CIVIL AND ENVIRONMENTAL ENGINEERING REPORTS

No. 6 2011

DEWATERABILITY OF THERMAL CONDITIONED SEWAGE SLUDGE AFTER ANAEROBIC STABILIZATION

Mariusz MAŁKOWSKI, Paweł WOLSKI*, Lidia WOLNY
Częstochowa University of Technology
Faculty of Engineering and Environmental Protection
Institute of Environmental Engineering
Brzeźnicka st. 60A, 42 – 200 Częstochowa, Poland

Thermal pretreatment of sewage sludge influences the improvement of biochemical decomposition of sludge in the anaerobic stabilization process. At the same time the ratio of fermentation impacts on the effectiveness of sludge dewatering. The aim of investigation was the evaluation of thermal conditioned excess sludge dewaterability after anaerobic stabilization process. In the tests excess and digested (10%) sludge from municipal wastewater treatment plant was used. Experiments were carried out in the laboratory flasks filled with the tested sludge and located in the laboratory incubator. Unconditioned and conditioned sludge in temperature of 50, 60, 70, 80 and 90°C was stabilised during 10 days. In each day of the process the capillary suction time (CST), thickening degree and dry matter content were determinated. Thermal conditioning of excess sludge influenced the increase of CST values. For sludge after mesophilic anaerobic stabilization in the successive days of the process, the decrease of CST values, dry matter content and thickening degree were noticed.

Keywords: sewage sludge, thermal conditioning, anaerobic stabilisation, dewatering

1. INTRODUCTION

Methane fermentation is the well–known and generally used method of sewage sludge stabilization. The correct running digestion process should lead to the following aims: mineralization of organic compounds which include mass reduction, less energy use, and more significantly, the energy recovery in the form of biogas [1,2]. Complete microbial digestion process of sludge to CH_4 and CO_2 is a slow process and requires high retention time and big volume of

* Corresponding author. E-mail: pwolski@is.pocz.czest.pl

anaerobic digesters. The conversion pathway of substrate to biogas occurs in four stages, namely hydrolysis, acidogenesis, acetogenesis and methanogenesis [2, 3].

Interference into the digestion process through the sludge modification before stabilisation process influences the final dewaterability of sludge. Sludge pretreatment before stabilisation changes phisico – chemical properties of sludge releasing the intercellular components into the aqueous phase. It affects directly the sludge ability to dewatering [4,5,6].

Primary aim of physical methods of sludge conditioning (including thermal methods) is the sludge biodegradability increase to enhance the methane production at lower HRT(Hydraulic Retention Time) in the anaerobic digester. Using thermal method to excess sludge pretreatment before methane fermentation causes reduction of hydrolytic phase, increase of digestion degree and biogas output intensification [cited by 7].

The aim of investigation was determination of dependence between the thermal pretreatment of excess sludge and dewatering ability of sludge after anaerobic stabilization.

These tests were stage of recognition, which results may lead to further experiments in the selected direction.

2. EXPERIMENTAL PART

2.1. Tests substrate

The main substrate of investigation was the excess activated sludge (90%) and digested sludge (10%), which was inoculum. Sludge was from the Central Wastewater Treatment Plant ‘Warta’ in Częstochowa

2.2. Materials and methods

Investigations were conducted in the laboratory flasks (V = 0.5dm^3), which were put in the laboratory incubator for the optimal fermentation temperature maintenance (37°C).

The following mixtures were stabilised in the anaerobic terms:

- Mixture A (unconditioned excess sludge and digested sludge),
- Mixture B (thermal conditioned excess sludge in temperature 50°C during 2.5h and digested sludge),
- Mixture C (thermal conditioned excess sludge in temperature 60°C during 1.5h and digested sludge),
- Mixture D (thermal conditioned excess sludge in temperature 70°C during 1.5h and digested sludge),

- Mixture E (thermal conditioned excess sludge in temperature 80°C during 2.5h and digested sludge),
- Mixture F (thermal conditioned excess sludge in temperature 90°C during 1.5h and digested sludge).

