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THE INFLUENCE OF MECHANICAL AND THERMAL DISINTEGRATION ON GRAVITATIONAL SEPARATION OF SURPLUS SLUDGE

WPŁYW DEZINTEGRACJI MECHANICZNEJ I TERMICZNEJ NA SEPARACJĘ GRAWITACYJNĄ OSADU NADMIERNEGO

Abstract: The primary effect of sewage sludge disintegration process is the physical, chemical or biological change of their structure, which causes destruction of flocs, fragmentation of microbial cells and thus release of cell contents into the surrounding liquid. Pre-treatment of the sludge can be used for the process of thickening and dewatering of sludge.

In this paper, the influence of hydrodynamic, microwave and freezing/thawing disintegration on selected properties of gravitational surplus activated sludge, were assessed. The scope of the research included the parameters characteristic of the sedimentation process, *ie* sludge density index (*SDI*), sludge volume index (*SVI*), sludge thickening speed (v), sludge concentration (C_i) and changes in the liquid phase of sludge chemical oxygen demand (*SCOD*) and turbidity.

The obtained results as well as performed calculations have confirmed the impact of used disintegration in terms of improving the properties of surplus activated sludge.

Keywords: hydrodynamic cavitation, microwave radiation, dry ice, surplus activated sludge, gravitational separation sludge

Introduction

Sludges are an inseparable element of each sewage treatment plant. They are created on different stages of a sewage treatment process line and they are a specific waste of the treatment processes. They are produced in primary settlement tanks – as the primary sludge and in secondary tanks – as the secondary sludge, they can be produced as a final product of chemical precipitation – as chemical sludge and also as a result of mixing of the primary sludge with a different one. However, they are always an essential technical problems due to large water content and mass as well as sanitary hazard. Recent

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regulations [1, 2] require the improvement of such unfavourable sludge properties by producers (sewage treatment plants).

Sludge thickening is a process of a technological line of sewage sludge in which separation of solids from liquids takes place. The sludge does not change its fluid consistency and an increase of dry weight sludge and reduction of its volume is obtained [3, 4]. Gravitation thickening takes place spontaneously in the devices called settlement tanks (primary, secondary, intermediate) or might be carried out in separate thickeners. These devices are thickening sludge in a continuous or periodic system.

Methods of sewage sludge pre-treatments are very expensive and time consuming and do not always give satisfactory results. A selection of an appropriate method of processing is necessary, while maintaining a relatively low investment and operating costs.

The main task of the sludge conditioning process is to transform its properties and composition to make thickening and drainage more effective.

Disintegration methods are processes of initial conditioning of sewage sludges. They are based on destroying flocs and rapture of microorganisms cells envelopes with the help of external forces and release of intracellular substance into the liquid phase of the sludge [5]. They are used mainly to improve efficiency of biological degradation processes, reduce a phenomenon of foaming, sludge swelling and lowering of sludge volume index.

The applied and tested disintegration methods include, the following: mechanical [6, 7], chemical [8, 9], biological [10], thermal [11, 12] and hybrid [13].

The article describes the influence of the applied disintegration methods – hydrodynamic cavitation, microwaves and dry ice, on gravitational separation of the surplus activated sludge.

Hydrodynamic cavitation results in formation of cavities (bubbles) filled with a vapour-gas mixture inside the flowing liquid, or at the boundary of a constriction devices due to rapid local pressure drop. Subsequently, the pressure recovers down the constriction (valve or nozzle) and causes cavities to collapse. The collapse of cavitation bubbles is defined as implosion and the forces associated with results in mechanical and physique-chemical effects. The physical effects include the production of shear forces, shock waves, generating local high temperatures and pressures, whereas the chemical effects result into the generation of radicals *eg* formation of reactive hydrogen atoms and hydroxyl radicals which can recombine to form hydrogen peroxide [14–16].

One of the sewage sludge disintegration methods is the usage of microwaves. Microwaves are a form of electromagnetic radiation with wavelengths ranging from one meter to one millimeter; with frequencies between 300 MHz (100 cm) and 300 GHz (0.1 cm) [17]. Some materials can absorb microwaves. Materials which absorb the energy of microwaves are heated. This is a property of dielectric substances, for example of water. In dielectrics, microwaves cause a dipole polarization. Dielectrics have a dipole structure, this causes rotation of the molecules. Microwaves vary from other electromagnetic waves in the fact that they generate the molecular move in the alternating electric field without breaking the stability of chemical bonds. The energy carried by the microwave radiation is considerably smaller than the energy of a chemical bond decay. Electromagnetic waves undergo all physical phenomena that are characteristic for wave motion [18, 19]. They can be transmitted or absorbed and also undergo reflection, refraction, deflection, interference and polarisation. Microwave radiation can be absorbed by matter through dipolar polarisation (dielectric), which is responsible for the microwave heating effect and through ionic conductivity.

