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SOLIDIFICATION AS A PROCESS OF TREATMENT OF POST-COAGULATION SLUDGE FROM THE WATER TREATMENT PLANT

ZESTALANIE JAKO PROCES PRZERÓBKI OSADÓW POKOAGULACYJNYCH POCHODZĄCYCH ZE STACJI UZDATNIANIA WODY

Abstract: Post-coagulation sludge is a mixture of pollutants removed from water and coagulants, which was added to the water. It has a hydrophilic and colloidal character. It is important to search processes whereby this sludge could be reused or eventually disposed of. The studies of solidification of post-coagulation sludge were carried out. The solidification process consists in the appropriate and rapid mixing the sludge with the material used for solidification in order to ensure the adequate homogenization conditions. The reagent used in solidification absorbs water contained in the sludge as a result of rapid homogenization with the sludge due to hydration, in a strongly exothermic process. The excess water evaporates form the sludge. This reduces the mass and volume of the sludge and leads to the formation of granules. During the tests, quicklime and cement Gorkal 40, Gorkal 50 and Gorkal 70 were used as a solidifying material, in doses of 0.7; 1.4; 2.1; 2.8; 3.5 g/kg *TS.* During the maturing process of the lime-sludge and cement-sludge mixtures, changes in the total solids concentrations were checked. The obtained test results show that increasing the solidification material dose and extending the maturation time results in a significant increase in the total solids concentration of the mixtures. Changing the structure and consistency of the sludge from plastic to solid gives the possibility to use sludge as a building material, for the reclamation of dumps, hardening roadsides or creating slopes and embankments.

Keywords: post-coagulation sludge, conditioning, dewatering, solidification, disposed

Introduction

The processes used for water treatment generate a significant amount of technological wastewater (so-called backwash water) and sludge, which due to the existing

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legal regulations and high costs associated with their treatment, present a huge problem for operators of the Water Treatment Plant (WTP). The amount of sludge formed is from 2 to 5 % of the volume of the treated water, depending on the quality of water consumed, the technology applied, the type and doses of reagents used and the requirements for the quality of water intended for consumption [1, 2].

The technological processes of treatment of sludge used for removing water from sludge consists of: thickening, dewatering, drying, combustion. The use of the above processes allows to obtain several or even several dozen decreases of the volume of sludge. Each of the stages of sludge treatment, to a different extent, allows for the removal of individual forms of water contained in the sludge. Thickening of sludge is the first unit process of treatment of sludge, in which separation of the solid phase from the liquid phase takes place, as a result of which the sludge volume decreases while not losing its liquid consistency. Depending on the method of thickening used, the process enables removal of free water at the range of 40–90 %. The dewatering process is aimed at further reduction of the water content in the sludge. In this process, free water and partly bound water is removed depending on the technology used. Low pressure dewatering only removes small amounts of water bound in colloids but the free and semi-physically bound water is well removed. The sludge is conditioned before dewatering. The process aims to change the structure and properties of the sludge by reducing the specific resistance, which allows to increase the efficiency of its dewatering. The costs of construction and operation of sludge treatment appliances in Water Treatment Plants can reach up to 50 % of the total costs borne by the given institution [1, 2, 5–7].

According to the Waste Act [8], sludge from the Water Treatment Plants is treated as waste. Pursuant to the Act, an entity that generates waste is required to select a technology that guarantees the least possible negative impact on the environment and minimizing the generated waste. The methods of disposal and use of sludge from WTPs include:

– land reclamation,

– creating a sludge-lime granulate used for land reclamation and construction,

– using aluminum and iron post-coagulation sludge as coagulants in the wastewater treatment – process or for the removal of phosphorus compounds,

– use of post-coagulation sludge for the production of cement,

– disposal of sludge including municipal sewage sludge,

– use for the construction of slopes for reinforcing embankments and roadsides of post-coagulation sludge, in which the content of AL_2O_3 does not exceed 50 % of the solid phase after dewatering and solidification,

– application of iron sludge to bind hydrogen sulfate in sewage network and sewage treatment plants,

– use of sludge from the treatment of backwash water containing aluminum particles, aluminum material, humic substances and insignificant amounts of organic substances for agricultural use, reclamation of degraded areas or landscaping,

– use of sludge with at least 50 % content of organic compounds for the production of compost, for possible natural use [2, 3–6, 9].

