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Disintegrating Influence of Sonication on the Excess Sludge Liquification and their Microbiological Indicator

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1. Introduction

Sewage sludge is created at various stages of wastewater treatment as a result of physical, chemical and biological processes. Due to the sanitary hazard and high degree of hydration, they are treated as hazardous waste and require proper management (Wolski, & Małkowski 2014, Wolski 2016, Podedworna & Umiejewska 2008). The variety of chemical composition and different properties of sewage sludge impose the necessity of applying various technological solutions during the disposal and processing of sewage sludge (Pietraszek & Podedworna 1990, Wolski, & Wolny 2011). As part of the activated sludge stream, excess sludge is directed in the technological process of wastewater treatment to separate closed fermentation chambers. This sludge is formed as a result of the growth of microorganisms during the removal of dissolved and colloidal pollutants from sewage. Depending on the applied treatment methods, excess sludge contain about 97% of water and from 30% to 50% of mineral substances. In addition, they are characterized by a large number of facultative bacteria, which affects their low susceptibility to degradation under anaerobic conditions. The application of a properly selected disintegration technique before the stabilization process contributes to the destruction of the structure of sludge, the breakdown of cell membranes of microorganisms and the release of intracellular substances into the supernatant liquid, and thus the initiation and increase of biological degradation (Podedworna & Umiejewska 2008, Zhang et al. 2007) As a result of this process, the organic components of the cell become potentially available as a substrate of the living heterotrophic mass. The released organic compounds contained in the sludge are easier to undergo anaerobic stabilization processes. This has the effect of shortening the hydrolytic phase of methane fermentation and accelerating and intensifying the processes taking place in subsequent phases.

The introduction of disintegration techniques also causes an increase in the degree of dry organic matter reduction, and also influences the intensification of biogas production during methane fermentation (Wójtowicz 2006, Bień 2005). According to Penaud and others (Penaud 1999) in the case of disintegration conditions considered optimal, the highest percentage of soluble chemical oxygen demand (SCOD) in total chemical oxygen demand (TCOD) of the substrate should be obtained. However, complex hard-decomposition compounds may form under certain conditions. Consequently, the optimal conditions determined to obtain the SCOD maximum may be different from those that are appropriate to achieve the highest biodegradability of the substrate.

The criterion for the effectiveness of disintegration is the increase in the content of organic matter in the supernatant liquid expressed in the value of SCOD and the disintegration degree of sludge. The use of disintegration methods prior to the methane fermentation process contributes to an increase in the amount of hydrolysates rich in soluble fractions of chemical oxygen demand (Zielewicz-Madej, 2001, Bień & Szparkowska 2004). The use of ultrasonic technology in anaerobic stabilization of sewage sludge leads to the improvement of the sedimentation properties of the digested sludge, increased enzyme activity, metabolic intensification, increased organic matter decomposition and biogas production (Wolny & Kamizela 2003). The use of ultrasonic techniques in the sewage economy requires the optimization of operational parameters such as: frequency, vibration amplitude, wave intensity, input energy and duration of impact (Zielewicz et al. 2008, Kidak et al. 2009, Nanzai et al. 2009). According to Tiehm et al. (Tiehm et al. 1997), the use of ultrasound at 31 kHz prior to the stabilization process contributes to shortening the duration of methane fermentation and leads to increased biogas production intensity. Conducting research in the frequency range of 10-30 kHz and with increasing ultrasound power values, the highest degree of disintegration was recorded at 30 kHz (Zielewicz- Madej & Fukas – Płonka 2002). The most intensive process took place with low frequency values of around 20 kHz. Gonze et al. (Gonze et al. 2003) showed that the operation of ultrasonic field with low frequency and high intensity ultrasonic field affects the effective breakdown of sludge particles and degradation of microbial cells, leading to a clear modification of the structure of sludge. In the initial stage of sonication, no significant changes are observed in the structure of sludge. The short duration of ultrasound action causes scattering of the sludge flocs, without disturbing the cell structure. As a result of the longer action of the ultrasonic field, permanent damage to the cells of microorganisms contained in the sludge occurs. Cichowicz (Cichowicz 2007) reports that sowing of sewage sludge in a short time, a high-power ultrasonic field, results in higher efficiency of sludge biodegradation than the use of ultrasonic field of low power and long duration of ultrasound.