Another method of sewage sludge disintegration is freezing/thawing. Several conceptual models have been developed to describe the interaction between the ice and sludge particles during freezing [20]. When the ice front approaches sludge flocs, it also pushes the flocs at a certain speed. Depending on the freezing rate and other factors, the flocs are entrapped in ice or pushed ahead of the ice front. Once the flocs is trapped in the ice, dewatering process initiates, resulting in releasing of bound water (dehydration) and more compacted sludge particles [20, 21]. On the other hand, advancing flocs ahead of the ice front results in the thickening of flocs [21]. Moreover, water freezing in microorganisms is caused break-up of cells walls and release to liquid phase organic/inorganic matter [22].

Materials and methods

The research material was surplus activated sludge (from the secondary settling tank) with a concentration of dry solid – in average – 11.81 g $\cdot$ dm^{-3}. Sewage sludge samples were taken from a large municipal waste water treatment plant in Silesia region. Wastewater treatment plant uses advanced processes simultaneously, biological removal of carbon compounds of nitrogen and phosphorus (*EBNR* – Enhanced Biological Nutrients Removal). The treatment plant was designed for the flow of 12 000 m^3 $\cdot$ d^{-1}. For the time being, the amount of flowing sewage is ca. 90 000 m^3 $\cdot$ d^{-1}, solid retention time ca. 14 days and concentration of activated sludge in the bioreactor 4.32–4.64 mg $\cdot$ dm^{-3}.

Disintegration methods of sewage sludge – the disintegration by hydrodynamic cavitation

The sample of surplus activated sludge (volume 25 dm^3) was treated by hydrodynamic cavitation. The experimental set up consisted of a 1 200 000 Pa pressure pump, rating 0.54 kWh, output 500 dm^3 $\cdot$ h^{-1}, which recirculated sludge from a container, through a 1.2 mm cavitation nozzle. The process was carried out for 15, 30, 45 and 60 minutes, which corresponded to 3, 6, 9 and 12 multiplicity flow by the cavitation nozzle.

The disintegration by microwave radiation

The sample of surplus activated sludge with the volume of 5 dm^3 was subjected to the microwave destruction. Disintegration process was carried by the frequency of microwaves 2.45 GHz and nominal power 900 W. Disintegration was carried out over periods of 30, 60, 90 and 120 seconds.

Such a short time resulted from avoiding the thermal (boiling) effect which is rising at longer acting of microwaves.

The disintegration by freezing/thawing

Dry ice, sometimes referred to as "cardice" or as "card ice", is the solid form of carbon dioxide. It is used primarily as a cooling agent. At pressures below 519 797.25 Pa and temperatures below 217.15 K (the triple point), CO_2 changes from a solid to a gas with no intervening liquid form, through a process called sublimation. The opposite process is called deposition, where CO_2 changes from the gas to solid phase (dry ice). At atmospheric pressure, sublimation/deposition occurs at 195.15 K. The density of dry ice varies, but usually ranges between about 1.4 and 1.6 $g \cdot cm^{-3}$ [23].

For disintegration of surplus activated sludge (1 dm^3), the following volume ratios of the surplus sludge to dry ice were used, *ie* 1 : 0.25; 1 : 0.5; 1 : 0.75; 1 : 1.

Sewage sludge at room temperature mixed with a certain volume of dry ice. The samples were then thawed at room temperature until completely dry ice sublimate.

Analytical method

All chemical analyses were performed for samples before and after each phase of disintegration. Soluble Chemical Oxygen Demand (*SCOD*) value and turbidity value were determined according to the procedures given in the Standard Methods for Examination of Water and Wastewater [24].

In the taken samples of surplus activated sludge content of suspended solids (*SS*) were determined according to the Wastewater Engineering Treatment and Reuse [25].

$$X = \frac{(a-b)\cdot 1000}{c} \tag{1}$$

where: X – dry weight sludge [$g \cdot dm^{-3}$];
a – weight of the crucible with the dried sludge [g];
b – weight of the crucible without sludge [g];
c – sludge weight used for the test [g].

For colorimetric determinations, a spectrophotometer HACH DR5000 was applied. Chemical analyses were measured for samples before and after each time of disintegration (microwave, hydrodynamic process) and for each volume ratio of sludge to dry ice.

The results here presented were performed 10 times, arithmetic average was calculated. The standard deviation was determined according to the estimator of the highest credibility in STATISTICA 6.0.

Sludge density index (*SDI*), sludge volume index (*SVI*), surplus activated sludge thickening speed (*v*) and concentration of sludge (C_i)

The scope of the study included determining the sedimentation kinetics based on the curves of sludge falling and thickening speed. Kynch's theorem was applied here, which says that the falling speed of sludge particles is a function of suspension concentration in immediate vicinity [26].

Sludges sedimentation has been observed in cylinders of $V = 1000$ cm^3 capacity and cross-sectional area of $F = 26.4$ cm^2.

