APPLICATION OF RESPIROMETRIC TESTS FOR ASSESSMENT OF METHANOGENIC BACTERIA ACTIVITY IN WASTEWATER SLUDGE PROCESSING

Abstract. Production of a methane-rich gas (‘biogas’) is contemporary popular sludges processing technology which allows to generate thermal and/or electrical energy. Formal requirements issued by the European Union to promote so called renewable energy resources mad these process more attractive leading to its application in WWTPs which were designed based on different sludges handling processes. Authors (as active design engineers) noted that dimensioning of sludge digestion chamber is usually based on SRT assessment without any emphasis on sludges characteristics. Biomass characteristics and estimation of its activity with respect to methane production are of great importance both from scientific and practical points of view, as anaerobic digestion appears to be one of crucial processes in municipal wastewater handling and disposal. Authors propose respirometric tests to estimate a biomass potential to produce ‘a biogas’ and several years’ laboratory and full scale experience proved its usefulness and reliability both as a measurement and a design tool applicable in sludge handling. Dimensioning method proposed by authors, allows to construct and optimize operation of digestion chambers based on a methanogenic activity.

Keywords: Sewage sludge, methanogenic activity, sludge digestion, renewable energy, energy recovery.

INTRODUCTION

Role of anaerobic digestion in contemporary sludge processing

Wastewater treatment processes, especially based on so called ‘activated’ sludge concept are based on general principle that an atmospheric air (rarely pure oxygen) is introduced to a mixture of municipal (or in some cases industrial) wastewater, which creates proper conditions for bacteria growth, using a organic matter (as well as other nutrients) present in human excreta and other wastes carried with wastewater. This growth produces concentration of bacteria suspended in treated wastewater called ‘activated sludge’, which is composed mainly of saprotrophic bacteria but also has an important protozoan flora such as: amoebae, Spirotrichs, Peritrichs including Vorticellids and a range of other filter feeding species. In activated sludge plants (also multiphase biological reactors) once the wastewater has received proper treatment, excess mixed liquor is discharged into settling tanks and the treated supernatant is discharged to receiving waters or undergoes further treatment before discharge. Part of the settled...
material, the ‘sludge’, is returned to the head of the aeration system to re-seed the new
wastewater inflowing the biological, while the excess sludge which eventually accumu-
lates beyond what is returned is called Waste Activated Sludge (WAS) and must be
removed from the treatment process to keep the ratio of biomass to food supplied in
balance. Application of anaerobic process to process WAS was initially focused on
stabilization of wastewater sludge with the use of methanogenic bacteria. Anaerobic
digestion has been recognized proper technology for WWTP of a capacity over 10000-
20000 m$^3$/day average flow. Later on it was found that a by-product of anaerobic sta-
bilization of wastewater sludge is a methane-rich gas (usually called a ‘biogas’) which is
combustible and can be easily converted into heat. Latest attempts towards sustainabil-
ity of municipalities led WWTPs operators to rethink a role of anaerobic processes in
overall energy balance of these facilities. Methane can be converted to thermal and
electrical energy was found promising renewable source of energy. Another advantage
was that carbon dioxide emission due to digestion of methane for energy production is
of 22% lower than summarized CO$_2$ produced during aerobic stabilization and CO$_2$
production related to electrical energy supply for aeration purposes.

Problems arose with first attempts towards increase of methane production ef-
ficiency, due to complexes character of methanogenesis phenomena. Digestion in
fact is a biochemical decomposition of organic matter from sludge by bacteria The
anaerobic degradation of organic material has been described as a multi-step conver-
sion of many, parallel, biochemical reactions. Many groups of anaerobic bacteria are
involved in this process. Four main stages of this degradation can be distinguished:
I hydrolysis of complex organic materials to soluble products (hydrolytic fermenta-
tive bacteria),
II acidogenesis – generation of intermediary products such as short-chain fatty
acids, (hydrogen producing and acetogenic organisms),
III acetogenesis – acetate production (hydrogen-producing, hydrogen-consuming
acetogenic organisms),
IV methanogenesis – methane production (methane-forming bacteria).