The phenomenon of ultrasonic cavitation is also used for hygienization of sewage sludge.

The aim of the study was to determine the disintegrating influence of sonication on the excess sludge liquification expressed as the increase in the soluble chemical oxygen demand (SCOD). value of the modified excess sludge as well as estimating of the microbiological indicators of sonicated sludge.

2. Experimental part

2.1. Substrate

Excess sludge, sampled from the municipal wastewater treatment plant with a capacity of 90 000 m^3d^{-1}, was the main substrate of the research. The characteristics of selected physico-chemical parameters of excess sludge are presented in Table 1.

Table1. Selected physico-chemical parameters of excess sludge

Indicators	Excess sludge
Total Solids (TS)	11.29 g L^{-1}
Volatile Suspended Solids (VSS)	8.02 g L^{-1}
Soluble Chemical Oxygen Demand (SCOD)	132 mg O_2 L^{-1}

Microbiological analyzes performed for non-modified and disintegrated sludge concerned the number of mesophilic and psychrophilic microorganisms, *Salmonella spp* bacteria and *Escherichia coli* type bacteria, which is a pathogenic species. The characteristics of selected groups of microorganisms of excess sludge are presented in Table 2.

Table 2. Markings of selected groups of excess sludge microorganisms

Microbiological indicators	Excess sludge
Mesophilic microorganisms, JTK/cm^3	$30{\cdot}10^4$
Psychrophilic microorganisms, JTK/cm^3	$80{\cdot}10^4$
Type of bacteria *Escherichia coli*, count	10^{-5}
Salmonella spp	*it was not isolated*

2.2. Methodology

During the first stage of research, the process of excess sludge disintegration was carried out. The most favorable conditions for the sludge sonication were determined, i.e. disintegration time and the value of ultrasonic field vibration amplitude. While in the next stage the process of conventional methane fermentation and methane fermentation of sludge modified by ultrasonic field was conducted (Fig. 1).

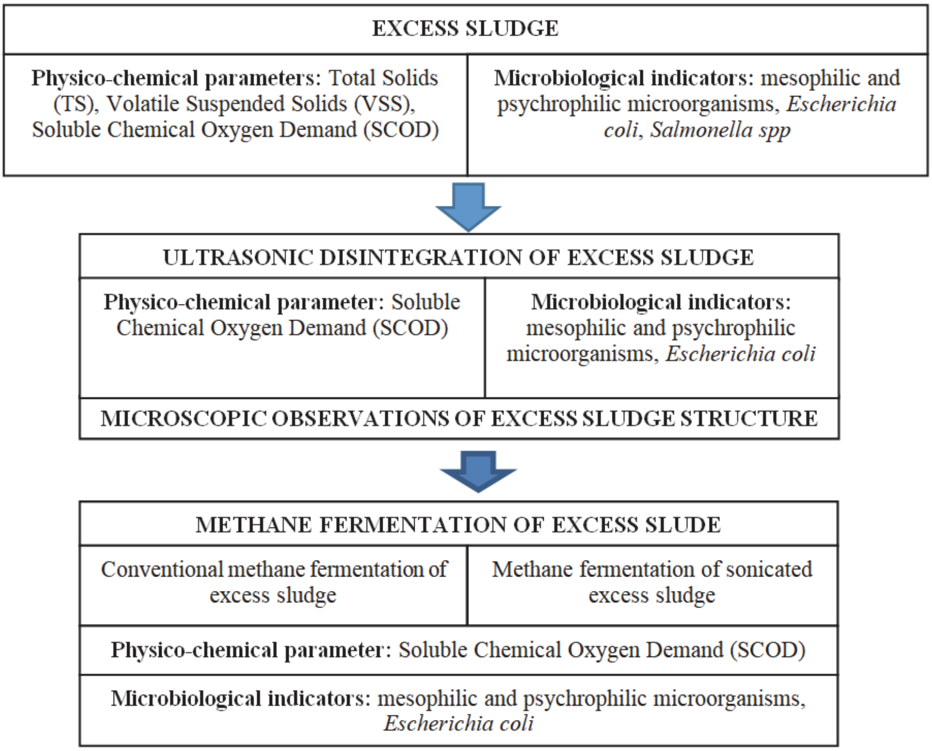


Fig. 1. Diagram showing the stages of research

In the study the following physico-chemical parameters were made: the volatile suspended solids (VSS) (PN-EN-12879) and soluble chemical oxygen demand (SCOD) by dichromate method, using a colorimetric spectrophotometer Hach Dr 400 (PN-EN ISO 7027).