The following calculations have been made in the sludge samples, both in control ones and those subjected to the process of disintegration, based on Tchobanoglous et al [25]:

Sludge density index (*SDI*) – Donaldson index [g · cm^{-3}], based on the following formula:

$$SDI = \frac{m}{V \cdot 10} \tag{2}$$

where: m – mass of total suspensions in a sample [g · dm^{-3}];
V – volume of sludge read after 30 minutes of sedimentation of a sample of 1000 cm^3 volume [cm^3 · dm^{-3}].

Sludge volume index (*SVI*) – Mohlman index [cm^3 · g^{-1}], based on the following formula:

$$SVI = \frac{1}{SDI} \tag{3}$$

Sludge thickening speed (*v*) [mm · min^{-1}], based on the following formula:

$$v = \frac{v_r - v_n}{t_n} \tag{4}$$

where: v_r – sludge column height in sedimentation process 400 [mm];
v_n – sludge volume for "n" sedimentation time [mm];
t_n – sedimentation time [s].

Sludge concentration (C_i) [$g_{d.w.}$ · dm^{-3}] **and thickening time (t_i),** based on the following formula:

$$C_i = \frac{c_0 \cdot h_0}{h_i + v_i \cdot t_i} \tag{5}$$

where: c_0 – dry mass concentration [$g_{d.w.}$ · dm^{-3}];
h_0 – initial height of the sludge layer [cm];
v_i – falling speed in the $h_i$point [cm · min^{-1}];
t_i – any falling time [min];
h_i – height of the sediment layer after t_i time [cm].

Results and discussions

Sewage sludges, after the process of sewage treatment contain form 97 to 99.5% of water [3]. During thickening of sewage sludges, the dry mass content in the sludges is increased as a result of sedimentation of sludge particles and their compression due to the influence of gravity and is followed by a reduction of free water content. This results in a reduction of their volume. Sewage sludges thickening can be treated either as pre-processing before fermentation or as initial processing before dehydration in a sewage treatment plant, which does not use anaerobic stabilization.

In the framework of research, various methods that can be applied to improve gravitational properties, are needed.

The aim of a disintegration method used (hydrodynamic cavitation, electromagnetic radiation, freezing/thawing) was to destroy the structure of flocs and microorganisms of the surplus activated sludge [16, 27, 28].

The studies conducted showed the effectiveness of the applied hydrodynamic cavitation and electromagnetic field depends mainly on the amount of operation time. While the effectiveness decomposition of surplus activated sludge by dry ice depended on the used value relationship: sludge to dry ice.

A measure of effectiveness of disintegration methods was organic matter release from a solid into a liquid phase of sludge, as well as an increase in turbidity of the sludge liquid. Releasing of organic substances, expressed in the value of *SCOD* and turbidity of liquid phases show the effectiveness of destroying flocs and microorganisms of the sludge.

After a 60-min of disintegration by hydrodynamic cavitation the *SCOD* values in sludge liquidphase changed from 63 mg $O_2 \cdot dm^{-3}$ to 2248 mg $O_2 \cdot dm^{-3}$ (Fig. 1). The microwave radiation and destruction with dry ice caused an increase of the *SCOD* value of about 549 mg $O_2 \cdot dm^{-3}$ and 840 mg $O_2 \cdot dm^{-3}$, respectively (Figs. 2–3).

Similar results of using microwaves received Grubel and Machnicka [17].

Many researchers examined release of the organic matter during the destruction of the flocs and microorganisms by freezing/thawing. The crystallization of intra-aggregate moisture was claimed to be responsible for the damage of cell membranes and release of intracellular substances to the surroundings. Release of organic matter in the process of freezing was examined by Hu et al [29]. They obtained more than 15% increase of *SCOD* value. This level of solubilization is comparable to that from sewage sludge sample treated at $100^{o}C$ for 30 min [30] and with 0.8 $W \cdot cm^{-3}$ of ultrasonication for 5 min [31].

The methods of mechanical and thermal disintegration causing microbiological destruction of the structure of flocs contributed to the increase of turbidity of a liquid phase of a sludge, mainly due to the release of intracellular substance and extracellular polymers. The supernatant turbidity of the surplus activated sludge amounted to 10 NTU (Figs. 1–3). Upon the process of hydrodynamic (60 min), microwave (120 s) and dry ice (the volume ratio of sludge to dry ice of 1 : 1) disintegration, the turbidity increased by 258 NTU (Fig. 1), 17 NTU (Fig. 2) and 101 NTU (Fig. 3), respectively.