Time of preliminary thermal conditioning of sludge was selected from the initial tests results, for which the most advantageous values of VFA and COD were obtained. Excess sludge was conditioned in the selected values of temperature and time in the water bath and then sludge was stabilized in the anaerobic and mesophilic conditions during 10 days.

As well as before process and in the each day of stabilization the following determinations were made: capillary suction time (CST), thickening curves and dry mass content. CST was indicated on the base of Baskerville's and Galle's method, which was introduced as an easy - to - conduct test for measuring dewaterability of sludge. Gravitational thickening of sludge was carried out using a 1000ml measuring cylinders. Sludge samples were observed during the sedimentation process in the suitable time intervals of 5, 10, 15, 20, 25, 30, 45, 60, 90, 120 minutes. On the base of sludge volume measurement the thickening curves were determined. Dry mass of sludge was indicated according to Hermanowicz methodology [8].

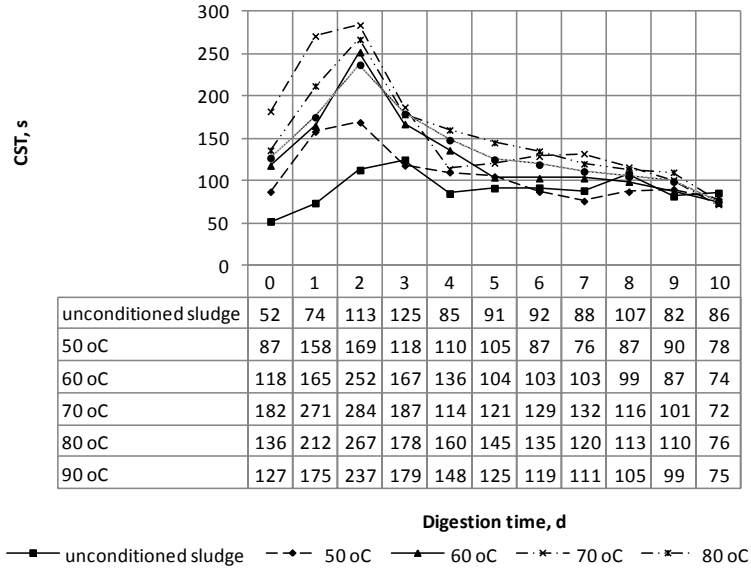
3. RESULTS

In the first two days of stabilisation process the increase of CST values was noticed and in the next days it was the decrease (Fig.1). This result was observed until the last day of process for each of investigated sludge samples. The cause of initial increase of capillary suction time values was the course of hydrolysis process, which in the first days of stabilisation took place. The highest value of CST was noticed for sludge conditioned of 70°C temperature, and the lowest for sludge conditioned of 50°C.

The similar dependences were noted in the case of thickening process where after second day of stabilization process the increase of thickening degree of tested sludge was determinated.

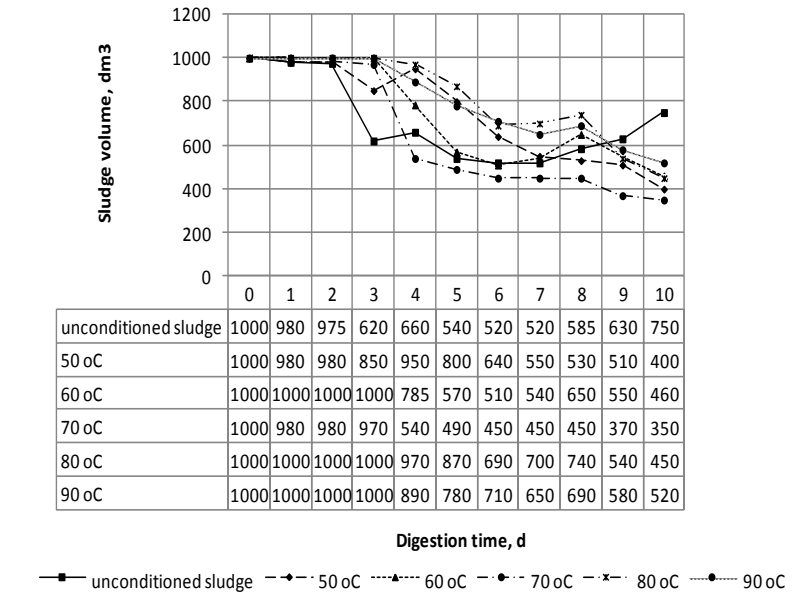
Hydrolysis process caused increase of sedimentation degree, because the highest drops of sludge volume were observed during 4 and 5 day of stabilisation process. The most advantageous result was for sludge conditioned with temperature equal 70°C and for sludge conditioned with 80°C the worst result was obtained (Fig.2).

