INFLUENCE OF DIGESTED SLUDGE CONDITIONING ON THE DEWATERING PROCESSES AND THE QUALITY OF SLUDGE LIQUID

Abstract: To increase the dewatering effect, sewage sludge should be properly prepared before dewatering. Sludge conditioning is a process whereby sludge solids are treated with chemicals or various other means to improve dewatering characteristics of the sludge by reducing the specific resistance and compressibility of the sludge. The aim of the research was to determine the possibility of increasing the efficiency of sewage sludge dewatering by applying chemical agents and ultrasonic field. Some parameters, such as suspension, chemical oxygen demand (COD), phosphorus and ammonium nitrogen content in sludge supernatant, were also analysed.

Digested sludge belonged to the group of hardly dewatered sludge, its capillary suction time (CST) was of high value (2639 s). The lowest CST value (88.5 s) was obtained for the unsonicated sludge prepared only with PIX 113 at a dose of 7.0 mg/g d.m. Both the dose and the type of chemicals used, as well as the time of sonication, had an impact on the changes occurring in sludge properties. The increase in mechanical dewatering efficiency was obtained by using a combination of methods applied for sludge preparation, where the sonication of sludge was used at the preliminary stage and followed by dosing chemical substances. This resulted in the reduction of sludge final hydration and changes of other parameters. In addition, combined action of PIX 113 and Zetag 8180 allowed to reduce the content of suspended solids and COD in sludge supernatant.

Keywords: sewage sludge, sludge conditioning, filtration, effect of sludge dewatering, sludge sonication

Introduction

Modern and innovative ways of improving technological lines of sludge processing in sewage treatment plants are i.a.: intensifying final sludge dewatering processes, solving the problem of reject water and implementing methods of thermal sludge processing [1-5]. The degree of dewatering of sewage sludge is very important, as it is related to energy consumption and costs of drying and facilitates the transportation of sludge [6-8]. The cost of drying 1 m³ sludge with 80 % hydration to 10 % hydration is between 40 and 74 USD [9, 10]. The amount and kinds of water contained in the sludge depend on the composition of the sewage and the processes it undergoes in all stages of treatment. High water content and the colloidal and compressible character of slurry are the common properties of different kinds of sludge, which can still contain up to 95 % water after gravitational
condensation [11]. The kinds of water occurring in sludge flocules have a great practical value, since they determine the possibility and scale of water removal. Considering the amount of water that is biologically bound in the sludge, we need to assume it can basically only be released in the dewatering process with thermal methods. With complete drying of the sludge, the mean demand for heat is between 0.6 and 1.2 kWh/kg depending on the construction solutions and installation parameters [9]. We can see, then, that the process of mechanical dewatering as part of the technological line of sludge disposal measures is really important from the economic point of view. In addition, it is one of the most difficult problems to solve in sludge processing at treatment plants, which is confirmed by many publications [12-17]. Using well-known technologies of mechanical dewatering of sewage sludge, we are able to obtain the level of 30 % d.m. [18]. Studies [19-22] on the process of sludge dewatering showed that its course and the final effect depend on many factors, such as: initial hydration, the content of solids, initial preparation of sludge, the quality of sludge, and its specific resistance. One of the factors is sludge conditioning, i.e., its pre-treatment before mechanical dewatering. Sludge conditioning can be carried out by different methods. The effectiveness of chemical conditioning was proved by many researches. They used different type of chemical reagents. Jin et al. [23] used cationic polyacrylamide to improve sludge dewatering. Kuglarz et al. [24] proved that the application of Praestol 610BC cationic polyelectrolyte in a dosage of 2.5 g/kg dm helped to decrease sludge specific resistance to filtration (SRF) as well as the moisture, respectively by 81 and 4 %. However some researches indicates limitations of chemical composition. Wu et al. [25] stated that conditioned sewage sludge might be more compact during filtration, in result further dewatering could be limited. Other limitations are associated with the use of high dosages of chemical reagents and the relatively high cost of polyelectrolytes [26]. Recently, standard processes of conditioning have been modified so as to reduce the consumption of expensive chemical reagents [27-29]. According to Yang et al. [30] application of hydrogen peroxide, jute fibre waste and cationic polyacrylamide (CPAM) resulted in good sludge performance during dewatering. Apart from chemical conditioning, physical conditioners are applied, mostly in a laboratory research. The addition of different fractions of waste, such as: wood chips, fly ash, gypsum, rice powder and wheat bran into sludge has been tested [25, 31-35]. However results of sludge dewatering are not satisfactory, physical conditioners do not improve the process in a significant way [26]. Many other sludge treatment methods, such as alkaline/acid treatment [36, 37], ultrasonic treatment [38], microwave treatment [39], hydrothermal treatment [40], freezing treatment [41] have been also studied to facilitate the deep-dewatering of sewage sludge [42]. The idea behind these methods is to transfer the bound water in sludge into free water by decomposing or breaking extracellular polymeric substances and sludge cells. Recently, researchers have focused on nanomaterials instead [43, 44]. The physico-chemical properties of nanomaterials, such as enhancing molecular magnetism, conductivity and optics, make them a good means of treatment of sewage sludge before dewatering [45, 46].