Methanogenic bacteria play a key role in conversion process by keeping the
hydrogen partial pressure low a condition necessary for the growth of acetogenic
bacteria. The balance activity of the mixed population of bacteria is needed to se-
cure stability of anaerobic digestion. However, this stability can be easily disturbed
by different factors causing a rapid increase of volatile fatty acids concentration fol-
lowing the decrease methane production. Failure of digesters and anaerobic reactors
has been affected by a number of compounds that may be present in sewage. One of
this group are heavy metals. The basic pre-requisite of proper operation of this proc-
ess is a balance between substrates and quantity of bacterial microorganisms. As
particulate matter cannot transfer through the microorganisms’ cell it is required
that organic and inorganic substrates are in soluble form. Conversion of an organic
matter into methane and carbon dioxide leads to decrease of degradable organic matter content in sludge down to 50-55%. The process is performed on so called technical level when approx. 50% of total organic matter is being decomposed [1]. Quantity of digestion gas obtained from an organic matter may vary depending on proportion of main sludge constituents: carbohydrates, proteins and fats. Usually it is estimated that 1 std m³ of a biogas can be obtained from 1 kg of decomposed organic matter. Average composition of digestion gas is following: \( \text{CH}_4 \) – 65-70%, \( \text{CO}_2 \) – 25-30%, and \( \text{N}_2, \text{H}_2, \text{H}_2\text{S} \) < 1%, however it may vary from case to case.

**Process characterization**

Typical characterization of a biomass being treated anaerobically is determination of a Total Suspended Solids (TSS) and volatile suspended solids (VSS) concentrations. Basing on these parameters some rough estimation of process performance can be done, and traditional methods of sludge digestion chambers dimensioning are using these data. However there is no way to differentiate between active biomass (volatile compound in bacteria cells) and substrates for the reaction (short chainy fatty acids). That is why various methods are being developed focusing on characterization which describes exactly ability of a biomass to convert substrates into methane under anaerobic conditions. This is not only ‘curiosity driven’ experiment but rather searching for tool applicable in design and operate of sludge processing facilities.

**Methods applied for process estimation**

Three groups of measurements technology have been applied by now, including[3][9]:

I. Assessment of microorganisms’ quality and quantity
   a. Assessment on most probable number of microorganisms,
   b. Immunological tests,
   c. Microscopic observation.

II. Analyses of chemical composition of microorganisms
   a. Tests on presence of a \( F_{420} \) co-enzyme,
   b. Assessment of etheric bounds (C-O-C) in cells ,
   c. Hydrogenaze activity tests.

III. Biochemical activity tests
   a. Determination of quantity and dynamics of a gas production,
   b. Determination of quantity and specific velocity of a methane production based on substrates and VSS;
   c. determination of decomposition of substrates (short chainy fatty acids)

All methods based on determination of methanogenic bacteria species were found impracticable due to long time of growth of these microorganisms. Problems
associated with incubation of pure anaerobic bacteria were described by numerous authors [7][12][13][18]. Time (duration) of isolation of pure anaerobic cultures extends to months and even years and are rarely presented in papers. That is why some authors tended to use $F_{420}$ co-enzyme as a parameter [5][6][10], however due to high adverse impact of ambient conditions on method’s accuracy this procedure has not been widely applied. Biochemical methods appear to be most promising ones. The IIIa method is not precise enough to determine the activity of microorganisms due to complex of gas content. Therefore, remaining IIIb - based on calculation of methane quantity and IIIc as a rate of substrate conversion to CH$_4$ and CO$_2$ appears to be the most prospectus methods [5][15][16][18]. Authors of these paper proved that respirometric batch tests as described below are reliable enough.