Solidification is one of the methods of physical-chemical disposal of sludge, which can be used, for example in construction, for the production of building materials, land reconstruction, construction of embankments, and environmental acoustic screens to reduce traffic noise (rail, road, aircraft). The materials most commonly used for solidification of sludge include: lime, cement, gypsum and other ingredients with water-binding properties [2, 10, 11]. The solidification process requires adequate and fast mixing to ensure adequate conditions of sludge homogenization with the solidifying material used. The reagent used as a result of rapid homogenization with the sludge due to hydration, in a strongly exothermic process, absorbs water contained in sludge, the excess of which evaporates. As a result, there is a reduction in the mass and volume of sludge and the formation of granules. When the component is mixed with the sludge, significant amount of heat is released. The mixture formed in this way reaches its maximum strength (hardness) over time. The aim of the process is chemical transformation of the sludge and, if possible, improvement of some of its physical parameters, thus obtaining improvement in its mechanical strength allowing its easier use and transport. It also reduces the absorbability and increases the frost resistance. As a result of hydraulic binding, the components present in the sludge are transformed into hard or insoluble forms in water. This process is also called immobilization, because it allows binding of components contained in the sludge, including the non-biodegradable and migratable ones. The heavy metal cations are transformed into a highly insoluble or sparingly soluble form, e.g. carbonates or hydroxides. Alkaline materials, as a result of chemical dewatering occurring during solidification, support the maintenance of a suitable structure enabling the retention of polyvalent elements [2, 12–14].

Research methodology

The purpose of the conducted research was to determine the possibility of using quicklime and cement in the process of solidification of post-coagulation sludge from the Water Treatment Plant. The effect of the type and dose of solidification materials used on the increase of total solids content in the sludge was assessed. For the post-coagulation sludge, the following determinations were made: total solids (*TS*), volatile solids (VS), hydration, capillary suction time (CST), filtration resistance, pH, and color and smell of sludge, in compliance with applicable standards [15–18]. The solidification process was applied to a conditioned sludge, dewatered in laboratory centrifuge. The sludge before dewatering was conditioned with polyelectrolytes, and then optimal dewatering parameters were selected.

The type of polyelectrolyte was selected based on the flocculation tests, strength, whereas the dose of polyelectrolyte was selected based on the flocculation tests, strength and CST. Conditioning with polyelectrolyte enables to change the structure of the sludge and the surface of the dispersed solid phase particles, which leads to reduction of the interface and reduces the force of binding water from the surface of sludge flocks. In the conditioning process, 0.1 % polyelectrolyte solutions were used, they are presented in Table 1.

Table 1

Type of tested polyelectrolyte

Item	Type of polyelectrolyte	Ionic character
1	Zetag 64	weak cationic
2	Superfloc A130	weak anionic
3	Praestol 644-BC	anionic
4	Zetag 8846FS	cationic
5	Praestol 2360	cationic

The flocculation test was based on visual assessment of the size and structure of the flocks after the introduction of the sludge and mixing. To the beakers, 100 cm^3 of well mixed sludge were introduced, a dose of the 2.6 g/kg *TS* of the tested polyelectrolytes was added and mixed thoroughly with a baguette for 1 minute. Then, based on the strength test of the flocks, the strength was evaluated. That flocks structure should be robust, due to the action of the centrifugal force and the shearing forces occurring in the belt press. For this purpose, from the height of 10 cm, the sludge was poured from the beaker to beaker five times.