The basic goal of all tested and applied in practice conventional and unconventional methods of sewage sludge conditioning is to remove water, because its quantity affects the selection of equipment of processing sludge at WWTP, and therefore costs. However, the choice of agents (the type of physical and/or chemical agent) as well as methods (e.g. mixing conditions) remains difficult to solve. Among physical methods ultrasounds are considered to be an effective in modifying the structure of sludge and having little impact on the environment. Hence, this method is nowadays increasingly used at many
Influence of digested sludge conditioning on the dewatering processes and the quality of sludge liquid

municipal WWTP as a practical way for sludge disintegration, then in a connection with chemical reagents. In this paper the effect of such combined methods of conditioning: physical (ultrasonic field) and chemical (inorganic and organic reagents) on dewatering of digested sludge was analysed, which is a new approach in sludge management in relation to ecological and economic requirements. Moreover, the paper presents practical results how the ultrasonic field combined with the action of PIX 113 (inorganic coagulant) and Zetag 8180 (polyelectrolyte) impact on pressure filtration parameters of digested sludge (final hydration and specific filtration resistance) and on the chemical parameters of sludge liquids.

Material and methods

Research material

The research substrate was sludge originating from a municipal sewage treatment plant (with the mean flow capacity of 40,000 m$^3$/d), which is a mechanical biological plant that biologically removes nitrogen and phosphorus compounds. The technological installation of the sludge processing section includes: gravitational and mechanical concentrators of primary sludge, separate digesters for mesophilic digestion of mixed sludge, open digesters: stabilization and concentration of digested sludge as well as mechanical dewatering and drying of sludge. The sludge was collected from a pipeline, which transports sludge from open digesters to belt presses.

For experiments digested sludge with the following characteristics was used:
− colour: black;
− odour: earthy;
− pH = 6.9;
− initial hydration: 97.6 %;
− final hydration: 94.4 %;
− dry remains: 23.7 g/dm$^3$;
− mineral compounds content: 39.5 %;
− organic compounds content: 60.5 %;
− capillary suction time: 2,639 s.

Before the dewatering process, the sludge was subjected to chemical modification with
− 10 % solution of PIX 113 coagulant,
− 0.1 % solution of Zetag 8180 polyelectrolyte.