**METHODS**

**Description of a test stand**

Tests were performed using a respirometry method. Tests stand was located at the Cracow University of Technology Research Lab. The AER-208 (Challenge Systems, USA) respirometer consisted of two basic parts: apparatus to measure the gas volume and interface that transmits the obtained values to a computer for data registration. Sludge samples were placed in small air tight bottles (reaction chambers) of 0.5 liter volume, covered with rubber plugs and additionally secured with metal cups. Gas volume measurements were conducted in 8 separate compartments made from transparent plastic and mounted on a base. Photocells were installed in a base of each segment to monitor the number of gas bubbles. Primary sludge was transported from the 120,000 p.e. wastewater treatment plant. The tests stand has been presented in photograph 1, details of measuring device has been shown on photo 1. The tests stand allowed to adjust temperature within 0 to 50°C range.

![Test stand – general view](image1)

**Photo 1.** Test stand – general view

**Fot. 1.** Stanowisko badawcze – widok ogólny
Experimental protocols

Temperature: the incubation temperature was 35°C;

pH: with regard to the sensitivity of methanogenic bacteria to pH;

Experimental system: A mechanically stirred system was applied to ensure a full mixing of samples; Sample feeding: VFA substrate, mineral nutrients and yeast extract; Substrate and sludge concentration: The samples were fed with a volatile fatty acids (VFA) mixture. It was assumed that a substrate concentration in samples should range from 2 to 5g/L and the concentration of sludge from 3 to 5 g VSS/L extract [1][11].

The methanogenic activity of sludge was evaluated based on the measurements of the amount of methane produced during the fermentation process in the reaction vessels filled with anaerobic sludge, VFA substrates, mineral nutrients and yeast extract. The sludge methanogenic activity was determined by the amount of fatty acids, as g/L COD, which was consumed during the fermentation process and converted into methane (mLCH₄). The COD was referred to 1 gram of sludge VSS (volatile suspended solid) per 1 day. Based on the amount of the gas produced during the batch methanogenic test, cumulative gas production curves were plotted. Using those curves, the maximum gas production (mL CH₄) was calculated. From the maximum slope of the curves, the gas production rate R (mL CH₄/h), which determined the amount of gas produced during 1 hour, was obtained. The methanogenic activity (ACT) in g COD CH₄/g VSS*d, was calculated as follows:

\[ ACT = \frac{(R \times 24)}{(CF \times V \times VSS)} \]  

(Eq 1)

where:

R – gas production rate, mLCH₄/h
Estimation of inhibitory effect of heavy metals on methanogenic activity

Procedure applied

Respirometric tests can be used for estimation whether and to what extent heavy metals may influence a gas production. For these specific tests Cr (III) chromium was tested (pollution typical for obsolete small scale tannery industry, being important ecological problem in Southern Poland), however the same procedure can be used for other inhibitory factors. Short chain fatty acids (SCFA) substrates were added to eliminate impact of to low food to microorganism (F:M) ratio [17]. Results were presented as methanogenic activity value, which expresses ability of sludge to convert methane to substrate under unfavourable conditions.

The measurements of the amount of methane produced during the fermentation process was conducted from reaction vessels filled with:
- anaerobic biomass, SCFA substrates, mineral nutrients – as a control sample and
- anaerobic biomass, SCFA substrates, mineral nutrients, various dosage of Cr(III) - as a treatment samples
- The investigations included three test series with following doses of Cr(III): 200 mg/L, 500 mg/L, 1500 mg/L, 2000 mg/L, 3000 mg/L.

The 500 mL reaction vessels filled with anaerobic biomass, desired amount of substrate, mineral nutrients, yeast extract in control sample and toxicant added in treatment sample, were closed and sealed then placed in water bath at 35°C. The samples were mixed by a magnetic stirrer during the entire test period. At the beginning of the test, all vessels were saturated with nitrogen. The methane produced during the anaerobic process was transported by pipes through a respirometer system and was recorded by the computer system. A chromatographic analysis of gas quality was carried out for each sample separately (gas chromatograph; column Porapak QS, 80-100 Mesch, 4m, HWD-430; hydrogen). A control analysis of samples for COD, VFA, VSS and pH were performed as well.

Based on the amount of the gas produced during the batch methanogenic test and chromatography analyses of methane content, cumulative methane production curves were plotted (Fig. 2). Using those curves, the maximum methane production was determined.