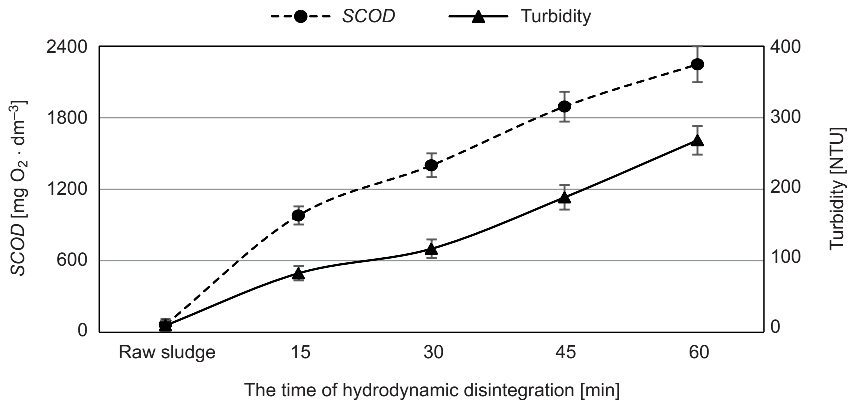

Fig. 1. The change of the *SCOD* value and supernatant turbidity during hydrodynamic disintegration

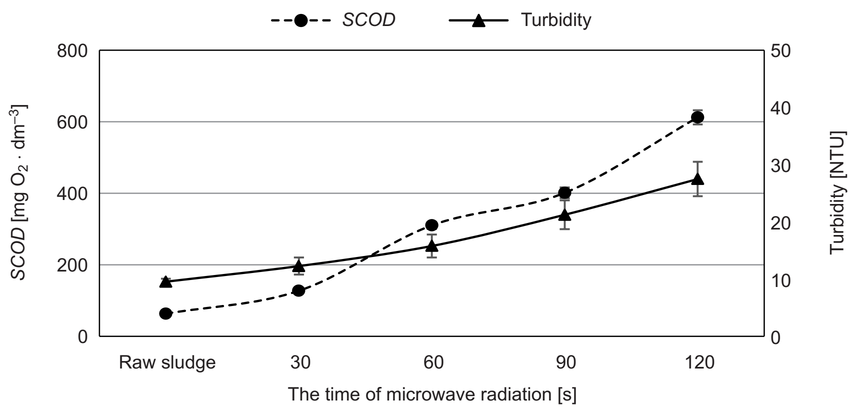

Fig. 2. The change of the *SCOD* value and supernatant turbidity during microwave disintegration

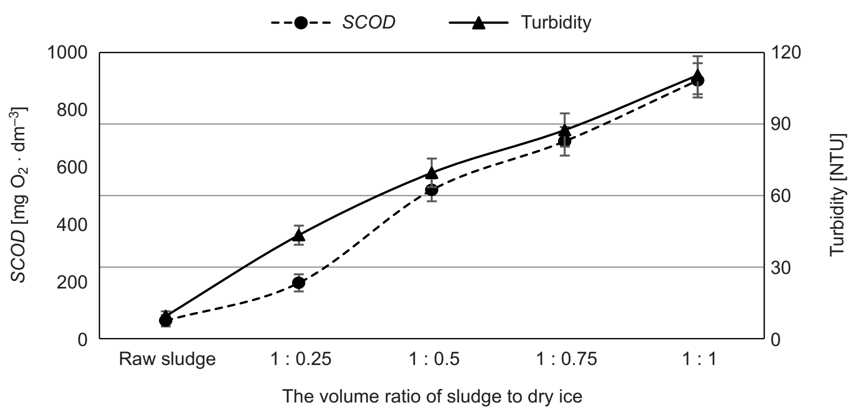

Fig. 3. The change of the *SCOD* value and supernatant turbidity duringfreezing/thawing disintegration

Interaction of electromagnetic field, hydrodynamic cavitation and low temperature on the surplus activated sludge resulted in changes of *SDI* and *SVI* in comparison to the sample of sludge, which has not been subjected to disintegration. *SDI* is defined as a mass of total suspension expressed in grams in the volume of 100 cm^3 of sludge subjected to a 30 min of sedimentation process [32]. However *SVI*, *ie* Mohlman's index, is the inverse of the Donaldson's index. It is defined as the volume (in cm^3) occupied by 1 gram of activated sludge after settling the aerated liquor for 30 min [32]. The change in the value of *SDI* and *SVI* depended on the applied action time of hydrodynamic cavitation and microwaves as well as the volume ratio of the sludge to dry ice (Figs. 4, 5).

SDI increased by 1.65 $g \cdot cm^{-3}$, 0.32 $g \cdot cm^{-3}$ and 1.17 $g \cdot cm^{-3}$ for surplus activated sludge disintegration with hydrodynamic cavitation (60 min), microwaves (120 s) and thermal disintegration (the volume ratio of sludge to dry ice of 1 : 1), respectively (Fig. 4). A disruptive action of the applied sludge conditioning methods decreased the value of *SVI*. The action of hydrodynamic cavitation on the sludge caused the biggest change in the value of *SVI* in comparison to the influence of magnetic field and freezing/thawing (Fig. 5). In case of a sludge disintegrated with a hydrodynamic cavitation within 60 min, the value of *SVI* amounted to 39 $cm^3 \cdot g^{-1}$ (Fig. 5). Reduction in the index value below 100 $cm^3 \cdot g^{-1}$ (Fig. 5) shows a high ability of surplus activated sludge to dehydration as a result of conditioning processes used.