During stablisation process of tested sludge the decrease of dry mass content in the next days of process was observed. This effect was connected with the biodegradation of sludge. Thermal pretreatment of sludge caused the decrease of dry masss content, which was the lowest in the final days of process for sludge conditioned in temperature equal 80°C (Fig.3).



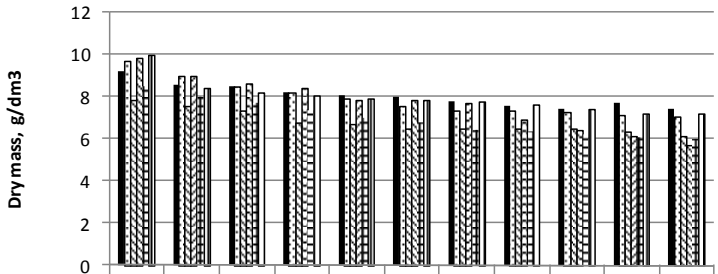
	0	1	2	3	4	5	6	7	8	9	10
unconditioned sludge	52	74	113	125	85	91	92	88	107	82	86
50 oC	87	158	169	118	110	105	87	76	87	90	78
60 oC	118	165	252	167	136	104	103	103	99	87	74
70 oC	182	271	284	187	114	121	129	132	116	101	72
80 oC	136	212	267	178	160	145	135	120	113	110	76
90 oC	127	175	237	179	148	125	119	111	105	99	75

Fig.1. Influence of digestion time on the CST of excess sludge after thermal conditioning



	0	1	2	3	4	5	6	7	8	9	10
unconditioned sludge	1000	980	975	620	660	540	520	520	585	630	750
50 oC	1000	980	980	850	950	800	640	550	530	510	400
60 oC	1000	1000	1000	1000	785	570	510	540	650	550	460
70 oC	1000	980	980	970	540	490	450	450	450	370	350
80 oC	1000	1000	1000	1000	970	870	690	700	740	540	450
90 oC	1000	1000	1000	1000	890	780	710	650	690	580	520

Fig. 2. Influence of digestion time on the thickening process of thermal conditioned excess sludge after 30 minutes sedimentation



	0	1	2	3	4	5	6	7	8	9	10
unconditioned sludge	9,20	8,60	8,50	8,20	8,10	8,00	7,80	7,60	7,40	7,70	7,40
50 oC	9,71	8,96	8,45	8,17	7,87	7,54	7,35	7,32	7,25	7,14	7,04
60 oC	7,81	7,54	7,30	6,77	6,69	6,48	6,46	6,44	6,43	6,29	6,13
70 oC	9,80	8,95	8,61	8,38	7,85	7,80	7,70	6,88	6,40	6,12	5,70
80 oC	8,48	7,99	7,69	7,34	6,99	6,79	6,44	6,37	6,18	6,09	6,01
90 oC	10,00	8,40	8,20	8,02	7,90	7,80	7,75	7,60	7,40	7,20	7,15

Fig.3. Influence of digestion time on the dry mass of excess sludge after thermal conditioning

4. SUMMARY AND CONCLUSIONS

Excess sludge after thermal pretreatment is characterized by lower ability to dewatering which was determined by capillary suction time values increase. Stabilisation process of excess sludge conditioned in this way caused the CST values decrease. This result was observed after hydrolysis process. Thickening process had more intensity run for digested sludge after preconditioning. Sludge mineralization which resulted in the thickening effectiveness was confirmed by content of dry mass of sludge.