Results and discussion – inhibitory effect

During the research significant differences in gas production amount were observed. Basing on the results of methane production obtained from 3 series carried
out with Cr(III) concentration from 200 to 3000 mg/L, cumulative gas production curves were plotted. The curves were drawn for control samples and samples with toxicant in the batch tests (Fig. 1). According to gas chromatographic analyses the amount of methane produced from samples during the test period was quite high: 80% and 70-74% for control and toxic samples respectively.

It can be stated that doses 200 and 500 mg Cr(III)/L\(^1\) caused decrease of a methane production of approx. 20% as compared to the reference sample. Increase of inhibiting compound dose up to Cr(III) 1500 i 2000 mg Cr(III)/L led to approx. 45% decrease of methane production. The concentration of Cr(III) equal to 3000 mg/L caused a approx. 47% decrease of methane production.

![Cumulative methane production in batch tests various Cr(III) doses](image)

**Fig. 1.** Total methane amount (expressed in volumetric units) produced during 12 days test period

**Rys. 1.** Całkowita produkcja metanu (wyrażona w jednostkach objętościowych) w okresie 12 dni

However, methane is produced until entire organic matter is converted its reaction rate tends to decrease as the concentration of substrates drops being consumed by microorganisms. After certain period of time an amount of methane produced is relatively small, and from energetic point of view energy required for facility operation becomes higher than amount of energy recoverable from a biogas. That is why for technical purposes, like digestion tanks design and/or operation optimisation solid retention time (SRT) in digestion tanks, estimation of length of period of maximum production rate is a crucial point. It is important to note that decrease of methanogenesis rate is a sign of stabilisation, showing that large part of organic matter has been decomposed into stable by products. It means that end of maximum gas production is the end of stabilisation. Length of period of maximum methane production can be estimated basing on summarisation curves plotted for each of Cr(III) doses.

\(^1\) 1 mg/L equals to 1 ppm.
Methane production under inhibitory conditions was expressed in relation to a reference (control) sample which was inhibitor free. Table 1 summarizes results of tests on an inhibitory effect.

Table 1. Period of maximum methane production at various Cr(III) doses

| Cr(III) dosage [mg/L] | Time of max CH₄ production [hours] |
|-----------------------|-----------------------------------|
| control               | approx. 96                        |
| 200                   | 120 - 144                         |
| 500                   | 144 - 168                         |
| 1500                  | approx. 168                       |
| 2000                  | to be repeated                    |
| 3000                  | exceeds test period               |

It is visible that volume of methane decreases as the inhibitory dose rises, on the other hand a length of maximum productivity period extends with doses. Based on the amount of the gas produced during the batch methanogenic test, cumulative gas production curves were plotted. Using those curves, the maximum gas production (mL CH₄) was calculated. From the maximum slope of the curves, the gas production rate R (mL CH₄/h), which determined the amount of gas produced during 1 hour, was obtained.

Results – application of methodology in practice

Exact dimensioning of digestion chambers

Determination of proper retention time in digestion chambers is of crucial importance in design optimization of these facilities. It is especially difficult, when there is no ‘real sludge’. In this specific case, the sludge was obtained in small portion as continuous operation of the plant was still based on a pattern: digestion of primary and simultaneous aerobic stabilization of a WAS. A procedure of estimation of these parameters for predicted mixture of a primary sludge and WAS has been proposed as based on cumulative curves of a gas production for digestion without an inoculation. Based on plotted curve VSS content vs. time the net length of the start-up (‘yield’) phase was estimated, similarly a length of effective gas production phase (‘decay’) was estimated. The procedure for mixed sludge (1:1 proportion) is shown in Fig. 2. The maximum theoretic effective gas production period was estimated as an interval between intersection point of tangent to a VSS content curve with a time-axis and a final point of an effective gas production period, which led to general SRT equal to 23 days adopted for design purposes.
The procedure for this proportion was illustrated in Fig. 1. Duration of a start-up period was estimated equal to 27 days but it must be recognized that these tests were completed without an inoculation. The effective digestion period has been determined as 23.5 days. If the digestion time was extended over this value it did not resulted in better stabilization of sludge. This value was adopted for a real-term design. Lab tests proved that common digestion of primary and WAS sludge is technically feasible but requires some capital improvements of the plant. Basing on our tests it was decided by the plant owner that a design a capacity of the biogas generation system will be 2000 Stdm$^3$/day with possible extension of a gas production to maximum value approx. 28000 Stdm$^3$/day. Results of tests were approved than adopted as a process calculations by a designer.