Destruction (mechanical and thermal) of flocs and microorganisms of the surplus activated sludge caused changes in its structure and properties. The release of fixed water and biologically fixed water appeared, which contributed to faster dewatering and better thickening of the sludge.

Another parameter that was calculated was the thickening speed (v) of the activated sludge depending on the time of exposure of surplus activated sludge to applied

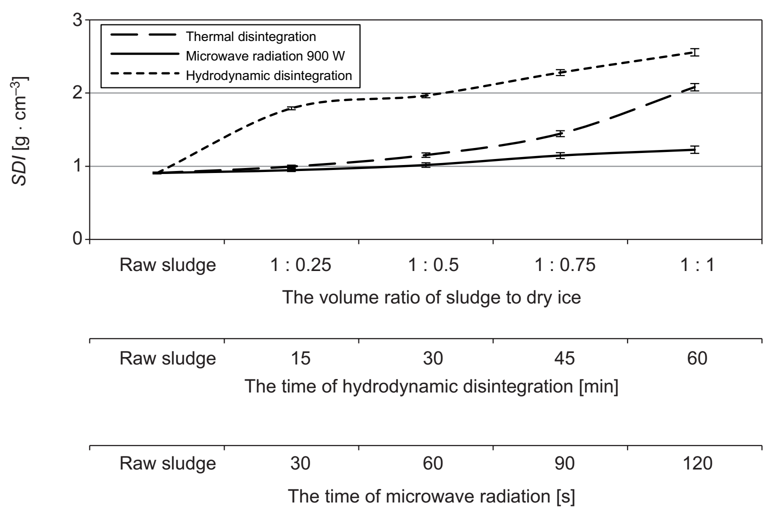

Fig. 4. The change of *SDI* during hydrodynamic, microwave and freezing/thawing disintegration

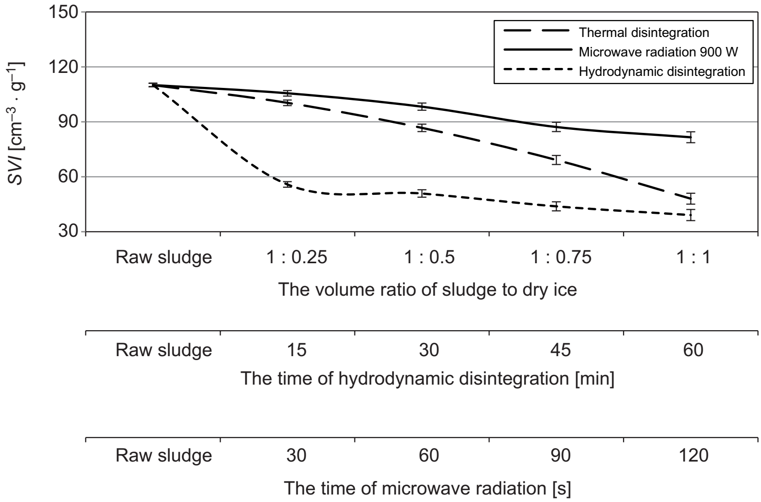

Fig. 5. Change of *SVI* during hydrodynamic, microwave and freezing/thawing disintegration

mechanical disintegration and volume ratio of sludge to dry ice. It is one of the most important parameters of assessing the sludge thickening process. Sludge thickening speed (v) is a process of particles falling of a solid in liquid by the action of gravity and inertia forces. A necessary condition for the occurrence of the phenomenon is the difference in density of solid and liquid. In case of gravitational separation, zonal falling matters. This type of falling is characteristic for flocculating suspensions or non-flocculating suspension but with a very high concentration [32]. Changes of thickening speed (v) of the surplus activated sludge under the influence of preparing with hydrodynamic cavitation, microwaves and thermal are presented in Figs. 6–8. An intensive increase in sludge thickening speed (v) of disintegrated sludge takes place in the first 5 minutes of sedimentation. It was connected with an earlier destruction of flocs and then their flocculation, formation of aggregates of higher density and lower porosity in respect to sludge deposits before disintegration.

Similar results of increase of a sedimentation phase (falling speed) of sewage sludge for thermal disintegration have been obtained by Hu at al [29] and Bien [33] for ultrasonic disintegration.

Changes in concentration of sludge mass depending on the time of sedimentation are presented in Figs. 9–11.

