano wpływ wybranych pojedynczych polielektrolitów oraz polielektrolitów z dodatkiem popiołów lotnych na stopień odwodnienia osadów. Ocenę efektywności prowadzonych procesów przeprowadzono na podstawie testu ssania kapilarnego (CSK) oraz parametrów procesu filtracji próżniowej, głównie oporu właściwego osadu. Wykazano pozytywny wpływ popiołu na proces odwodnienia osadu. Najkorzystniejsze rezultaty odnotowano dla dawki 8% wag. Zastosowanie zintegrowanej metody kondycjonowania umożliwiło obniżenie dawki polielektrolitu o około 30%.

Keywords: **Sewage sludge; Conditioning; Fly-ash; Polyelectrolytes; Dewatering.**

1. INTRODUCTION

The sludge generated in sewage treatment processes have a multi-phase structure, in which the sludge liquid constitutes the dispersion phase and solid particles as well as gas bubbles – dispersed phase. The ratio of solid to liquid content in the sludge structure influences the degree of hydration, which is one of the most prominent features of sewage sludge. Effective dewatering decreases the sludge volume and also has a positive effect on the further stages of the sludge treatment [1-2]. The main process which affects dewatering is conditioning.

A good conditioning agent allows to [3]:

- neutralize the electric charge of the sludge particles, which induces the particles to form larger flocs
- destroy the gelatinous structure of the flock, which facilitates dehydration
- increase the flock's compression
- increase the solids content of the sludge cake.

Although there exist a number of conditioning methods, the chemical methods tends to be used more than any other methods. Among them, polyelectrolytes, i.e. polyacryloamide-based high-molecular compounds have become the most frequently used. Conventionally, single polyelectrolyte systems are used for sludge dewatering. In this case, the main mechanisms of action are charge neutralization and interparticle briding [4-6]. However, some evidence exists in the literature [7-11] that dual conditioning systems have advantages over those of single polymers. For example, activated sludge pre-conditioned with iron salt, or cationic surfactant showed better dewaterability when conditioned with cationic polyelectrolytes. In another example, flocculation of alumina was enhanced by dual flocculants. In this case, an anionic polyelectrolyte was first adsorbed on the alumina surface by means of electrostatic interaction, and facilitated the adsorption of a long chain cationic polyelectrolyte.

The aim of this research project was to assess the application of dual-conditioning methods, based on sequential dosing for sludge dewatering. The application of fly-ash in combination with polyelectrolytes is expected to enhance the susceptibility of the sludge to dewatering. As a consequence, the dual method is supposed to reduce the polyelectrolyte dose.

2. RESEARCH MATERIAL AND METHODS

The sludge taken from a municipal wastewater treatment plant was used as a research material. It is a biological treatment plant operated on the activated sludge method. Sludge samples were taken after anaerobic stabilisation. The scope of the research project encompassed: chemical analysis of the sludge treated, determination of the optimal fly-ash dose, selection of the appropriate polyelectrolytes as well as their optimal doses and determination of vacuum filtration parameters for the samples selected on the basis of the CST.

Table 1.
Sewage sludge chemical properties

Parameter	Unit	Average value
pH	-	7.49
Initial hydration	%	96.80
Dry matter	g/dm^3	21.50
Organic matter	%	77.25
Mineral matter	%	22.75
CST	s	425
Resistivity	m/kg	1.62×10^{13}

2.1. Conditioning procedure

Fly-ash from the incineration process as well as two polyelectrolytes, i.e. cationic (Praestol 610BC) and anionic (Praestol 2540) were used in the research project. The sludge was conditioned by 0.1% polyelectrolytes. The samples were taken under the following conditions: the sludge of 100 cm^3 was treated with an appropriate dose of the polyelectrolyte and mixed together for two minutes. The experiment was carried out at the constant temperature of 291 K.

2.2. Capillary suction time (CST)

Capillary section time (CST) was based on the wetting time measurement. Special filtrating paper was applied. The wetting time was measured as long as a filtration layer covered the area between the circles of 32 and 45 mm [12].