Some conclusions were formulated on the base of experiments:

1. Thermal conditioning of excess sludge caused the increase of CST values;
2. After stabilisation process capillary suction time values were lower than before process. The decreasing of CST was observed after second day of process i.e. after hydrolysis;
3. Stabilisation influenced the improvement of sedimentation abilities of sludge. The best result of thickening effectiveness was noticed for sludge after thermal pretreatment, particularly for 70°C ;
4. This way of sludge preparation had also advantageous influence on the biodegradation of organic substances in sludge.

ACKNOWLEDGEMENTS

Scientific work founded by grant BG 401/402/10 resource sponsored by the State Committee for Scientific Research (KBN) in the year 2010-2012.

REFERENCES

1. Fukas-Płonka Ł., Zielewicz-Madej E.: *Fermentacja osadów a koszty eksploatacyjne oczyszczalni*, Konferencja Naukowo-Techniczna nt. Problemy gospodarki osadowej w oczyszczalni ścieków, Częstochowa 1995, 85 – 92.
2. Bień J., Szparkowska I.: *Proces fermentacji metanowej osadów nadmiernych kondycjonowanych polem ultradźwiękowym*, Konferencja Naukowo-Techniczna nt. Aktualne problemy gospodarki wodno-ściekowej, Częstochowa 2004, 305 – 316.
3. Kempa E.S., Bień J.: *Problemy przeróbki osadów ściekowych*, Konferencja Naukowo- Techniczna nt. Problemy gospodarki osadowej w oczyszczalni ścieków, Częstochowa 1995, 51 – 61.
4. Bień J.: *Osady ściekowe – teoria i praktyka*. Wydawnictwo Politechniki Częstochowskiej, Częstochowa 2007.
5. Zielewicz – Madej E.: Szwabowska E., Fukas – Płonka Ł., Kawczyński A., *Zmiany odwadnialności osadu w procesie fermentacji*, Konferencja Naukowo – Techniczna, Problemy gospodarki osadowej w oczyszczalniach ścieków, Wydawnictwo Politechniki Częstochowskiej, Częstochowa 1993, 69-77.
6. Małkowski M., Wolski P.: *Wpływ termicznego kondycjonowania na efekt odwadniania osadów ściekowych poddanych stabilizacji beztlenowej*, Inżynieria i Ochrona Środowiska, tom 13, nr 2, Częstochowa 2010, 103-109.
7. Zielewicz E.: *Dezintegracja ultradźwiękowa osadu nadmiernego w pozyskaniu LKT*, Politechnika Śląska, Gliwice 2007.
8. Hermanowicz W., Dojlido J.: Dożańska W, Koziorowski B., Zerbe J., *Fizyczno-chemiczne badania wody i ścieków*, Arkady, Warszawa 1999.

EFEKTYWNOŚĆ ODWADNIANIA TERMICZNIE KONDYCJONOWANYCH OSADÓW ŚCIEKOWYCH PODDANYCH STABILIZACJI BEZTLENOWEJ

S t r e s z c z e n i e

Wstępna termiczna obróbka osadów ściekowych wpływa na poprawę ich biochemicznego rozkładu w procesie stabilizacji beztlenowej. Stopień przefermentowania oddziaływuje tym samym na efektywność odwadniania osadów. Celem prowadzonych badań było określenie wpływu termicznego kondycjonowania osadów nadmiernych poddanych stabilizacji beztlenowej na końcowe ich odwadnianie.
W badaniach wykorzystano osady nadmierne i przefermentowane (10%) pochodzące z komunalnej oczyszczalni ścieków. Badania prowadzono w kolbach laboratoryjnych, które po napełnieniu badanymi osadami umieszczono w cieplarce laboratoryjnej. Osady niekondycjonowane oraz kondycjonowane w temperaturze 50, 60, 70, 80 i 90 ^{o}C poddano stabilizacji przez okres 10 dni. W każdym dniu prowadzenia procesu oznaczano czas ssania kapilarnego (CSK), stopień zagęszczania oraz zawartość suchej masy.
Termiczne kondycjonowanie osadów nadmiernych wpłynęło na wzrost wartości CSK. Poddając osady mezofilowej stabilizacji beztlenowej odnotowano w kolejnych dniach prowadzenia procesu obniżenie wartości czasu ssania kapilarnego, suchej masy, jak również stopnia zagęszczenia.