The characteristics of the coagulants are shown in Table 1.

| Coagulant | Coagulant properties |
|-----------|----------------------|
| PIX 113   | A ferric coagulant, a dark brown water solution of ferric sulphate, with total iron (Fe) content of 11.4 ± 12.2 %, and iron ions Fe$^{2+}$ content of 0.4 ± 0.3 %.
| Zetag 8180| Zetag 8180 is a copolymer of acrylamide and quaternized cationic monomer. It operates over a wide pH range (4-9). It is recommended that stock solutions at 0.25-0.5 % are prepared. For maximum effect, the solutions should be used within 5 days. After that, some loss in the efficiency of the product may occur. Zetag 8180 is a synthetic polyacrylamide with a high molecular mass. It is provided as loose white powder. |
Procedure

The research involved three stages (Table 2) for sonicated and non-sonicated sludge. Stage I was the study of digested sludge only with the addition of PIX 113, stage II involved the use of Zetag 8180, and in stage III the two chemical substances were combined: PIX 113 in a constant dose of 1.0 mg/g d.m. and Zetag 8180 polyelectrolyte in changing doses.

| Series | Stage I | Stage II | Stage III |
|--------|---------|----------|-----------|
|        | PIX 113 [mg/g d.m.] | Zetag 8180 [mg/g d.m.] | PIX 113 [mg/g d.m.] | Zetag 8180 [mg/g d.m.] |
| I      | 1.0     | 1.0      | 1.0       | 1.0       |
| II     | 2.0     | 2.0      | 1.0       | 2.0       |
| III    | 3.0     | 3.0      | 1.0       | 3.0       |
| IV     | 4.0     | 4.0      | 1.0       | 4.0       |
| V      | 5.0     | 5.0      | 1.0       | 5.0       |
| VI     | 6.0     | 6.0      | 1.0       | 6.0       |
| VII    | 7.0     | 7.0      | 1.0       | 7.0       |

Fig. 1. Sonics VC750 ultrasonic processor

A high power, microprocessor-based ultrasonic processor Sonics VC750 (Fig. 1) with automatic tuning, the frequency $f = 20$ kHz and amplitude $A = 30.5 \, \mu$m was used to sonicate the samples of sewage sludge. The disintegration time was $t = 60$ s. The sewage sludge was sonicated in static conditions, with a constant sample volume of 400 cm$^3$. The following abbreviations are used hereafter: DS - non-sonicated digested sludge, and SS - sonicated digested sludge.

The scope of the study was: to select the doses of chemicals using the capillary suction time test, to determine the dewatering parameters during pressure filtration (final hydration
and specific filtration resistance), application of ultrasonic field and chemical agents for conditioning and to analyse the sludge liquid.

The sludge was mixed with selected chemicals using a magnetic stirrer MMS-3000N from Biosan. In stage I, after adding PIX 113 to the sludge, first it was stirred quickly for 60 s (200 rpm) in order to mix the whole volume thoroughly, and then slowly for 14 minutes (30 rpm), which ensured the formation of flocculi that made larger agglomerates. In stage II, Zetag 8180 polyelectrolyte was introduced into the sludge and quickly stirred for 2 minutes (200 rpm). Following that, in stage III, first PIX 113 was added and stirred like in stage I, and then a specific dose of Zetag 8180 polyelectrolyte was added; after 2 minutes the whole sample was stirred thoroughly again for 2 minutes.

The water removal capacity of the sludge was measured using the capillary suction time (CST). CST was determined using the Baskerville and Galle methodology [47], based on measuring the transition of the boundary layer of filtrate as a result of suction forces in the used paper - Whatman 17. The apparatus measuring capillary suction time was made of: an upper and lower plate, a metal cylinder, and a digital recording timer.

![Fig. 2. Pressure filtration station](image)

Pressure filtration was performed using a device made of: a pressure filter with filtration felt inside (ET 18II polyester felt), a compressor, measurement cylinders for the filtrate, cut-off valves, a manometer and a stopwatch (Fig. 2). Compressed air with the pressure of 0.5 MPa was used in the filtration process. The specific resistance of filtration, SRF was determined using the following equation according to [48]:

$$ SRF = \frac{2PF^2b}{\mu c} \quad [\text{m/kg}] $$

where $b$ is the slope of filtrate discharge curve $[\text{s/m}^3]$, $F$ is the filter area $[\text{m}^2]$, $P$ is the filtration pressure $[\text{N/m}^2]$, $\mu$ is the viscosity of the filtrate $[\text{Ns/m}^2]$ and $c$ is the weight of
cake solids per volume of filtrate \([\text{kg/m}^3]\). The data obtained during filtration was used to determine and the final hydration. The final hydration \(U_k\) was calculated with the following equation:

\[
U_k = (1 - \frac{m_d - m_p}{m_w - m_p})100 \quad [%]
\]

where \(m_d\) is the weight of a sludge after drying \([\text{g}]\), \(m_w\) is the weight of a sample before drying \([\text{g}]\) and \(m_p\) is the weight of empty dish \([\text{g}]\).

The findings of the experiments presented on charts are an arithmetic mean made up of three repetitions.

The following parameters were determined in the sludge liquid: pH with the potentiometric method (pH-meter CP401 from Elmetron), total suspended solids with the weighing method, with the short dichromate method (PN ISO 6060:2006 [49]), ammonium nitrogen and phosphates \(\text{PO}_4^{3–}\) as well as total phosphorus, \(P_{\text{tot}}\) with the spectrophotometric method (Spectrophotometer JENWAY 6300).

**Results and discussion**

CST changes of the sludge depending on the dose of selected chemicals are presented in Figure 3, used to choose the doses of reagents for the study of its dewatering through pressure filtration. The doses for each preparation were: 4.0; 5.0; 6.0; 7.0 mg/g d.m. For the combination of both chemical compounds, we used: PIX 113 (in the dose of 1.0 mg/g d.m.) and Zetag 8180 in doses: 4.0; 5.0; 6.0; 7.0 mg/g d.m. Capillary suction time of the sludge decreased as the doses of the chemicals increased (Fig. 3). The lowest CST value achieved during the measurement was 88 s at the dose of 7.0 mg/g d.m. for non-sonicated sludge treated with PIX 113, which was 96.7 % reduction. The highest CST values were obtained for sonicated sludge treated with Zetag 8180 polyelectrolyte.

The final water content in non-sonicated sludge (DS) and in sonicated sludge (SS) was 94.4 and 92.5 % respectively. Changes in final water content obtained for non-sonicated sludge treated with selected chemicals were in the range of 79-90 % (Fig. 4). For sludge that was initially sonicated and conditioned, the range was 77-84 % (Fig. 6). Thus, lower values of final water content were obtained for sludge that was first sonicated and then selected chemicals were added to it. Zhu et al. [50] found a similar synergistic effect of combined conditioning using ultrasounds and polyelectrolytes. The analysis of charts in Figures 4 and 6 shows that the values of final water content of prepared sludge were lower than in the case of non-sonicated and sonicated sludge. As the doses of chemicals added to the sludge grew, in most cases the value of final water content dropped. This is because the special macromolecular structure of polyelectrolyte could wrap around the sludge colloids into larger and denser flocs through charge neutralization and inter-particle bridging mechanisms. In result free water and partial interstitial water is more easily released [50-54]. Only for sonicated sludge treated with Zetag 8180, beginning with the dose of 5.0 mg/g d.m., the final water content grow.

The greatest decrease in final water content was observed for sonicated sludge conditioned with PIX 113 in the dose of 7 mg/g d.m.: it was 77 %. Treating sludge with ultrasonic field and then with a chemical substance led to changes in the final water content as compared to the parameters of untreated sludge. Ultrasonic field as a physical method of modifying sewage sludge conditioned with a chemical substance was the factor that intensified the dewatering processes [20, 50, 51, 55].
Influence of digested sludge conditioning on the dewatering processes and the quality of sludge liquid

Zhang et al. [56] found that a hybrid conditioning is a very useful method. Sonication allowed to cut the FeCl$_3$ dose by almost 50% and it was sufficient to achieve 80% final water content. For further reduction of FeCl$_3$ dose and to improve sludge dewatering a polyelectrolyte was added. With addition of polyelectrolyte Zhang et al. observed that
final water content of sludge reached 75.9 %. Sonicating sludge using a short time of exposure to ultrasound (60 s) caused disturbances in the system equilibrium. This causes dispersion and partial homogenization of the suspension. Combining chemical conditioning with the physical method proved to be a satisfactory solution, reducing the amount of dewatered municipal sludge.