2.3. Vacuum filtration process

The experiment unit consisted of Büchner funnel with filtration paper with in, a conical flask, a measuring cylinder, a suction gauge as well as a vacuum pump. The experiment was carried out in accordance with the following rules: the sludge was poured into the Büchner funnel and kept several seconds in it to create a layer on the filter paper. Then the vacuum pump was switched on to generate an underpressure of 0.06 MPa and the filtrate volume was measured. The results obtained in the process were used to calculate the sludge resistivity [12].

The sludge initial hydration, i.e. before vacuum filtration process as well as final hydration, i.e. after the process was calculated as follows:

$$U_{(i/f)} = \frac{(m_1 - m) - (m_2 - m)}{m_1 - m} \times 100\%$$

where: $U_{(i/f)}$ – initial/final hydration, %;
m – weight of dish, mg;
m_1 – weight of sludge + dish, mg;
m_2 – weight of dried sludge (278K) + dish, mg.

3. RESULTS AND DISCUSSION

In the beginning, fly-ash was used as a conditioner. Particular doses were calculated as a percentage of total sludge weight. The conditioning effectiveness was based on the CST test – Figure 1. It was established that CST value decreased with in the whole range of agent used. The best results were achieved for the dose of 8%, i.e. 340 s, which is 20% lower than in case of non-conditioned sludge. Further addition of ash beyond 8% did not lead to a significant decrease of the CST value. That is why the dose of 8% was selected for further experiments.

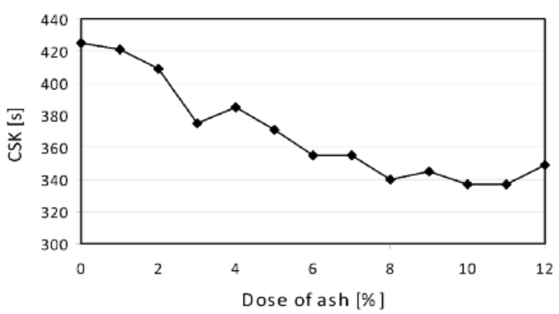

Figure 1.
The influence of fly-ash on the CST value of the tested sludge

Further experiments were carried out with the application of polyelectrolytes. The latter were used to treat sludge samples after ash addition as well as non-conditioned sludge. The following polyelectrolytes were used in the scope of the experiments: cationic one (Praestol 610BC) referred below asto polyelectrolyte A and anionic one (Praestol 2540) referred below to as polyelectrolyte B.

Firstly, the sludge was conditioned with polyelectrolyte A. The results are depicted in figure 2. In both cases, it was recorded that the polyelectrolyte A had a positive impact on the treated sludge. When the sludge was treated exclusively with polyelectrolyte, the CST value decreased. The best results were recorded for the dose of 2.5 mg/g d.m., i.e. 49 s. The dose of 2.5 mg/g d.m. was assumed as optimal because further polyelectrolyte addition did not affect the CST value in a significant way. In the second case, i.e. when the sludge was pre-conditioned by means of fly-ash, a similar relationship was confirmed as long as the dose did not exceed 1.5 mg/g d.m. The latter dose allowed to achieve the lowest CST value, i.e. 44 s and was considered to be the optimal. If the dose was higher, the CST value fluctuated. In this case, the pre-conditioning method allowed to reduce the polyelectrolyte dose from 2.5 mg/g d.m. to 1.5 mg/g d.m.