In the case of microbiological analysis a solid medium called nutrient agar was used for the cultivation of mesophilic and psychrophilic microorganisms. For the *Escherichia coli* culture, however, the Eijkmana liquid medium was used and, in order to confirm the presence of microorganisms, the culture was performed on a permanent Endo medium. Salmonella - Shigella (SS) agar medium was used to detect *Salmonella spp*. Before starting the tests, a series of dilutions from 10^{-8} to 10^{-1} were prepared from the collected sludge samples.

The process of disintegration of excess sludge with the ultrasonic field was carried out with the use of a disintegrator type UD-20 produced by "Techpan" with a vibration frequency of 22 kHz and a maximum output power of 180 W. The energy of electric vibrations using a transducer was transformed in the system into the energy of mechanical vibrations, and then, via the sonotrode, transferred to the tested system in the form of an acoustic wave. Disintegration was carried out in glass vessels in a non-flow system. The active volume of the excess sludge was 0.5 L. The sonotrode in the tested sludge was placed at a depth of 2 cm from the bottom of the vessel. Investigations of disintegration of excess sludge with ultrasonic field were carried out in the time interval 30-360 s, for amplitudes of ultrasonic field vibrations in the range of 8-16 μm and ultrasonic wave intensity in the range of 3-10 Wcm^{-2}.

Microscopic observations of excess sludge structures were carried out using the Olympus BX 41 microscope with instrumentation for taking pictures. The micrographs were taken using a 500-fold magnification, and the assessment of excess sludge structure changes was performed by a visual method taking into account selected morphological features of the sludge.

Periodic methane fermentation of excess sludge was carried out for 10 days in specially constructed methane fermentation systems, which are models of fermentation chambers with an active volume of 0.5 L. The sludge was stabilized at a constant temperature of 37°C, characteristic of conducting the process in a mesophilic temperature regime. Fermentation chamber models were placed in a laboratory incubator with constant shaking. In the case of methane fermentation processes, in order to initiate the process, excessive sludge was mixed with digested sludge in a volume ratio of 10 to 1, respectively. Volatile Suspended Solids (VSS) content of the sludge mixture was 8.79±0,18 g L^{-1}.

Anaerobic stabilization was carried out on:

- untreated excess sludge,
- excess sludge disintegrated by an ultrasonic field with an vibration amplitude of 16 μm and a sonication time of 300 s.

3. Results and discussion

3.1. Impact of the ultrasonic field on the changes of soluble chemical oxygen demand

Research on the modification of excess sludge by ultrasonic field was carried out in order to determine the degree of their susceptibility to biodegradation by determining the increase in the concentration of organic substances in a dissolved form. The values of SCOD were measured. It was assumed that the effectiveness of the disintegrating action of the ultrasonic field on excess sludge depends on the operating conditions used for the process. Obtained results of research on the influence of ultrasonic field on the increase of disintegration of excess sludge expressed in the value of SCOD are presented in Figure 2.