The initial dry weight of sludge without disintegration was 8.35 g · dm^{-3}, and after 30 min sedimentation value was 8.95 $g_{d.w.} \cdot dm^{-3}$. On the basis of obtained results and calculations, sludge concentration (C_i) increases with the time of exposure to a disintegration method (Figs. 9–11). After disintegration of the surplus activated sludge in a hydrodynamic process (60 min), obtained sludge concentration (C_i) increase from 8.57 $g_{d.w.}$ to 23.74 $g_{d.w.} \cdot dm^{-3}$, after microwave disintegration to 12.10 $g_{d.w.} \cdot dm^{-3}$, and after thermal disintegration to 19.77 $g_{d.w.} \cdot dm^{-3}$. The concentration of sludge which has not been subjected to disintegration changes definitely less intensively. Extending the

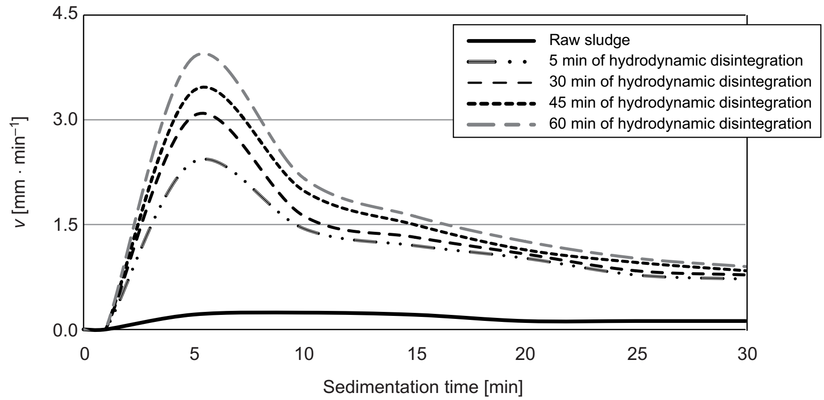

Fig. 6. Sludge thickening speed (v) during hydrodynamic disintegration

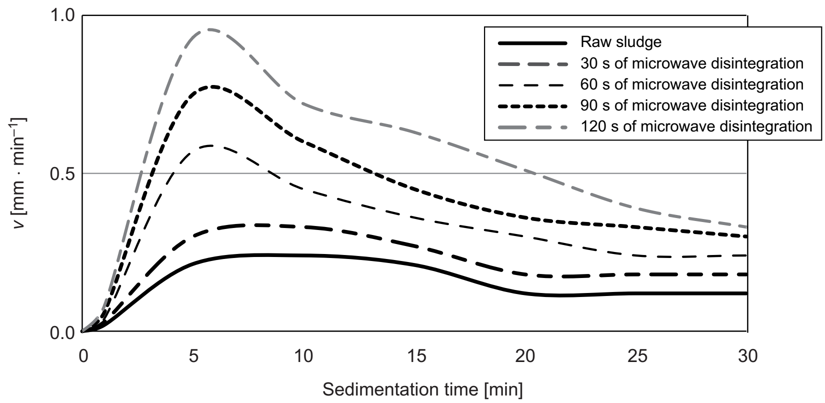

Fig. 7. Sludge thickening speed (v) during microwave disintegration

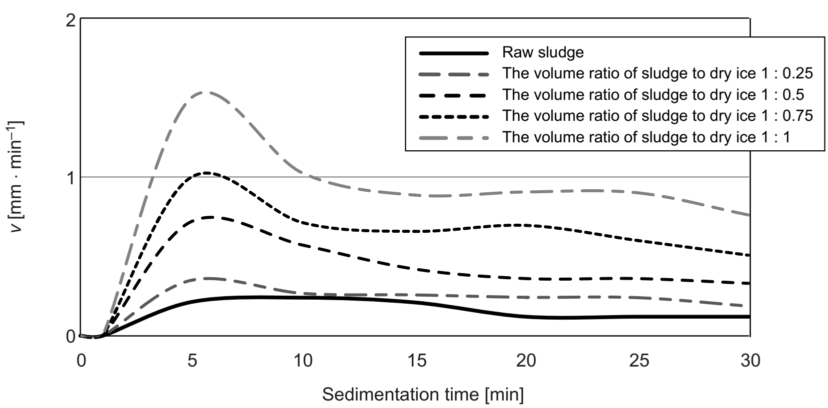

Fig. 8. Sludge thickening speed (v) during disintegration with dry ice

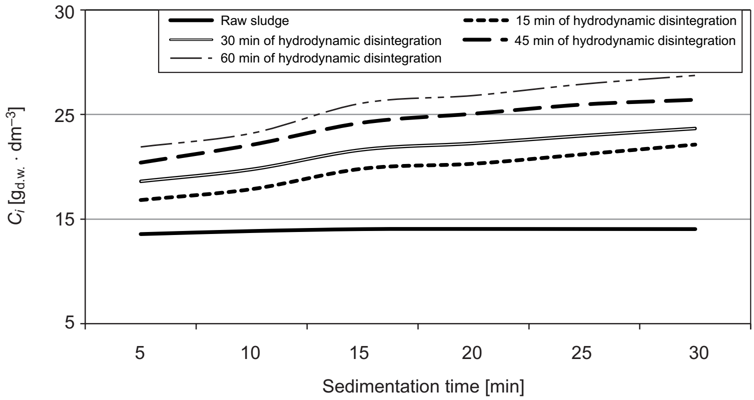

Fig. 9. Changes of sludge concentration (C_i) during hydrodynamic disintegration

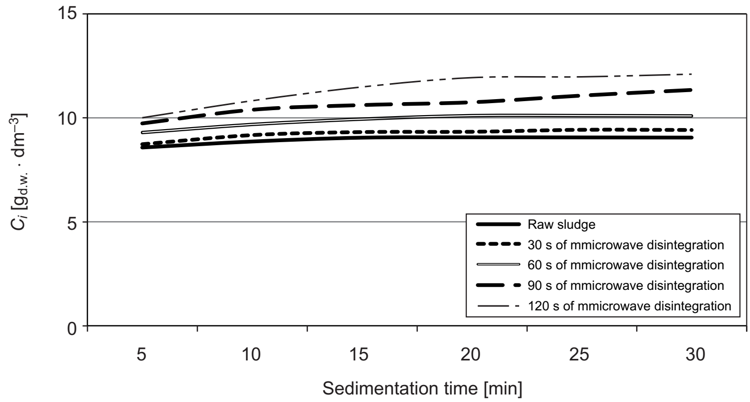

Fig. 10. Changes of sludge concentration (C_i) during microwave disintegration

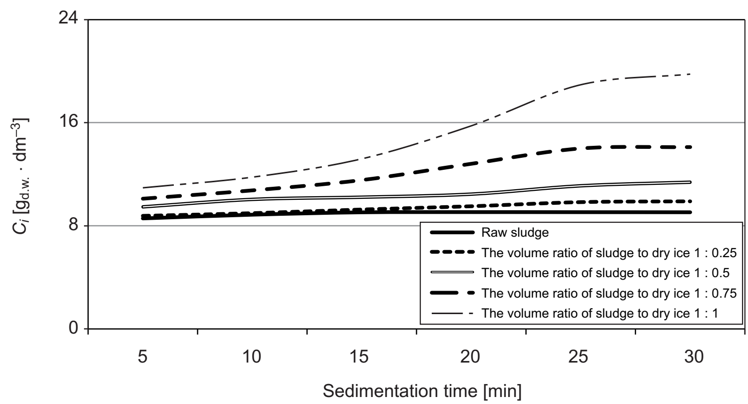

Fig. 11. Changes of sludge concentration (C_i) during disintegration by dry ice

duration of disintegration and increasing the volume ratio of sludge to dry ice, causing destruction of flocs and cytoplasmic membrane and/or cell wall of microorganisms, to faster water release during thickening as well as connecting previously fragmented flocs into larger aggregates. Water in the sewage sludge is present in free and bound water (free water, colloid water, capillary