Fig. 5. Influence of the doses of chemicals on the specific filtration resistance of non-sonicated digested sludge (DS) in the process of pressure filtration

Fig. 6. Influence of the doses of chemicals on the final hydration of sonicated digested sludge (SS) in the process of pressure filtration
Analysing changes in the values of specific filtration resistance (Fig. 5, Fig. 7) we found out that filtration resistance increased in all the tested ways of conditioning the sludge, which did not have a negative influence on the obtained effects of final hydration. This relationship may have been the result of the applied chemicals causing an increase in sludge porosity. A thicker structure of sludge, able to maintain high porosity under the influence of high pressure contributed to the removal of a considerable amount of water. During the dewatering process we obtain a dry cake and filtrate, i.e., sludge liquid. The quality of sludge liquids produced during mechanical dewatering of sludge depends on the stabilization technology and the kind of device, its proper operation, and an appropriate choice of conditioning chemicals [57]. Crude sludge liquids had very high concentrations of ammonium nitrogen (1,354.7-1,718.9 mg N-NH$_4^+$/dm$^3$), phosphates (122.4-184.5 mg PO$_4^{3–}$/dm$^3$) and organic compounds referred to as COD (2,240-2,960 mg O$_2$/dm$^3$). In samples of sludge liquid (Table 3) obtained from non-sonicated sludge treated with PIX 113, the pH values were lower. The value of pH decreased with the increasing dose of the coagulant. For 7.0 mg/g d.m. of PIX 113 it was 5.02 (reduced by 31.4 %). In liquid samples treated with Zetag 8180 and in samples treated both with 1.0 mg/g d.m. of PIX 113 and different doses of Zetag 8180, pH slightly rose up to 7.45 (by 1.7 %). Similar relationships were obtained for the liquid from sludge that was first sonicated and then treated with chemical substances. The content of phosphorus and nitrogen decreased in all samples. The lowest value of phosphorus was observed in samples in which PIX 113 was used: for non-sonicated sludge, 1.4 mg P-PO$_4^{3–}$/dm$^3$ (reduction by 96.5 %) and for sonicated sludge, 3.6 mg P-PO$_4^{3–}$/dm$^3$ (reduction by 94 %). The coagulant bound and retained the compounds in the sludge proportionally to the administered dose. The lowest value of ammonium nitrogen was observed for samples of liquid separated from non-sonicated sludge in which PIX 113 and Zetag 8180 were used together: 564.8 mg N-NH$_4^+$/dm$^3$ (reduction by 67.1 %), and for sludge liquid from sonicated sludge, 778.8 mg N-NH$_4^+$/dm$^3$ when treated with Zetag 8180 (reduction by 42.5 %). Adding PIX 113 coagulant, Zetag 8180 polyelectrolyte, and a combination of PIX 113 and Zetag 8180...
caused a reduction of total suspended solids in the liquid as compared to crude sludge liquid. We found that as the doses of reagents increased, the amount of suspended solids in the samples decreased.

The amount of organic compounds (COD) in sludge liquids decreased during the process of sewage sludge conditioning. The efficiency of their removal grew with the growing dose in the case of each coagulant and the method combining PIX 113 and Zetag 8180 (Table 3). The best effect of organic compounds removal was observed for the liquid separated from non-sonicated sludge treated with PIX 113: between 65.6 and 87.5%. In the other methods the reduction in the amount of organic compounds was between 0.4 and 25.4% (for Zetag 8180) and between 32.1 and 35.7% (for the method combining PIX 113 and Zetag 8180). In the case of liquid removed from sonicated sludge treated with PIX 113, COD decreased from 69.6 to 86.5%. In the following methods, the reduction in