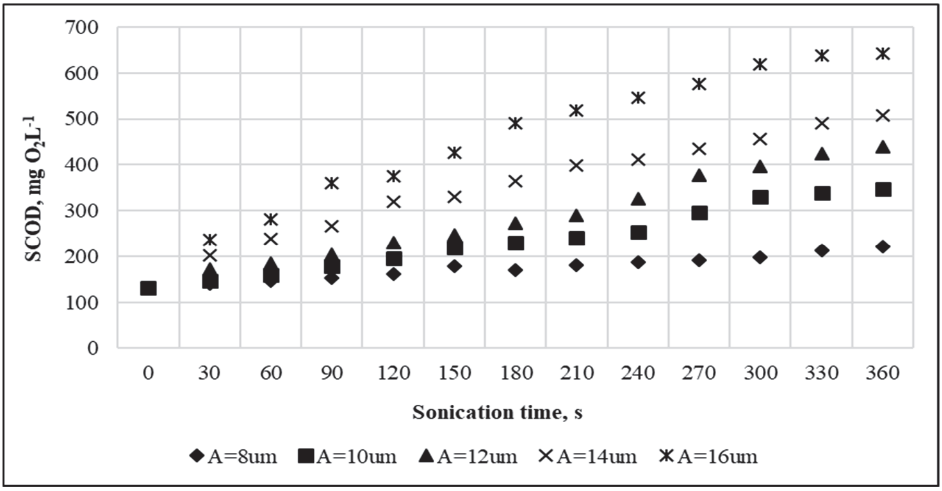


Fig. 2. Influence of ultrasonic disintegration on the SCOD values, depending on the disintegration time of excess sludge and the amplitude of ultrasonic field vibrations

Based on the obtained values of SCOD of excess sludge disintegrated by an ultrasonic field, along with the increase in the value of applied ultrasonic field vibration amplitudes, an increase in the concentration of organic matter in the supernatant liquid was observed. Increase in value of SCOD was also noted along with the extension time of sonication of the prepared sludge. Increase of SCOD value was determined with reference to the value of SCOD of excess sludge unmodified in relation to the obtained values of this index for sludge after the disintegration process. The increasing SCOD value was the effect of the destruction process of cell walls of excess sludge microorganisms and the subsequent sonolysis of organic substances released into the supernatant liquid. Ultrasonic modification of excess sludge used to increase the SCOD value in the leachate has been observed by many scientists. The SCOD increase in the range from 10 to 90% was observed when specific energy was used in the range from 1000 to 100000 kJ kg TS^{-1} (Lehne et al. 2001, Müller et al. 1998). The highest increase of the value of SCOD for individual vibration amplitudes, we obtained for different values of the time of sonication, which was defined as the most favourable disintegration time, as shown in Table 2.

Table 2. Determination, of the most favorable exposure time of the ultrasonic field, based on the increment of the SCOD value

Amplitude of ultrasonic field vibrations, μ m	The most favorable exposure time, s	SCOD of non-modified sludge, mgO_2 L^{-3}	SCOD of modified sludge, mgO_2 L^{-3}	Ratio of SCOD of non-modified sludge/ SCOD of modified sludge
8	300	132	198	1/2
10	300	132	331	1/3
12	270	132	378	1/3
14	330	132	490	1/4
16	300	132	619	1/5

Disintegration of excess sludge with an ultrasonic field with an amplitude of 8 μm caused a two-fold increase of the value of SCOD in relation to the initial value. This result was obtained for an exposure time of 300 s. A threefold increase of the SCOD value was obtained in the case of the use of 10 μm and 12 μm vibration amplitudes at ultrasonic field exposure times of 300 s and 270 s, respectively. Using an ultrasonic field with 14 μm vibration amplitude and 330 s sonication time, a fourfold increase of the index value was obtained. The highest, fivefold increase of the value of SCOD was noted as a result of using an ultrasonic field with a vibration amplitude of 16 μm and a sonication time of 300 s. For technological reasons, the above disintegration conditions were considered the most favourable. Extending the disintegration time, due to the energy consumption of the sonification process, is not indicated. Moreover in the case of ultrasonic wave propagation with the value of ultrasonic field vibration amplitude in the range of 8-16 μm, the wave intensity in the range of 3-10 Wcm^{-2} was obtained. The value of 1 Wcm^{-2} is considered in the literature (Stępniak 2006) to be threshold, above which in the modified medium the cavitation phenomenon is initiated. In addition, according to Gronroos et al. (Gronroos et al. 2005) during ultrasonic treatment of sludge, the degree of liquefaction increases with the passage of sonication time and the increase of the wave intensity.

In the methane fermentation process of non-modified excess sludge, it was observed that the SCOD value gradually increased to the third day of fermentation. For non-treated excess sludge, the SCOD value was 132 mg O_2 L^{-1}, while the value of 934 mg O_2 L^{-1} was recorded in the third day of methane fermentation. In the last day of anaerobic stabilization, the SCOD value was 591 mg O_2 L^{-1}.

