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VARIABILITY OF SELECTED PARAMETERS AS A RESULT OF MICROWAVE DISINTEGRATION OF SEWAGE SLUDGE

S u m m a r y

The article contains the results of research carried out at the SGGW Water and Sewage Institute in Warsaw regarding the pre-treatment of sewage sludge by means of microwave disintegration. Sewage sludge came from the "Mokre Łąki" sewage treatment plant in the Izabelin commune. Experiments were carried out on thickened and unthickened sludge. Every sludge was disintegrated in portions of various volumes, as well as at different times of microwave influence. Significant changes in the values of the tested parameters were noted, such as: COD, turbidity and temperature due to the use of sludge sonification process. These parameters have a significant impact on the course of further processes, which may be subject to processed sewage sludge and supernatant liquid. Therefore, determining the variability of these parameters is important

Key words: sewage sludge, disintegration, sludge sonification

INTRODUCTION

Each, even the smallest sewage treatment plant in addition to its basic function - purification and disposal of non-hazardous sewage - must process the sewage sludge created on it [Sadecka et al. 2011; Kazimierczak 2013]. Raw sewage sludge discharged in preliminary and secondary settling tanks is a threat to the environment caused by the occurrence of organic matter, susceptible to rotting. Therefore, it is necessary to stabilize the sludge by aerobic or anaerobic means.

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Stabilization is a process in which the decomposition of organic substances occurs by microorganisms living in the sludge. The costs of stabilization and removal of sludge are large and can constitute up to 60% of the total operating costs in the sewage treatment plant [Czajkowska, Kazimierczak 2016]. The efficiency of these processes is limited by hydrolysis. This stage is considered to limit the speed of the entire stabilization process, which is why aerobic stabilization of the disintegrated sludge is carried out [Czajkowska et al.2017]. In order to accelerate the hydrolysis, and thus the stabilization process, among others, disintegration is used. We distinguish a number of disintegration methods: mechanical (homogenization, ultrasounds, microwaves), chemical (ozonation, acid and alkaline hydrolysis), biological (enzymes, autolysis, fungi, bacteria), thermal (low temperature, high temperature). Among the disintegration methods mentioned above, the mechanical disintegration by means of microwave radiation deserves particular attention. to change the properties of excess sludge [Nowicka 2015] and activated sludge [Grübel, Machnicka 2011a and b]. The main purpose of these pre-treatment methods is to dissolve and reduce the particle size of the organic compounds so that they are more susceptible to biological degradation.[Sadecka 2010]

RESEARCH METHODOLOGY

The sewage sludge from the "Mokre Łąki" sewage treatment plant in the Izabelin commune was used for the research. It is a sewage treatment plant working on the basis of the activated sludge method. The material was taken from the pumping station after the secondary settling tank, and then transported to the Laboratory of Chemistry and Water and Sewage Technology at the Warsaw University of Life Sciences. A microwave oven with 700 W and frequency 2.45 GHz was used for disintegration. Two types of sewage sludge were subjected to disintegration: unthickened and thickened. The concentration of the sludge consisted in removing the supernatant liquid from the portions of the transported sludge in the amount of 40% of the volume. Two types of sludge prepared in this way were disintegrated in the following variants:

- variable disintegration time (1, 2, 3, 4, 5, 6, 7 and 8 min) with a constant volume of disintegrated sludge (500 ml),
- constant disintegration time (4 min) with a variable volume of disintegrated sludge (250, 500, 750, 1000, 1250, 1500, 1750 and 2000 ml).

The following was determined in the supernatant liquid:

- turbidity - nephelometric method [PN-EN ISO 7027:2003, chapter 6] using the 2100N IS Turbidimeter,
- pH - electrometric method [PN-EN ISO 10523:2012] using the Eutech Instruments pH 510 meter and Elmetron IJ44C electrode,
- COD - titration method [PN-ISO 6060:2006],
- All tests were carried out at room temperature of 20oC±1.

RESEARCH RESULTS AND DISCUSSION

Table 1 shows the results of the supernatant liquid test after microwave disintegration of the unthickened sludge for a variable sonification time with a constant sample volume of 500 ml. Samples of supernatant were analysed for temperature, pH, turbidity and COD.

Tab. 1. Variability of selected parameters of unthickened sludge disintegrated at different times with a volume of 500ml

Time of disintegration	COD	Temperature	pH	Temperature for pH	Turbidity
[min.]	[mg O_2/dm^3]	[°C]	[-]	[°C]	[NTU]
0	100	19	7.08	19.9	14.5
1	100	36	6.99	20.3	16.1
2	500	51	6.98	20.8	48.0
3	800	62	7.03	21.0	59.2
4	1080	72	7.04	21.1	92.9
5	1240	81	7.05	21.2	129.0
6	1360	84	7.04	21.4	147.0
7	1440	92	6.99	21.1	148.0
8	1400	94	7.05	21.0	167.0

On the basis of the results presented in Table 1, it can be concluded that with the increasing time of disintegration (sonification) of sludge COD values, temperature and turbidity in the supernatant liquid tend to increase. The pH values do not fluctuate much and are in the range of 6.98 to 7.08.