CST measurement was performed in accordance with the PN-EN 14701-1 [17] standard. The CST measurement method is based on the phenomenon of sucking up the liquid from the sludge by chromatographic paper. The speed with which the paper becomes moist from the filtrate is dependent on the ability of sludge to dehydrate. The capillary sucking time (CST) is defined as the time of the passage of the front boundary layer of the filtrate between two circles of different diameters. The CST measurement is carried out in a special apparatus equipped with a metal cylinder, bottom plate, upper plate with a set of circular coaxial electrodes and an electronic timer (Fig. 1). The sludge sample is placed in a metal cylinder with a hole in the bottom resting on the Whatman 17 filter paper. On the lower plate with the tissue paper, the upper plate is placed with the electrodes enabling measurement of the time in which the liquid soaks the paper. The liquid from the sludge, saturating the paper, is spreading radially, and

Fig. 1. Apparatus for measuring the CST

when there is an electrode placed on the smaller circle, the timer is activated and the time measurement starts. The test is continued until the liquid reaches the circle with the larger diameter, then the timer is stopped.

Then, the optimal dose was chosen for the selected type of polyelectrolyte. 250 cm^3 of well mixed sludge and polyelectrolyte in doses 0.8; 0.9; 1.0; 1.2 and 1.3 g/kg *TS* were introduced into beakers. After flocculation of the sludge particles, the appearance of flocs was visually assessed. Then a sieve test and CST measurement were performed.

For the optimal dose and type of the polyelectrolyte, the dewatering process was carried out in a laboratory centrifuge. In the study a laboratory centrifuge Centrifuge company MPW – type 340 was used. The scope of the research included determination of the impact of time and the rotational speed on the result of sludge dewatering for the selected type and dose of the polyelectrolyte. Samples of well mixed and conditioned sludge with a volume of 100 cm^3 were placed in the centrifuge and subjected to centrifugation for 1, 2, 3 minutes at a constant rotational speed of 2000 rpm. After the centrifugation, the volume of the effluent was measured for each sludge sample and its clarity was visually evaluated. This allowed to determine the optimal centrifugation time of the tested sludge. Then for the optimal time, the sludge was centrifuged at speeds of 1000 and 3000 rpm. It made it possible to determine the optimal parameters of the dewatering process.

The object of the study was sludge collected from the post-coagulation sludge tank at the Water Treatment Plant. The technological process of water treatment includes the processes:

- preliminary ozonation,
- coagulation using aluminum sulfate,
- sedimentation in primary settling tank,
- filtration on contact filters,
- indirect ozonation,
- filtration through a bed of activated carbon,
- disinfection.

In these processes, technological wastewater is formed, which in turn is treated in the process of contact coagulation with the aluminum sulfate. The solidification process was applied to the mixture of post-coagulation sludge from the water coagulation process (from the primary settling tank) and post-coagulation sludge from the technological sewage treatment (from the sludge tank).

The post-coagulation sludge was subjected to a process of conditioning, dewatering in a laboratory centrifuge, followed by solidification. For the sludge, the type and dose of polyelectrolyte and dewatering parameters were selected. In the conditioning process Zetag 64 and a dose of 0.78 g/kg *TS* was used. The sludge was then centrifuged in a laboratory centrifuge for 1 min. at 3000 rpm. After the dewatering process, a total solids content of 7.1 % was obtained. The dewatered sludge has undergone a solidification process. The following solidifying materials were used: quicklime (CaO) in powdery form and calcium and aluminum cement Gorkal 40, Gorkal 50, Gorkal 70.

Quicklime was produced by Avantor Performance Materials Poland in Gliwice. Calcium oxide is an inorganic chemical compound belonging to the group of basic oxides, containing calcium in the second oxidation state, has hygroscopic properties, binds water rapidly to form calcium hydroxide, while releasing significant amounts of heat. Calcium oxide is used in construction, metallurgy, ceramics and glass industry, as an insecticide, as a fertilizer in agriculture. However, in laboratory conditions it was used in the process of ammonia production and as a dewatering reagent. The remaining solidifying materials were various types of calcium-aluminum cement: Gorkal 40, Gorkal 50 and Gorkal 70. The characteristic properties of Gorkal 40 cement, such as short setting time and quick increase in mechanical strength, allow it to be used in urgent home repair work. It can therefore be used to make screeds, window sills and lintels. Also Gorkal 50 is a hydraulic binder with a fast increase in strength (80 % after 12 hours from earning) and a short setting time. Typical chemical composition of Gorkal 50: AL_2O_3 cement – 50–55 %, CaO – 36–38 %, SiO_2 – 2–4 %, Fe_2O_3 max 10 %. Due to the stable phase composition it has excellent mechanical properties (highly active hydraulically), thanks to which it can be used in mortars and concretes in construction chemistry and can be a component of insulating refractory masses or other monolithic materials. Cement Gorkal 70 is widely used in various industries, including the glass, ceramic, chemical and cement industries. The composition of cement Gorkal 70: Al_2O_3 – 69–71 %, CaO – 28–30 %, SiO_2 less than 0.5 %, and Fe_2O_3 less than 0.3 % [19–21].