In the process of methane fermentation of excess sludge disintegrated with an ultrasonic field, an increase in the concentration of organic substances in the supernatant liquid expressed of SCOD increase was noted. It was observed the increase of SCOD value from the value of 794 mg O_2 L^{-1} up to the value of 1532 mg O_2 L^{-1} determined on the 4th day of the process, followed by a decrease in the value of this indicator to 657 mg O_2 L^{-1} in the 10th day (Fig. 3).

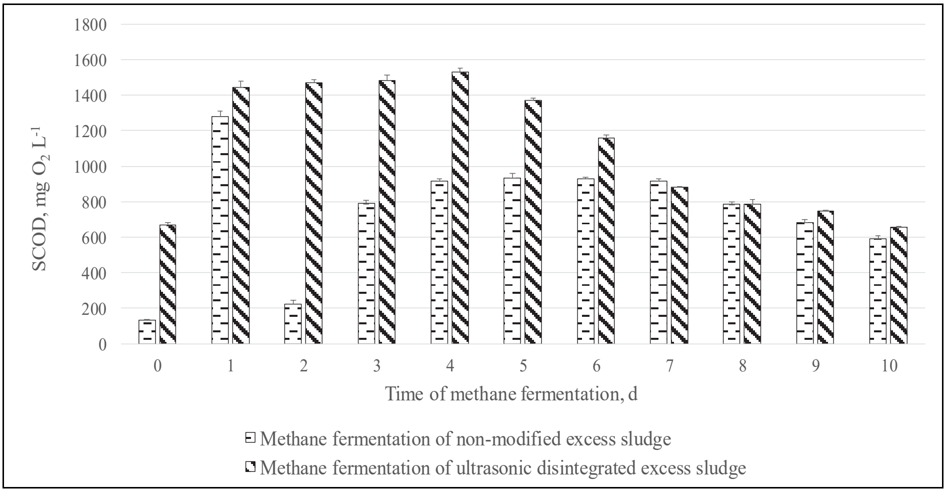


Fig. 3. Changes in the SCOD value of excess sludge in the process of conventional methane fermentation and methane fermentation supported with an ultrasonic field

3.2. Impact of the ultrasonic field on the structure of excess sludge

On the basis of microscopic tests, the structure of excess sludge not subjected to the modification process was evaluated as well as changes occurring in the structure of sludge modified by ultrasonic field, Fenton reagent and combined method. The unmodified excess sludge was characterized by a homogeneous structure, uniform dispersion of fine solid phase particles was observed throughout the liquid phase (Figure 4). The analysis of microscopic preparations of modified sludge showed a clear change in the structure of sludge. As a result of the impact on the sludge with the ultrasound field, along with the prolongation of the exposure time and the increase of the vibration amplitude value of the ultrasonic field, the solid phase particles gradually formed a compact structure. In the field of view of the preparation presenting the structure of overexpressed excess sludge, as compared to unprocessed sludge, there was an increase in the liquid phase space (Fig. 5a-f). The highest efficiency of the dispersive effect of the active ultrasonic field on excess sludge was obtained for a time of 300 s using a vibration amplitude of 16 μm. A similar trend was noted by Hogan et al. (Hogan et. al.) stating that during ultrasonic treatment of sludge, the degree of liquefaction increases with the passage of sonication time and the increase of ultrasonic field intensity.

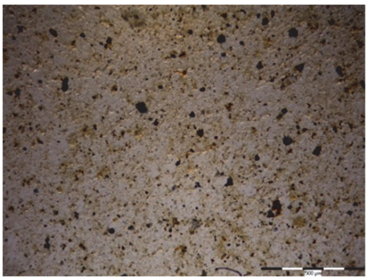
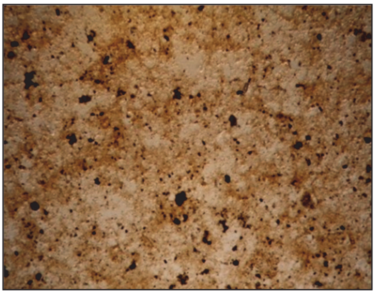
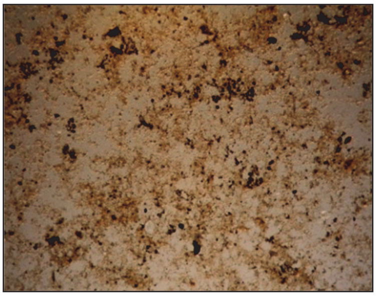