### Table 3

| Parameters of sludge liquids | Dose [mg/g d.m.] | pH | Phosphates [mg PO₄³⁻/dm³] | Phosphorus [mg P-PO₄³⁻/dm³] | Ammonium nitrogen [mg N-NH₄⁺/dm³] | COD [mg O₂/dm³] | Suspension [mg/dm³] |
|-----------------------------|-----------------|----|--------------------------|-----------------------------|----------------------------------|---------------|-------------------|
| Crude sludge liquids        |                 |    |                         |                             |                                  |               |                   |
|                            | -               | 7.32 | 122.4 | 4.93 | 40 | 4.93 | 1718.4 | 3.62 | 2240 | 5.53 | 1142 | 4.0 |
| PIX 113                    | 4.0             | 6.27 | 10.1 | 0.6 | 3.3 | 0.6 | 1.427 | 3.56 | 770 | 4.83 | 350 | 2.0 |
|                            | 5.0             | 5.95 | 8.9 | 0.36 | 2.9 | 0.36 | 1155.7 | 3.97 | 500 | 3.42 | 300 | 3.61 |
|                            | 6.0             | 5.56 | 7.0 | 0.50 | 2.3 | 0.50 | 984.8 | 3.11 | 320 | 3.31 | 260 | 2.65 |
|                            | 7.0             | 5.02 | 4.3 | 0.70 | 1.4 | 0.70 | 969 | 2.40 | 280 | 2.82 | 110 | 4.00 |
| Zetag 8180                 | 4.0             | 7.43 | 50.5 | 1.54 | 16.5 | 1.54 | 1241.1 | 2.08 | 2230 | 2.26 | 540 | 3.61 |
|                            | 5.0             | 7.44 | 41.6 | 0.59 | 13.6 | 0.59 | 788.4 | 1.20 | 1930 | 3.61 | 340 | 4.58 |
|                            | 6.0             | 7.45 | 38.7 | 0.80 | 12.7 | 0.80 | 648.2 | 1.05 | 1850 | 2.65 | 240 | 5.29 |
|                            | 7.0             | 7.47 | 26.6 | 0.32 | 8.7 | 0.32 | 612.7 | 1.14 | 1670 | 3.00 | 140 | 6.00 |
| PIX 113 (1.0) + Zetag 8180 | 4.0             | 7.38 | 26.9 | 0.42 | 8.8 | 0.42 | 655.2 | 1.97 | 1520 | 2.00 | 690 | 4.58 |
|                            | 5.0             | 7.42 | 16.5 | 0.50 | 5.4 | 0.50 | 651.1 | 0.87 | 1500 | 3.61 | 600 | 4.00 |
|                            | 6.0             | 7.44 | 11.6 | 1.06 | 3.8 | 1.06 | 582.8 | 2.13 | 1480 | 2.52 | 320 | 4.36 |
|                            | 7.0             | 7.45 | 7.9 | 0.96 | 2.6 | 0.96 | 564.8 | 2.58 | 1440 | 2.00 | 180 | 5.57 |
| Sludge liquids separated from non-sonicated, digested sludge treated with different coagulants | | | | | | | |
| Crude sludge liquids        |                 |    |                         |                             |                                  |               |                   |
|                            | -               | 7.88 | 184.5 | 3.24 | 60.3 | 3.24 | 1354.7 | 3.69 | 2960 | 6.0 | 1230 | 7.81 |
| PIX 113                    | 4.0             | 6.4 | 63.0 | 1.05 | 20.6 | 1.05 | 1241.1 | 3.06 | 900 | 4.58 | 580 | 5.29 |
|                            | 5.0             | 6.2 | 17.1 | 0.66 | 5.6 | 0.66 | 1155.7 | 1.68 | 590 | 4.36 | 470 | 5.00 |
|                            | 6.0             | 5.8 | 15.9 | 0.91 | 5.2 | 0.91 | 1150.6 | 4.33 | 570 | 2.65 | 370 | 7.00 |
|                            | 7.0             | 5.52 | 11.0 | 0.65 | 3.6 | 0.65 | 1040.1 | 3.15 | 400 | 5.29 | 310 | 1.73 |
| Zetag 8180                 | 4.0             | 7.88 | 156.7 | 4.52 | 51.2 | 4.52 | 1190.8 | 4.78 | 2880 | 5.29 | 770 | 4.36 |
|                            | 5.0             | 7.89 | 134.9 | 1.51 | 44.1 | 1.51 | 1215.9 | 3.62 | 2800 | 3.00 | 560 | 3.61 |
|                            | 6.0             | 7.90 | 131.9 | 0.69 | 43.1 | 0.69 | 803.9 | 3.33 | 2640 | 7.00 | 480 | 4.00 |
|                            | 7.0             | 7.95 | 111.7 | 2.26 | 36.5 | 2.26 | 778.8 | 5.01 | 2400 | 7.81 | 440 | 3.00 |
| PIX 113 (1.0) + Zetag 8180 | 4.0             | 7.29 | 134.0 | 2.23 | 43.8 | 2.23 | 1251.1 | 3.68 | 2400 | 5.00 | 900 | 5.29 |
|                            | 5.0             | 7.31 | 102.8 | 1.81 | 33.6 | 1.81 | 1165.7 | 7.25 | 2280 | 4.58 | 840 | 4.58 |
|                            | 6.0             | 7.56 | 67.3 | 2.62 | 22.2 | 2.62 | 1145.6 | 4.86 | 2200 | 5.57 | 760 | 6.00 |
|                            | 7.0             | 7.7 | 42.2 | 2.97 | 13.8 | 2.97 | 1095.4 | 6.22 | 1840 | 7.00 | 530 | 3.00 |
the amount of organic compounds was between 2.7 and 18.9 % (for Zetag 8180) and between 18.9 and 37.8 % (for the method combining two chemical substances: PIX 113 and Zetag 8180).