Solidification was carried out for dewatered sludge (in laboratory conditions) with content of total solids of 7.1 %. The solidification material was introduced into the sludge in amounts of 0.7; 1.4; 2.1; 2.8; 3.5 g/kg *TS*. After introducing the reagent, the samples were immediately mixed using a paddle agitator. Mixing time for cement was 1 minute, whereas for quicklime 2 minutes. This allowed to obtain a mixture with a uniform composition and homogeneous consistency. Then from the resulting cement-sludge and lime-sludge mixture, rolls were formed of a length of approx. 20 cm and allowed to dry at ambient temperature about 20 ^{o}C. The control test was prepared from a dewatered sludge without the addition of a solidifying material. After 2, 4, 7, 9, 11 days of the process in the mixtures, the total solids content was determined.

Results and discussion

The post-coagulation sludge from the Water Treatment Plant was characterized by a hydration of 99.2 %, typical for this type of sludge. The total solids content and volatile solids contents were 0.8 % and 34.4 % *TS* respectively. The obtained measurement of the CST at the level of 52 seconds indicates that the sludge in question quickly releases free water. Post-coagulation sludge was characterized by a brownish-brown color, without a characteristic odor (Table 2).

The post-coagulation sludge was subjected to the conditioning process in order to change the structure and properties to the extent that their drainage efficiency could be increased. Changing the structure of the sludge allows to significantly reduce the forces binding water to the surface of solid phase particles and facilitates the removal of water during mechanical binding. Five different polyelectrolytes were used in the conditioning process: Zetag 64, Superfloc A130, Praestol 644-BC, Zetag 8846FS, Praestol 2360 at

Table 2

Characterization of post-coagulation sludge

Parametr	Unit	Value	
Total solids	%	0.8	
Volatile solids	% *TS*	34.4	
Hydration	%	99.2	
CST	s	52.0	
Filtration resistance	m/kg	$8.5 \cdot 10^{12}$	$4.6 \cdot 10^{14}$
pH	—	7.7	

a dose of 2.6 g/kg *TS* each. Initial visual assessment of the structure of the flocs formed as a result of aggregation of particles allowed to compare the types of polyelectrolytes used. However, for the ultimate selection of the most effective polyelectrolyte, a strength test was carried out, which strongly indicated that Zetag 64 as a cationic polyelectrolyte would be the most preferred option. The flocs formed with influence of this polyeletrolyte were characterized by large size, were not damaged or fragmented, and were of identical structure after both tests. This indicates their durable structure. The remaining polyelectrolytes generated good or sufficient results, including unstable flocs undergoing fragmentation (Table 3).

Table 3

The results of selection of polyelectrolyte type

Type of polyelectrolyte	Dose [g/kg] *TS*	Results	
		Flocculation test	Strength test
Zetag 64	2.6	large flocs, good sedimentation properties	flocs not undergoing defragmentation,
Superfloc A130	2.6	very small flocs, bad sedimentation properties	flocs partially undergoing defragmentation
Praestol 644-BC	2.6	large flocs, good sedimentation properties	flocs undergoing defragmentation
Zetag 8846FS	2.6	small flocs, bad sedimentation properties	flocs partially undergoing defragmentation
Praestol 2360	2.6	large flocs, good sedimentation properties	flocs partially undergoing defragmentation

In the next stage, for the most effective polyelectrolyte Zetag 64, the selection of the optimum dose of the reagent out of 0.8; 0.9; 1.0; 1.2; 1.30 g/kg *TS* was made. For this purpose flocculation tests, sieve test and the CST were carried out. The results of these tests are presented in Table 4.