Results – Application of respirometric tests on assessment of disintegration of sludge

Recent application of respirometric tests was in the field of sludge disintegration. This technology was invented to improve overall methane-rich gas production by partial disintegration of microorganisms’ cells. Before respirometric tests were applied, typical assessment of efficiency of disintegration was done by steady state measurements of COD solubilisation, change of sludge flocs’ size or change in protein concentration [1][2][14]. Results from these measurements technology cannot be simply incorporated into design procedures of wastewater treatment plants. Data necessary for a process engineer usually include a real change (increase) in a biogas yield and an effective digestion time within a chamber (SRT in digestion chamber). The methanogenic activity procedure has been invented as an accurate tool for prediction of a net gas production and estimation of its dynamic [11]. Typical scope of tests were as follows:

![Fig. 2. Determination of a retention time for design purposes. Mixed sludge : primary and WAS (1:1 proportion)](image-url)

Rys. 2. Wyznaczenie czasu zatrzymania osadu w reaktorze – dla celów projektowych (proporcja osadu wstępnego do nadmiernego równa 1:1)
Inżynieria Ekologiczna Nr 25, 2011

- Determination of sonication parameters based on initial calculations of a sludge disintegration degree for the WAS;
- Fermentation tests performed at a respirometric test stand for the WAS, after its disintegration at various parameters;
- Methanogenic activity tests – batch tests of the WAS.

Based on results described above, the first stage of investigations on methanogenic activity has been performed. It was completed for the following parameters of disintegration:
- Sound intensity \(24 \times 10^3\) W/m\(^2\)
- Sonotrode draught. 4 cm
- Time of disintegration 3,5,7,9 minutes
- Repeatability of results (two identical samples from each WWTP, digested at the same time)
- Frequency of a biogas measurement; 2 hours
- Duration of tests; 14 days (plus incubation)

Gas production measured during one of the selected series has been presented in Figures 3 and 4 as gas cumulative curves, plotted from the data obtained at a sonication intensity equal to \(24 \times 10^3\) W/m\(^2\) (ultrasound density \(5,8 \times 10^4\) W/m\(^3\)).

They reflected a fermentation gas production at a changing sonication time, prior to fermentation. A gas production curve for non-sonicated samples has been drawn in each figure to show how the sonication process impacts changes in a gas yield. Figure 3 proves that this time of sonication appears to be too short to decompose a cells’ structure properly. Increase of a sonication time to 5 and then to 7 minutes resulted in higher both gas production and a sludge methanogenic activity (ACT) parameter. A further increase of gas production was observed for a sonication time of 7 minutes. Figure 4 presents results for both sonication times: 7 and 9 minutes, and confirms that increase of this parameters over 7 minutes did not result in a dynamic increase of gas production. Similar changes in gas production and sludge activity were observed for a lower ultrasound density. Remaining experimental series confirmed the observations presented in Table 2.

**Table 2. Methanogenic activity and disintegration calculations – , intensity \(24 \times 10^3\) W/m\(^2\); ultrasound density \(11,6 \times 10^4\) W/m\(^3\)**

| Time [min] | 0  | 3  | 5  | 7  | 9  |
|------------|----|----|----|----|----|
| COD reduction [%] | 90 | 92 | 90 | 91 | 91 |
| VSS [g/L]   | 4,03 | 4,12 | 3,99 | 3,77 | 3,80 |
| R           | 4,25 | 5,6 | 5,9 | 6,5 | 6,8 |
| ACT         | 0,11 | 0,16 | 0,18 | 0,20 | 0,21 |
Microbial observations

Photographs 3 and 4 present microscopic images of the sludge before and after ultrasound disintegration. All images were taken during tests, at the following parameters: intensity $24\times10^3$ W/m$^2$; ultrasound density $5,8\times10^4$ W/m$^3$; optical magnification 100 x.