Table 2 presents the results of the supernatant liquid test after microwave disintegration of the unthickened sludge for the variable volume of the sludge sample at a constant 4-minute sonification time. Samples of supernatant were analysed for temperature, pH, turbidity and COD.

Tab. 2. Variability of selected parameters of unthickened sludge disintegrated in 4 min. in different volumes

Volume	COD	Temperature	pH	Temperature for pH	Turbidity
[ml]	[mg O_2/dm^3]	[°C]	[-]	[°C]	[NTU]
250	1480	85	7.11	21.4	175.0
500	1080	72	7.04	21.1	92.9
750	920	62	7.08	27.0	56.9
1000	680	47	7.12	25.2	45.6
1250	400	38	7.11	24.5	46.4
1500	200	37	7.09	23.8	27.2
1750	160	34	7.10	23.6	20.7
2000	220	32	7.11	23.1	23.8

In the case of test results with the variable volume and constant disintegration time presented in Table 2, the reverse tendency is noticeable contrary to the experiment with the increasing disintegration time shown in Table 1. With the increasing sample volume, COD, temperature and turbidity of the supernatant liquid decrease. The pH value remains constant at 7.04 - 7.12.

Table 3 shows the results of the supernatant liquid test after microwave disintegration of the thickened sludge for a variable sonification time with a constant sample volume of 500 ml. Samples of supernatant were analysed analogously to the unthickened sludge for temperature, pH, turbidity and COD.

Tab. 3. Variability of selected parameters of thickened sludge disintegrated at different times with a volume of 500ml

Time of disintegration	COD	Temperature	pH	Temperature for pH	Turbidity
[min.]	[mg O_2/dm^3]	[°C]	[-]	[°C]	[NTU]
0	260	19	7.03	19.1	42.6
1	220	35	7.02	21.1	50.4
2	450	49	7.03	21.2	107.0
3	1320	59	7.03	21.2	119.0
4	2000	70	7.02	21.1	185.0
5	2400	82	7.02	21.0	296.0
6	2320	86	7.03	20.9	307.0
7	2240	89	7.02	20.6	330.0
8	2440	97	7.02	20.2	394.0

Similarly, to the case of unthickened sludge (Table 1), based on the results presented in Table 3, it was found that with increasing time of disintegration (sonification) of sludge, the COD values, temperature and turbidity of the supernatant liquid increase. The pH of the samples maintains a similar tendency as in the case of unthickened sludge and is maintained at pH 7.02 - 7.03.

Table 4 presents the results of the supernatant liquid test after microwave disintegration of the thickened sludge for the variable volume of the sludge sample at a constant 4-minute sonification time. Analogously, the temperature, pH, turbidity and COD were determined in the excess liquid samples.

Tab. 4. Variability of selected parameters of thickened sludge disintegrated in 4 min. in different volumes

Volume	COD	Temperature	pH	Temperature for pH	Turbidity
[ml]	[mg O_2/dm^3]	[°C]	[-]	[°C]	[NTU]
250	2280	84	7.10	19	138.0
500	2000	70	7.02	21.1	185.0
750	900	62	7.10	22.9	72.0
1000	560	52	7.09	23.5	61.8

1250	320	48	7.09	22.7	47.2
1500	300	32	7.09	23.2	41.1
1750	180	31	7.06	22.4	37.0
2000	260	30	7.07	21.6	43.5

In the case of test results with the variable volume and constant disintegration time shown in Table 4, the results follow the same trend as for the unthickened sludge (Table 2).

With the increase of the sample volume, the COD values, temperature and turbidity of the liquid decrease. The pH value changes in a small range and remains at pH 7.02 - 7.10.

The disintegration time and the volume of the disintegrated sample affect the energy used in the sludge disintegration process. This is illustrated in Figures 1, 2 and 3, showing the dependences of COD, turbidity and temperature respectively in the supernatant liquid of the unthickened and thickened sludge against the energy consumed converted per unit of volume for all analysed samples of the supernatant liquid.