For all doses of the polyelectrolyte the flocculation test produced large, well sedimenting flocs. Increased dose of the polyelectrolyte did not affect the efficiency of the sieve test as in all cases the flocs did not pass through the sieve. However, the highest filtrate volume (66 cm^3) and the lowest capillary suction time (10 s) were obtained for the lowest polyelectrolyte dose of 0.8 g/kg *TS*. The CST measurement indicates that the lower its value, the easier (faster) the tested sludge releases the water (Table 4). On the other hand, the increase in polyelectrolyte dose slightly worsened the dewatering properties of the sludge.

Table 4

The results of selection of polyelectrolyte dose

Dose of polyelectrolyte Zetag 64 [g/kg] *TS*	Results		Filtrate volume [cm^3]	CST [s]
	Flocculation test	Sieve test		
0.8	large flocs, good sedimentation properties	flocs not passing through the sieve	66	10
0.9	large flocs, w good sedimentation properties	flocs not passing through the sieve	65	11
1.0	large flocs, good sedimentation properties	flocs not passing through the sieve	64	14
1.2	large flocs, good sedimentation properties	flocs not passing through the sieve	55	15
1.3	large flocs, good sedimentation properties	flocs not passing through the sieve	49	15

For the most effective dose of polyelectrolyte Zetag 64 amounting to 0.8 g/kg *TS*, dewatering tests were carried out in a laboratory centrifuge. The dewatering process allows to obtain solid sludge consistency. Three centrifugation times were used in the dewatering process: 1, 2, 3 minutes and three rotational speeds: 1000, 2000, 3000 rpm. On the basis of the laboratory tests (Fig. 2) the most favorable time of centrifugation was the process lasting 1 minute. Almost equal volumes and the same levels of clarity of effluents were obtained for all centrifugation times. However, due to economic reasons, it was decided to conduct the centrifugation process for 1 minute. The efficiency of the dewatering process depended on the speed used (Fig. 3). The higher

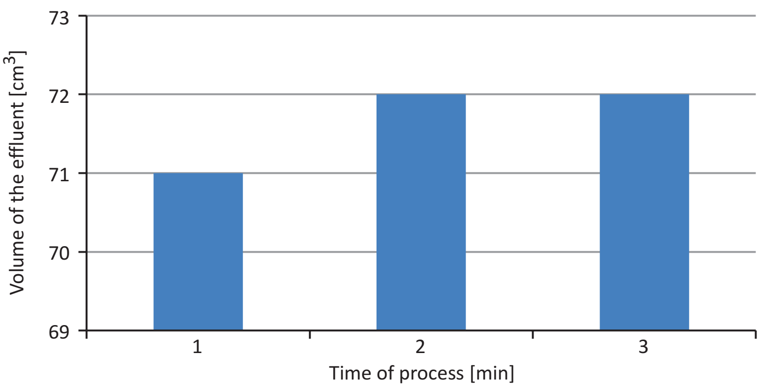

Fig. 2. Changes of volume of the effluent during different dewatering time

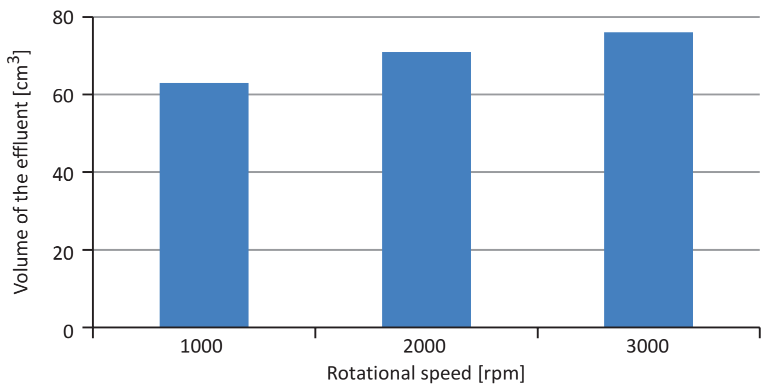

Fig. 3. Changes of volume of the effluent during different rotational speed

the speed, the greater the volume of the effluent obtained. The use of a rotational speed of 3000 rpm allowed obtaining a solid sludge.