Photo 3. Structure of sludge before sonication
Photo 4. Structure of sludge after 3 minutes sonication

Fot. 3. Struktura osadu przed sonikacją
Fot. 4. Struktura osadu po 3 min sonikacji
A non-dyed sample presented in Photo 3 shows a typical image of activated sludge with filamentous bacteria. Following images show changes in a sludge structure after an increase of sonication times (3, 5, 7, 9 minutes). The increase of a sonication time makes a microscopic image of sludge more ‘fuzzy’ and it is hard to observe a structure of sludge flocs and/or presence of filamentous bacteria. Such observations can confirm efficient mechanical decomposition of cells but have no application in a quantitative description of the process.

CONCLUSIONS

1. Common methods of assessment of microbial activity are not handy enough in case of methane generating organisms, neither for scientific nor for design purposes, as they do not express a gas production but focus rather on substrates’ accessibility.
2. Respirometric tests can be applied in estimating adverse impact of inhibitory factors on a biogas production and its compositions.
3. The method proposed in this paper, based on methanogenic activity, seems to be more flexible. Application of methanogenic activity tests is a valuable tool for a digestion chamber dimensioning in case when the content of sludge is unknown.
4. Proposed design procedures led to exact calculation of a digestion time which is considered the main parameter for the dimensioning of the sludge processing line at existing as well as being upgraded plant (e.g. in case of changing of general concept of sludge processing).
5. Respirometric tests were successfully applied for estimation of sludge disintegration efficiency. Results obtained with ultrasound disintegration assessment can be easily applied for any other disintegration method.

ACKNOWLEDGEMENTS

Experiments presented in this paper were financially supported by Ministry of Science, Republic of Poland; research grant NN 523 3773 33.

REFERENCES

1. Cimochowicz-Rybicka M., Kocwa-Haluch R. (1999) Assessment of trivalent chromium effect on anaerobic biomass methanogenic activity using batch test system. Toxicological and Environmental Chemistry, v.3.
2. Codina J. C. et.al. (1998) The inhibition of methanogenic activity from anaerobic domestic sludges as a simple toxicity bioassay. Wat. Res. v. 32, no 4, pp. 1338-1342.
3. Colleran et al. (1993) Use of Methanogenic Activity Tests to Characterize Anaerobic Sludges. Screen for Anaerobic Biodegradability and Determine Toxicity Thresholds Against Individual Anaerobic Trophic Groups and Species. Materiały otrzymane od autora z Dept. of Microbiology, University College, Galway, Irlandia.
4. Cywiński B., Gdula S., Kempa E., Kurbiel J., Płoszański H. (1983) Wastewater treatment (in Polish), v.2 ed. Arkady, Warszawa.
5. Dofling J., Bloemen W.G.B.M. (1985) Activity Measurements as a Tool to Characterize the Microbial Composition of Methanogenic Environments. J. Microbiol. Methods no 4, pp. 46-57.
6. Ferry J.G. (1993) Methanogenesis, Ecology, Physiology, Biochemistry and Genetics. Chapman and Hall, New York.
7. Guyot J.P., Noyola A., Monroy O. (1990) Evolution of Microbial Activities and Population in Granular Sludge from an UASB Reactor. Biotech. Letters v. 12, no 2, pp. 155-160.
8. IHE (1991); Laboratory Course Process Parameters and Microbiology; Handbook of AWWT Course. IHE Delft, Wageningen Agricultural University, Holandia.
9. Iza J. i in. (1991) International Workshop on Anaerobic Treatment Technology for Municipal and Industrial Wastewaters: Summary Paper. Wat. Sci. Tech. v. 24, no 8, pp.1-16.
10. James A., Chernicharo C.A.L., Campos C.M.M. (1990) The Development of a New Methodology for the Assessment of Specific Methanogenic Activity. Wat. Res. v 24, no 7, pp. 813-825.
11. Lettinga G., Hulshof Pol L.W. (1991) UASB-Process Design for Various Types of Wastewater, Wat. Sci. Tech. vol 24, pp 87-107.
12. Macario A.L., Macario de E.C. (1993) Immunology of Methanogenic Bacteria. Biomass and Bioenergy, v. 5, no 3-4, pp. 203-213.
13. Ng A., Melvin W.T., Hobson P.N. (1994) Identification of Anaerobic Digester Bacteria Using a Polymerase Chain Reaction Method. Bioresource Technology, v. 47, pp. 73-80.
14. Pavlostathis S.G., Giraldo-Gomez E. (1991) Kinetics of Anaerobic Treatment: A Critical Review. Critical Reviews in Environmental Control, 21(5,6): pp.411-490, CRC Press, Inc.
15. Petrozzi S., Mol N., Dunn I.J. (1992) Determining Specific Biomass Activity in Anaerobic Wastewater Treatment Processes. Bioprocess Engineering no 8, pp. 55-60.
16. Soto M., Mendez R., Lema J.M. (1993) Methanogenic and Non-methanogenic Activity Tests. Theoretical basis and Experimental Set Up. Wat. Res. v 27, no 8, pp. 1361-1376.
17. WEF (1992); Design of Municipal Wastewater Treatment Plants, tom II; WEF Manual of Practice No. 8, ASCE Manual and Report on Engineering Practice No. 76, Library of Congress Catalogue Card No. 91-30528, USA, Brattleboro, Vermont.
18. Young J.C., Kuss M.L., Nelson M. (1991) Use of the Anaerobic Respirometers for Measuring Gas Production in Toxicity and Treatability Tests. proc. 84th Ann. Meeting of the Air and Waste Manag. Assoc., Vancouver, B.C., Kanada.
19. Young J.C., Tabak H.H. (1993) Multilevel Protocol for Assessing the Fate and Effect of Toxic Organic Chemicals in Anaerobic Treatment Processes. Water Environ. Res., v. 65, no 1.