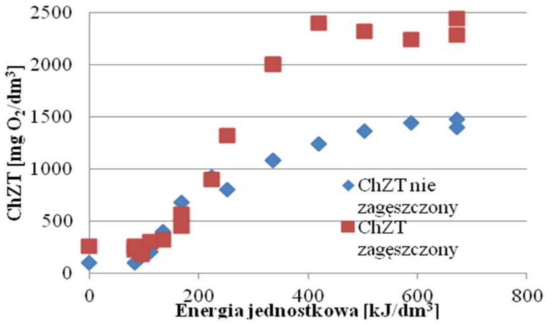

Fig. 1. Changes in the COD value as a function of unit energy for the supernatant liquid from unthickened and thickened sludge

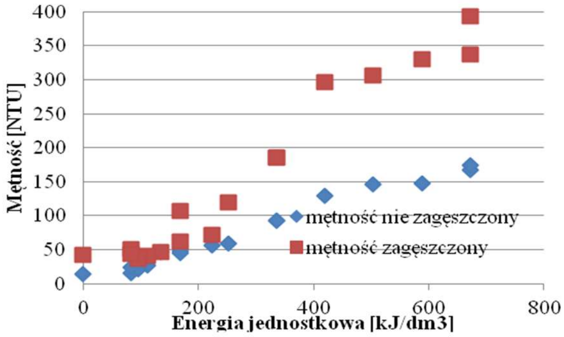

Fig. 2. Changes in the turbidity value as a function of unit energy for the supernatant liquid from unthickened and thickened sludge

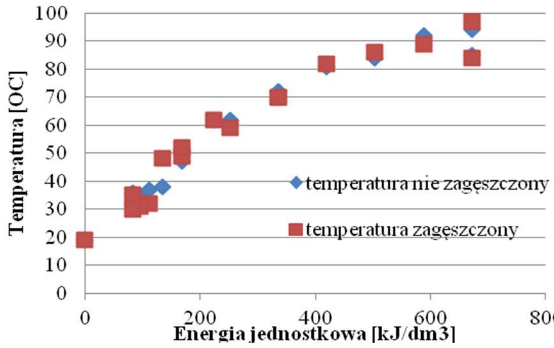

Fig. 3. Changes in the temperature value as a function of unit energy for the supernatant liquid from unthickened and thickened sludge

On the basis of the graphs presented in Figures 1 and 2, it is noticeable that in thickened sludge samples the COD and turbidity parameters assume higher values than in analogous samples of unthickened sludge. The concentration of sludge and its partial mineralization in the sonification process affect the quality of the supernatant liquid. Disintegration improves the homogenisation of samples at molecular terms, but it affects the values of the analysed indicators (COD, turbidity). In the case of temperature of the analysed sludge during the microwave disintegration, shown in Figure 3, no significant effect of sludge concentration on the obtained values was noticed. Temperature variability depends only on the time and volume of the disintegrated sludge.

CONCLUSIONS

As a result of the modernization of sewage treatment technology forced by environmental protection, and above all the quality of treated sewage discharged to surface water, the amount of sludge generated in sewage treatment plants increased. The sewage sludge formed constitutes 2-3% of the volume of sewage flowing, nevertheless the costs related to its treatment (compaction, stabilization, dehydration) reach 60% of the operating costs. The aim is, therefore, to limit them as much as possible, which is justified by the economic operation of the treatment plant.

One of the most important processes of sludge treatment is its stabilization. It aims to decompose the organic matter in the sludge thus limiting the ability to rot and the appearance of odours. To shorten the stabilization time, it was subjected to pre-treatment before entering the stabilization chambers. The disintegration method has become popular. The disintegration methods are used both as pre-stabilization processes, but also before or after the pre-sludge and excessive sludge concentration, as a by-pass on the recirculated sludge, before the final dehydration.

Microwave disintegration is one of the mechanical methods. The use of electromagnetic radiation can become a new, beneficial method allowing to improve the processes of sewage treatment and processing of sewage sludge.

The above tests show that the sludge treatment itself (concentration) has a very significant effect on the COD value in the supernatant liquid. With unit energy above 400 kJ/dm^3, the COD value assumes a similar value, while for unthickened sludge it varies in the range 1500 MgO_2/dm^3 and with the thickened sludge it assumes values close to 2500 MgO_2/dm^3. A similar situation concerns turbidity. With unit energy above 400 kJ/dm^3, the values for the supernatant liquid of unthickened sludge are approx. 150 NTU, and for the supernatant liquid, the compacted sludge is twice as large. The increase in the temperature of the sludge along with the increase of energy in the case of the use of microwaves prior to the stabilization processes has a positive effect - a warmer sludge means a shortening of the time necessary to heat it and faster stabilization.

As a result of sonification of sewage sludge, the characteristics of the supernatant liquid change. Therefore, it is important to select the parameters of the microwave disintegration process in order to obtain the best results.

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