A dewatered sludge with a content of total solids = 7.1 % was subjected to solidification process. The obtained results of the tests for quicklime have been illustrated in Fig. 4. It can be noticed that increasing the weight proportion of quicklime compared to the total solids of the sludge causes an increase in the total solids content in the mixtures on subsequent days of the process. Processing time also affects its efficiency. The solidification process is most effective between the 1st and 7th day, and then the increase in the efficiency of the binding process displays an almost linear tendency. Therefore, seven days can be considered as the most favorable maturing time. On 7th day in the sludge, without adding any solidifying material, the total solids content was 81.2 %. However, for the lowest dose (0.7 g/kg *TS*) total solids content was higher – 93.0 %. The highest content of total solids, at the level of 98.1 %, was characteristic of solidified sludge with quicklime for a dose of 3.5 g/kg *TS*, on the 11th day of maturing.

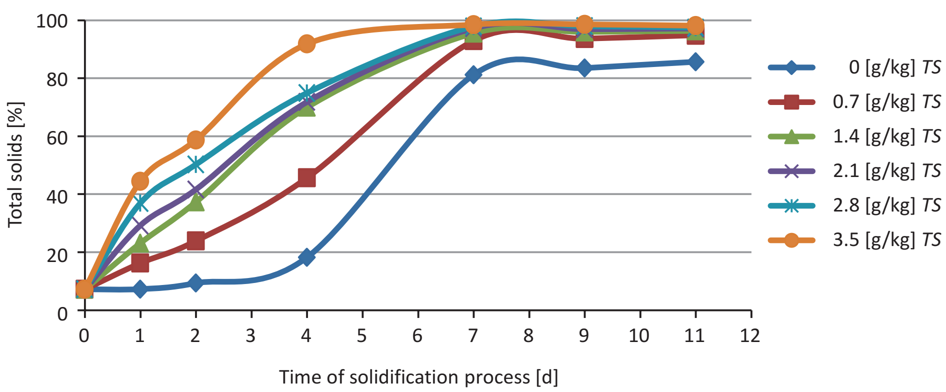

Fig. 4. Changes of the total solids during solidification with CaO

Figure 5 presents the results of the research on the solidification process using Gorkal G 40 cement. Based on the graph, it can be concluded that the higher the cement dose and the longer the process duration, the higher the efficiency of the process. In addition, the largest increase of total solids in the samples was observed between the 2nd and 7th days of maturing. On the 7th day of the process, in the case of doses 3.5 g/kg *TS* content of total solids was obtained 92.1 %. The best result was obtained using cement at the same dose on 11th day of the process. Then the share of the total solids of the cement-sludge mixture was 96.4 %.

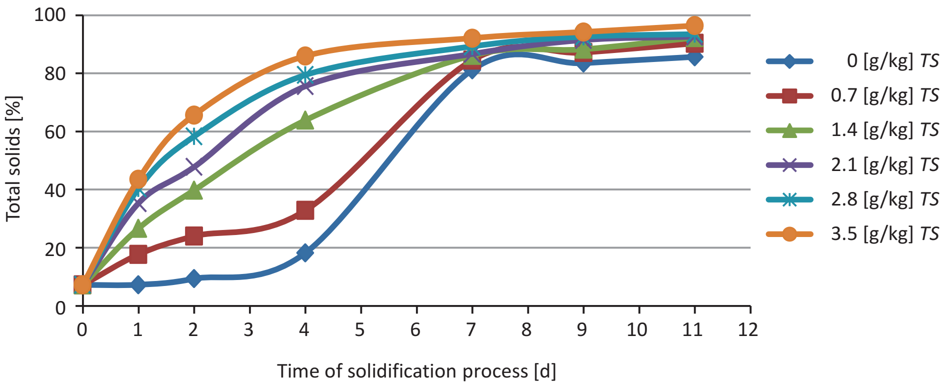

Fig. 5. Changes of the total solids during solidification with cement Gorkal G 40