**Conclusion**

In order to intensify the process of dewatering, we studied the application of selected methods of sludge conditioning. The conclusions from the experiments are as follows:

1. Physical conditioning of sludge with ultrasonic field increased its capillary suction time in relation to crude sludge. The use of a method combining ultrasonic field and chemicals decreased the capillary suction time. The best effect of reducing capillary suction time was obtained when using PIX 113 to treat the sludge that had been sonicated before.

2. Adding doses of chemicals to sonicated sludge gave a better dewatering effect in comparison to non-sonicated sludge. The use of PIX 113 coagulant in sonicated sludge caused a reduction of final hydration by 18.4 % in relation to non-sonicated and untreated sludge.

3. The selected doses of chemical reagents (PIX 113 and Zetag 8180 and PIX 113 together with Zetag 8180) improved the final hydration rate of sludge in the process of pressure filtration.

4. The reagents and ultrasonic field used to condition the sludge caused the reduction of contamination in the leachates in relation to crude sludge liquids.

5. The use of PIX 113, Zetag 8180 and a method combining PIX 113 and Zetag 8180 allowed to reduce the amount of total suspended solids in sludge liquid. The greatest reduction of suspended solids was achieved when using PIX 113 in liquid separated from non-sonicated sludge. It was 90.4 %.

6. The best effect of organic compounds removal was achieved for the liquid removed from non-sonicated sludge treated with PIX 113: 87.5 %. A minimally weaker effect was achieved for liquid from sonicated sludge treated with PIX 113: 86.5 % Zetag 8180 and the method combining the two chemical substances gave much worse effects: between 0.4 and 37.8 %.

7. In leachates from the dewatering of non-sonicated sludge treated with PIX 113, the amount of phosphorus was reduced to 96.5 %, and in sludge liquid from non-sonicated sludge, to 94 %.

8. The content of ammonium nitrogen was reduced from 67.1 % in sludge liquid from non-sonicated sludge and to 42.5 % in the filtrate from the dewatering of sonicated sludge in comparison to crude sludge liquid.

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