water, biological water). Free water is bound to sludge fractions. Can be separated from the sludge *eg* thickening of gravity. Colloid water is more difficult to separate. This water is related to the sludge particles, the forces of surface tension. This water can be removed only after the destruction of the structure flocs sludge. Capillary water is related to the forces of adhesion and cohesion (is removed, *eg* by centrifugation or drying). However, biological water is removed by destroying the cell covers (*eg* the methods of disintegration).

In the process with the use of hydrodynamic cavitation, the destruction of flocs and consistent structure of microorganisms cells – disrupt/lysis – took place by an increase in the speed of flow of disintegrated medium caused by reducing the cross-sectional area of the stream (the use of cavitation nozzle with a spraying angle of 0^o and a diameter of 1.2 mm). As a consequence, this caused local pressure drop of liquid (sewage sludge) to a boiling pressure. Dynamic pressure field of the liquid caused the phenomenon of mechanical cavitation associated with creation, zooming and vanishing of bubbles or other closed areas (caverns) containing a few liquids (a sewage sludge), gas or steam-gas mixture. Implosion of cavitation bubbles caused [34–36] high mechanical cutting (shearing) stress, which was so large that not only the biological phase of the sludge might have been destroyed, but even the solid structures.

The direct effect of any kind of radiation on a living cell is determined by its absorption, whereas the cellular components absorb waves of specific lengths. Microwave radiation is most effectively absorbed in the scope of wave of 10^{-3} m length [37]. Therefore, the effective application of microwave energy depends mainly on the time of its action (a radiation dose).