Secondly, polyelectrolyte B was applied. It was observed that anionic polyelectrolyte did not affect the value of CST significantly – Figure 4. However, when the pre-conditioned sludge was treated, the

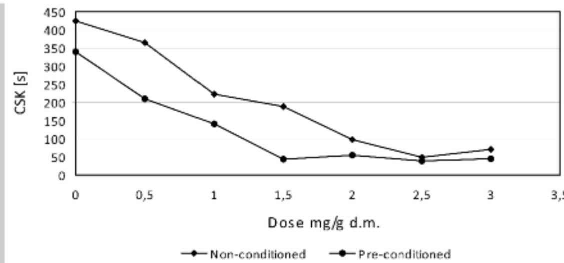

Figure 2.
The influence of polyelectrolyte A on the CST value of the tested sludge

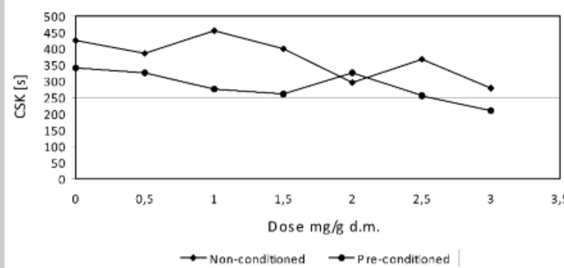

Figure 3.
The influence of polyelectrolyte B on the CST value of the tested sludge

CST value decreased slightly.

It was established that further research should focus on polyelectrolyte A. Research was conducted on an optimal range of doses, i.e. 1.5-2.0 mg/g d.m.; an increased dose of 2.5 mg/ g d.m., as well as decreased dose of 1.0 mg/g d.m. The aim of this stage of the study was to test the selected doses in the vacuum filtration process. Obtained results are presented in Table 2.

Considering the table contents, certain dependencies between the parameters of dewatered sludge can be observed. In case of non-conditioned sludge, the higher polyelectrolyte doses were applied, the lower value of sludge resistivity was achieved. The best result, i.e. 3.1×10^{12} m/kg was recorded for the dose of 2.5 mg/g d.m. When the sludge was pre-conditioned by means of fly-ash, analogical tendency was observed as long as the polyelectrolyte dose amounted to 1.5 mg/g d.m. The latter dose allowed to receive the lowest value, i.e. 1.8×10^{12} m/kg. Further addition of polyelectrolyte did not have an impact on the CST value. Taking into account the result of sludge final hydration, it should be emphasized that in both cases, doses above 1.5 mg/g d.m. did not influence the parameter in a positive way. As it was expected, better results were achieved when the sludge was conditioned by dual method. The best result, i.e. 75.4% was achieved for the dose of 1.5 mg/g d.m.

Table 2.
Parameters of dewatered sludge after vacuum filtration process

Parameter		Dose of polyelectrolyte [mg/g d.m.]									
		0.0	1.0	1.5	2.0	2.5	0.0	1.0	1.5	2.0	2.5
		Non-conditioned sludge					Pre-conditioned sludge				
CSK	s	425	220	189	98	49	340	146	44	57	39
Sludge resistivity	m/kg, $\times 10^{12}$	16.2	12.2	10.6	5.7	3.1	13.1	6.9	1.8	2.8	2.5
Final hydration	%	85.8	86.5	80.7	81.1	81.7	81.9	78.5	75.4	77.1	76.9

4. SUMMARY

Single conditioners, especially polyelectrolytes, are most widely used in the conditioning processes. The evidence to be found in literature, however, implies that dual conditioning methods may be more effective. The aim of the paper was to assess the suitability of dual conditioning methods for the sludge conditioning. The assessment was based on the CST tests as well as the parameters of vacuum filtration process.

The research project allows to draw the following conclusions:

1. The application of physical conditioner in the form of fly-ash had a positive effect on the sludge. The best results were achieved when the fly-ash dose amounted to 8%.
2. Both in single as well as dual method, the cationic polyelectrolyte, unlike anionic polyelectrolyte, had a positive effect on the treated sludge.
3. The application of the dual method, whereby a combination of polyelectrolyte and fly-ash is used, did not improve the vacuum filtration parameters in a significant way in comparison to the method where the sludge was treated exclusively with polyelectrolytes. However, it allowed to reduce the amount of used polyelectrolyte by about 30%.
4. The application of fly-ash for sludge conditioning seems to be a promising alternative since it is a waste material which requires neutralization. It must, however, be emphasized that further research should additionally be focused on the influence of ash on the dewatered sludge, especially, as regards the heavy metals content.

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