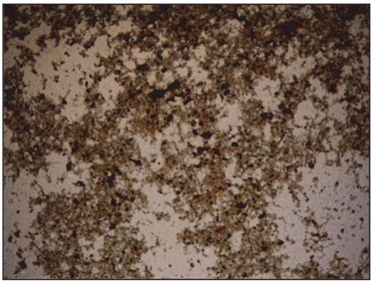
Fig. 4. Structure of non-modified excess sludge



a) t = 300 s, A = 8 µm

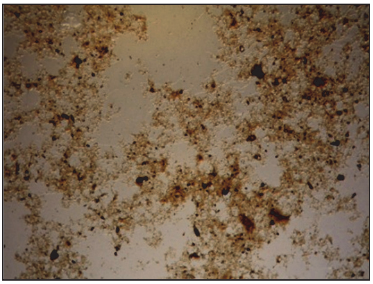


b) t = 300 s, A = 10 µm



c) t = 270 s, A = 12 µm

d) t = 330 s, A = 14 µm



e) t = 300 s, A = 16 µm

Fig. 5. Structure of excess sludge disintegrated by ultrasonic field with different modification time and variable vibration amplitude; a) t = 300 s, A = 8 µm, b) t = 300 s, A = 10 µm, c) t = 270 s, A = 12 µm, d) t = 330 s, A = 14 µm, e) t = 300 s, A = 16 µm

3.3. Effect of ultrasonic disintegration of excess sludge on microbiological indicators

The analysis involved microbiological changes occurring in excess sludge disintegrated by an ultrasonic field. It has been found that the use of sonication influences microbial cells in a destructive manner. The effect of this action is a decrease in the number of examined groups of microorganisms present in the prepared sludge. The phenomenon of ultrasonic cavitation is used to hygienie sewage sludge. The effectiveness of ultrasonic disinfection depends on the parameters of sonication, duration of sonication, as well as the type and number of bacteria destroyed (Goznze et al. 2003). The use of disintegration of excess sludge with an ultrasonic field did not cause a significant reduction in the number of microorganisms of the type *Escherichia coli*. Ultrasonic wave propagation has been effective in reducing the viability of other groups of microorganisms, i.e. mesophilic and psychrophilic microorganisms. During the sludge modification, an increase in the degree of reduction of mesophilic microorganisms from $49 \cdot 10^6$ JTK cm^{-3} to $16 \cdot 10^5$ JTK cm^{-3} and psychrophilic microorganisms from $61 \cdot 10^6$ JTK cm^{-3} to $48 \cdot 10^5$ JTK cm^{-3} was observed.

Table 4. Microbiological analysis of excess sludge subjected to ultrasonic disintegration

Disintegration conditions	Type of microorganisms					
	Mesophilic		Psychrophilic		*Escherichia coli*	
	The number of microorganisms, JTK cm^{-3}		The number of microorganisms, JTK cm^{-3}		Count	
	Non-modified excess sludge	Modified excess sudge	Non-modified excess sludge	Modified excess sludge	Non-modified excess sludge	Modified excess sludge
A = 16 µm, t = 300 s	$49 \cdot 10^6$	$16 \cdot 10^5$	$61 \cdot 10^6$	$48 \cdot 10^5$	10^{-4}	10^{-3}

As the time of sonication increases, the effect of inactivation of microorganisms increases. According to Woszczyk-Cierzyńska et al. (Woszczyk-Cierzyńska et al. 2007), using a longer sonication time of 15 minutes and a frequency of 22 kHz, the degree of destruction of psychrophilic bacteria was achieved, amounting to 97.9% for digested sludge, approximately 98.6% for primary sludge, degree of mesophilic bacteria destruction from 94.3% for primary sludge, up to 94.9% for digested sludge.