The process of freezing with dry ice/thawing was also the cause of destruction of flocs structure of the sludge and "cold" death of microorganisms caused by a group of factors such as: freezing and thawing speed, chemical composition of the living environment, a species of bacteria, time of freezing, temperature. However, mechanical destruction of the cells is done with the use of ice crystals, which tears them from the inside or damage them from the outside [38]. Microorganisms killed as a result of freezing/\thawing, lose their cellular components to the ground (environment). The greatest sensitivity to cold shock is shown mainly by Gram-negative bacteria and those which are in the logarithmic phase of growth. Their survival rate decreases by 10 000 times [37]. Gram-positive and Gram-negative bacteria (*eg Clostridium* sp. or *Salmonella* sp.) are common throughout the sewage sludge. Gram-negative bacteria are more vulnerable to adverse factors (physical, mechanical, chemical) such as, for instance: cavitation, microwave radiation or freezing than Gram-positive bacteria. These differences are explained by the chemical structure of the cell wall and primarily by the lower-concentration of peptidoglycan (murein) in these bacteria.

The test results obtained confirm a beneficial effect of an analysed methods of disintegration (hydrodynamic, microwave and thermal cavitation) on selected gravitational properties of the surplus activated sludge. Extending the duration of disintegration of mechanical processes and increasing the volume of dry ice to the surplus activated sludge results in elimination of expanding (volume decrease) and a change of sedimentation properties in relation to the disintegrated sludge.

However, an increase in turbidity of a liquid phase reveals effectiveness of disintegration but, at the same time, this means that a part of suspensions is suspended in the supernatant liquor. A load of suspensions in a sludge liquid might in a certain extent adversely affect gravitational separation of the sludge. There is, in fact, the probability of physical property changes due to negative modifications of solid particles and liquid-solid influences.

Conclusions

1. The disintegration of surplus activated sludge by means of hydrodynamic cavitation, microwave radiation and freezing/thawing treatment results in changing the state of organic matter from solid sediment to liquid (expressed as *SCOD*). *SCOD* increased from 63 mg $O_2 \cdot dm^{-3}$ to 2248 mg $O_2 \cdot dm^{-3}$ after 60 min of exposure to the hydrodynamic cavitation, 298 mg $O_2 \cdot dm^{-3}$ after 120 seconds of exposure to the microwave radiation and 749 mg $O_2 \cdot dm^{-3}$ for the volume ratio of dry ice to surplus activated sludge 1 : 1.

2. The sewage sludge conditioning processes have resulted in the turbidity increase of a liquid phase: hydrodynamic cavitation – 27 times, microwaves – 3 times and freezing/thawing – 11 times.

3. The disintegration of surplus activated sludge with mechanical methods and a thermal method caused, depending on the time of action and the volume ratio of sludge to dry ice, changes in its sedimentation parameters:

– an increase in the value of *SDI* (in relation to raw surplus activated sludge) amounted to 2.56 g $\cdot$ cm^{-3} for hydrodynamic disintegration, 1.23 g $\cdot$ cm^{-3} for electromagnetic field interaction and 2.08 g $\cdot$ cm^{-3} for the thermal process;

– *SVI* was reduced by 65% in case of hydrodynamic cavitation, by 26% in case of microwaves and 56% in case of freezing/thawing;

– an intensive increase of sludge thickening speed (v) of disintegrated sludge (hydrodynamicdisintegration, microwave radiation, freezing/thawing) takes place in the first 5 minutes of sedimentation;

– the concentration of the sludge (C_i) mass changes depending on the time of sedimentation. After disintegration of the surplus sludge in a hydrodynamic process (60 min), the sludge concentration (C_i) obtained amounted to 23.74 $g_{d.w.} \cdot dm^{-3}$ and after microwave disintegration to 12.10 $g_{d.w.} \cdot dm^{-3}$ and after thermal disintegration to 19.77 $g_{d.w.} \cdot dm^{-3}$.

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WPŁYW DEZINTEGRACJI MECHANICZNEJ I TERMICZNEJ NA SEPARACJĘ GRAWITACYJNĄ OSADU NADMIERNEGO

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Abstrakt: Podstawowym efektem procesu dezintegracji osadów ściekowych jest fizyczna, chemiczna lub biologiczna przemiana ich struktury, która powoduje destrukcję kłaczków, fragmentację komórek mikroorganizmów, a przez to uwolnienie treści komórkowej do otaczającej cieczy. Tak spreparowany osad może być wykorzystany w ciągu technologicznym przeróbki osadów, m.in. w procesach zagęszczania i odwadniania osadów ściekowych.

W niniejszej pracy przedstawiono wpływ dezintegracji hydrodynamicznej, mikrofalowej i termicznej na wybrane własności grawitacyjne osadu czynnego nadmiernego. Zakres badań obejmował parametry charakterystyczne dla procesu sedymentacji, tj. I.G.O., I.O.O., prędkość zagęszczania osadu, stężenie osadu oraz zmiany zachodzące w fazie płynnej osadu ($ChZT_{Cr}$ i mętność).

Uzyskane wyniki badań oraz przeprowadzone obliczenia potwierdziły wpływ zastosowanych metod dezintegracji na poprawę własności grawitacyjnych osadu czynnego nadmiernego.

Słowa kluczowe: kawitacja hydrodynamiczna, pole elektromagnetyczne, suchy lód, osad czynny nadmierny, własności grawitacyjne osadu