Analyzing the obtained results of the research presented in Fig. 6 showing the process of maturing of the cement-sludge mixture (Gorkal 50 cement), it can be observed that after subsequent days, the total solids content increases, together with increasing the proportion of cement dose in the mixtures created. However, optimal time for the process is 7 days. On the 7th day of the process, in the case of 4 doses (1.4–3.5 g/kg *TS*), the content of total solids was obtained ranging from 90.2 % to

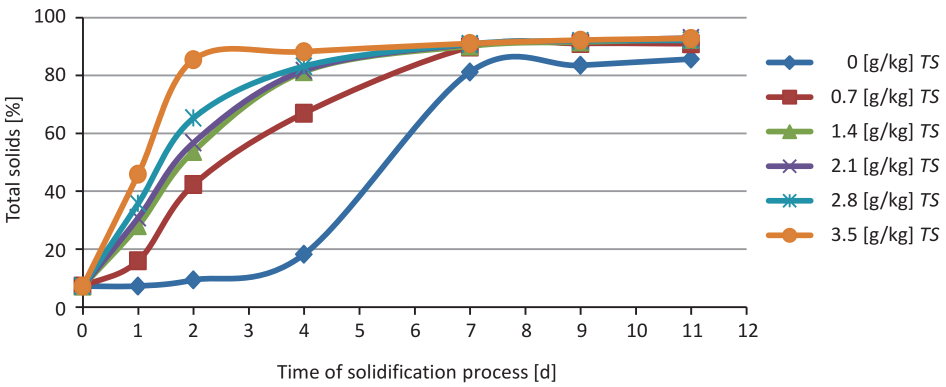

Fig. 6. Changes of the total solids during solidification with cement Gorkal G 50

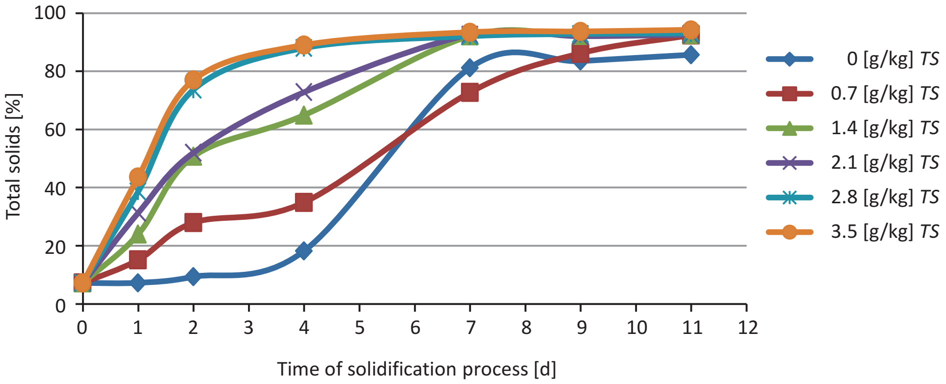

Fig. 7. Changes of the total solids during solidification with cement Gorkal G 70

91.0 %. The highest content of total solids was characteristic of the solidified sludge of 3.5 g/kg *TS* after 11 maturing days, which was 92.8 %.

Obtained results of tests for Gorkal 70 cement have been illustrated in Fig. 7. Processing time also affects the efficiency of the process. The dewatering process takes place most effectively between the 1th and 7th day. The content of total solids at the level from 92.1 % to 93.4 % was characteristic of solidified sludge for a doses from 1.4 g/kg *TS* to 3.5 g/kg *TS* on the 7th day of maturing. The highest content of total solids was characteristic of solidified sludge of 3.5 g/kg *TS* after 11 maturing days, which was 94.2 %.