The aim of the microbiological analysis was to determine the effect of ultrasonic disintegration of excess sludge subjected to methane fermentation to the number of individual groups of microorganisms present in modified excess sludge. In the stabilization process, a decrease in the number of mesophilic, psychrophilic bacteria as well as *Escherichia coli* bacteria determined by means of count was noted. A decrease in the number of psychrophilic microorganisms from $45 \cdot 10^5$ JTK cm^{-3} to $20 \cdot 10^5$ JTK cm^{-3} occurred in the initial stabilization period, during the first 5 days of the process. In subsequent days of methane fermentation, the amount of microorganisms decreased slightly to $15 \cdot 10^5$ JTK cm^{-3}. The Escherichia coli count equal to 10^{-3} in sludge during the entire stabilization cycle increased to 10^{-2}. The lowest decrease in numbers from $16 \cdot 10^5$ JTK cm^{-3} to $10 \cdot 10^5$ JTK cm^{-3} was observed in the case of mesophilic bacteria. Microbiological changes occurring in the process of methane fermentation of sludge disintegrated by an ultrasonic field are presented in Table 5.

Table 5. Microbiological analysis of ultrasonically disintegrated excess sludge subjected methane fermentation

Methane fermentation		Type of microorganisms		
		Mesophilic	Psychrophilic	*Escherichia coli*
		The number of microorganisms, JTK cm^{-3}	The number of microorganisms, JTK cm^{-3}	Count
Time of the process, d	1	$16 \cdot 10^5$	$45 \cdot 10^5$	10^{-3}
	5	$14 \cdot 10^5$	$20 \cdot 10^5$	10^{-3}
	10	$10 \cdot 10^5$	$15 \cdot 10^5$	10^{-2}

As a result of methane fermentation of unmodified sludge, a slight decrease in the number of psychrophilic bacteria was noted. Mesophilic microorganisms were also characterized by high resistance to anaerobic conditions. After stabilization, a slight decrease in the amount of this group of microorganisms was found. Based on the microbiological analysis performed during the methane fermentation of sonicated excess sludge, a high level of *Escherichia coli* removal was found, the titer of these microorganisms before the 10^{-5} process increased in the methane fermentation process to 10^{-2}.

The described technology based on the process of ultrasonic disintegration is a promising process solution that does not cause secondary pollution of the sludge environment, effectively affecting the methane fermentation process, both in terms of the value of physical and chemical indicators conditioning the process, as well as microbiological. Therefore, there is a potential possibility of implementing the proposed technology into the sewage sludge processing string.

4. Conclusions

Obtained results of research on sonication of excess sludge allow to formulate the following conclusions:

1. The excess sludge modification caused by the effect of the ultrasonic field influenced the increase of disintegration of the modified excess sludge, expressed by an increase of the value of dissolved chemical oxygen demand. The most favorable conditions for the disintegration of excess sludge with the ultrasonic field were considered as the amplitude of 16μm vibrations and sonication time of 300 s. About 5-fold increase of SCOD values in relation to initial values was obtained.
2. On the basis of the microscopic analysis of the structure of disintegrated excess sludge, it was found that the use of an active ultrasonic field causes a clear change in the flocculating structure of excess sludge, affecting the increase of their degree of liquefaction.
3. It was found that the use of ultrasonic disintegration had a destructive effect on microbial cells. The effect of this action was a decrease in the number of examined groups of microorganisms present in the prepared sludge. The use of disintegration of excess sludge by ultrasonic field did not significantly reduce the number of *Escherichia coli* microorganisms. Propagation of ultrasonic wave effectively reduced the viability of other groups of microorganisms, i.e. mesophilic and psychrophilic microorganisms. During the sludge sonication, an increase in the degree of reduction of mesophilic microorganisms from $49 \cdot 10^6$ JTK cm^{-3} to $10 \cdot 10^5$ JTK cm^{-3} and psychrophilic microorganisms from $61 \cdot 10^6$ JTK cm^{-3} to $10 \cdot 10^5$ JTK cm^{-3} was observed.

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Abstract

The rate of decomposition of organic matter during methane fermentation is limited by the speed of the first phase of this process, called hydrolysis, during which liquefaction process of organic compounds takes place. For the pre-treatment of sludge before methane fermentation, disintegration techniques are used, which depending on the type of energy supplied to the system, can be divided into four groups: chemical, thermal, mechanical, biological methods. An effective method of mechanical disintegration of sewage sludge is the technology associated with the use of ultrasound. The impact of ultrasonic waves distorts the state of balance in the system, leads to better spatial packing of molecules, changing the structure of sewage sludge and their physico-chemical properties. The aim of the study was to determine the disintegrating influence of sonication on the excess sludge liquification expressed as the increase in the soluble chemical oxygen demand (SCOD). value of the modified excess sludge as well as estimating of the microbiological indicators of sonicated sludge.

The process of disintegration of excess sludge with the ultrasonic field was carried out with the use of a disintegrator type UD-20 with a vibration frequency of 22 kHz and a maximum output power of 180W. Microbiological analyzes performed for non-modified and disintegrated sludge concerned the number of mesophilic and psychrophilic microorganisms, *Salmonella spp* bacteria and *Escherichia coli* type bacteria, which is a pathogenic species. Periodic methane fermentation of excess sludge was carried out for 10 days, in the temperature of 37°C. As a result of subjecting the excess sludge to disintegration with an ultrasonic field, an increase in the degree of liquefaction of sludge was noted, expressed as an increase in the value of soluble chemical oxygen demand (SCOD). For the vibration amplitude of 16μm and sonication time of 300 s about 5-fold increase of SCOD values in relation to initial values was obtained. The highest degree of elimination of the studied groups of microorganisms was noted on the 10th day of the methane fermentation process of modified excess sludge.

Keywords:
excess sludge, ultrasonic field disintegration, soluble chemical oxygen demand (SCOD), methane fermentation, microbiological indicators

Dezintegrujący wpływ sonifikacji na upłynnienie osadów nadmiernych oraz ich wskaźniki mikrobiologiczne

Streszczenie

Szybkość rozkładu substancji organicznych podczas fermentacji metanowej jest ograniczona szybkością pierwszej fazy tego procesu zwanej hydrolizą, podczas której następuje upłynnienie związków organicznych. W celu wstępnej modyfikacji osadów przed fermentacją metanową stosuje się techniki dezintegracji, które w zależności od rodzaju energii dostarczanej do układu można podzielić na cztery grupy: chemiczne, termiczne, mechaniczne, biologiczne. Skuteczną metodą mechanicznej dezintegracji osadów ściekowych jest technologia związana z zastosowaniem ultradźwięków. Oddziaływanie fal ultradźwiękowych zakłóca stan równowagi w układzie, prowadzi do lepszego przestrzennego upakowania cząsteczek, zmieniając przy tym strukturę osadów ściekowych oraz ich właściwości. Celem badań było określenie dezintegrującego wpływu sonikacji na upłynnienie osadów nadmiernych wyrażone wzrostem wartości rozpuszczo-nego chemicznego zapotrzebowania na tlen ($ChZT_{rozp.}$), a także oszacowanie wskaźników mikrobiologicznych sonifikowanych osadów. Proces dezintegracji osadów nadmiernych polem ultradźwiękowym przeprowadzono przy użyciu dezintegratora typu UD-20 o częstotliwości drgań 22 kHz i maksymalnej mocy wyjściowej 180 W. Analizy mikrobiologiczne przeprowadzone dla osadów niemodyfikowanych i dezintegrowanych dotyczyły określenia liczebności mikroorganizmów mezofilnych i psychrofilnych, bakterii *Salmonella spp* i bakterii typu *Escherichia coli*, która jest gatunkiem patogennym. Okresową fermentację metanową osadów nadmiernych prowadzono przez 10 dób, w temperaturze 37°C. W wyniku poddania osadów nadmiernych modyfikacji za pomocą pola ultradźwiękowego odnotowano wzrost stopnia upłynnienia osadów, wyrażony wzrostem wartości rozpuszczonego chemicznego zapotrzebowania na tlen. Dla amplitudy drgań 16 μm i czasu sonikacji 300 s uzyskano około 5-krotny wzrost wartości $ChZT_{rozp.}$ w stosunku do wartości początkowych. Najwyższy stopień eliminacji badanych grup mikroorganizmów odnotowano w 10 dobie procesu fermentacji metanowej modyfikowanych osadów nadmiernych.

Słowa kluczowe:
osady nadmierne, dezintegracja ultradźwiękowa,
rozpuszczone chemiczne zapotrzebowanie na tlen ($ChZT_{rozp.}$), fermentacja metanowa,
wskaźniki mikrobiologiczne