Summary and conclusion

The processes of mechanical dewatering and solidification of post-coagulation sludge offer an effective method of final disposal. The sludge prior to dewatering should be subjected to conditioning process. This process improves the structure of the sludge and increases the amount of free water. The conditioning process was conducted based on different types of ion-polyelectrolytes for the constant dose of 2.6 g/kg *TS*. The test results have shown that the best outcome was obtained when the cationic polyelectrolyte Zetag 64 was used at the dose of 0.8 g/kg *TS*. The proper selection type and the dose of the polyelectrolyte improves the filter parameters of the sludge and increases its susceptibility to dewatering. The sludge conditioned with this polyelectrolytes was mechanically dewatered in a centrifuge. The centrifuged sludge was characterized by a relatively low concentration total solid of 7.1 %. The efficiency of dewatering process was affected by the rotational speed. The best results were obtained after 1 min at a speed of 3000 rpm.

The dewatered sludge was subjected to solidification tests. During the tests, quicklime and cement Gorkal 40, Gorkal 50 and Gorkal 70 were used as a solidifying material, in doses of 0.7; 1.4; 2.1; 2.8; 3.5 g/kg *TS*. The use of solidifying materials allowed to obtain a material with low hydration and high content of total solids. The content of total solids in the case of cement-sludge and lime-sludge mix after 7 days of maturation amounted to 84.5 – 92.1 % (Gorkal G 40) and 93.0 – 98.5 % respectively. When comparing the results, it can be observed that the use of quicklime for the solidification process allows for a higher content of total solids than for cements. The duration of the maturing process had a positive effect on the hydration of the resulting mixtures, which was reduced day by day. Also, increasing the dose of the solidifying material relative to the total solids resulted in an increase in concentration of total solids on particular days. In addition, it was observed that the solidification process in all cases was most effective in the first seven days. As a result of solidification and physical-chemical processes (immobilization of harmful substances), a health-safe granulate was obtained. This granulate, due to its compact and relatively durable structure, can be easily transported and loaded. In addition, it may be used as a building material for reconstruction of areas, construction of embankments and environmental acoustic screens.

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ZESTALANIE JAKO PROCES PRZERÓBKI OSADÓW POKOAGULACYJNYCH POCHODZĄCYCH ZE STACJI UZDATNIANIA WODY

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Abstrakt: W Stacjach Uzdatniania Wody (SUW) powierzchniowej powstają osady pokoagulacyjne. Stanowią one mieszaninę usuniętych z wody zanieczyszczeń oraz dodanych do niej koagulantów wykazując hydrofilowo-koloidalny charakter. Ponadto charakteryzują się wysokim uwodnieniem powyżej 99 %. SUW zobligowane są do wprowadzania rozwiązań umożliwiających optymalne gospodarowanie osadami. W związku z tym istotne jest poszukiwanie procesów, w wyniku których osady te mogłyby być ponownie wykorzystane lub ostatecznie unieszkodliwione. Przeprowadzono badania zestalania osadów pokoagulacyjnych. Proces zestalania polega na odpowiednim oraz szybkim mieszaniu osadu z użytym materiałem zestalającym, aby zapewnić odpowiednie warunki homogenizacji. Zastosowany reagent w wyniku szybkiej homogenizacji z osadem na skutek hydratacji, w procesie silnie egzotermicznym, pochłania wodę zawartą w osadach, której nadmiar odparowuje. Powoduje to zmniejszenie masy i objętości osadów i prowadzi do powstania granulatu. Podczas badań jako materiału zestalającego użyto wapna palonego oraz cementów Górkal 40, Górkal 50 i Górkal 70 w dawkach 0,7; 1,4; 2,1; 2,8; 3,5 g/kg sm. W trakcie procesu dojrzewania mieszaniny wapienno-osadowej oraz cementowo-osadowej sprawdzano zmiany stężenia suchej masy. Uzyskane wyniki badań wykazały, że zwiększenie dawki materiału zestalającego oraz wydłużenie czasu dojrzewania powoduje znaczny wzrost stężenia suchej masy mieszanin. Zmiana struktury i konsystencji osadów od plastycznej do stałej daje możliwość wykorzystania osadów jako materiału budowlanego, do rekultywacji wysypisk, utwardzania poboczy dróg czy tworzenia skarp i wałów.

Słowa kluczowe: osad pokoagulacyjny, kondycjonowanie, odwadnianie, zestalanie, unieszkodliwianie