ZASTOSOWANIE TESTÓW RESPIROMETRYCZNYCH DO OCENY AKTYWNOŚCI BAKTERII W PROCESIE PRZERÓBKI OSADÓW ŚCIEKOWYCH

Streszczenie. Wytwarzanie gazu fermentacyjnego w procesie przeróbki osadów ściekowych jest powszechnie stosowaną technologią pozwalającą na produkcję energii cieplnej, lub w rozwiązaniach bardziej zaawansowanych także energii elektrycznej. Obecne naciski formalne UE na pozyskiwanie energii z tzw. źródeł odnawialnych spowodowały coraz szersze zainteresowanie tą technologią przeróbki osadów także w tych obiektach, które zostały zaprojektowane w oparciu o inne technologie przeróbki i stabilizacji. Uwagę autorów zwrócił fakt, że projektowanie komór fermentacyjnych opiera się najczęściej na arbitralnym przyjmowaniu czasu zatrzymania osadu, bez uwzględniania specyfiki składu osadów doprowadzanych do komór fermentacyjnych. Zaproponowana metoda – sprawdzona przez autorów w praktyce inżynierskiej – pozwala na bardziej precyzyjne zaprojektowanie urządzeń nowych i optymalizację układów istniejących. Podstawą zaproponowanego działania jest wykorzystanie testów respirometrycznych do wyznaczenia aktywności metanogennnej osadów poddawanych fermentacji. Parametr ten – w ogólnym zarysie – określa się na wyznaczaniu zdolności bakterii do wytwarzania gazu fermentacyjnego zawierającego metan przy różnym składzie osadu doprowadzanego do komór fermentacyjnych. Przedstawione stanowisko badawcze odtwarza w wysokim stopniu warunki panujące w rzeczywistej komorze fermentacyjnej. Pozwala to na badanie efektów inhibicji procesu produkcji metanu, w tych przypadkach w których osady ze ścieków o charakterze bytowym mogą zawierać substancje spowalniające lub hamujące proces metanogenezy.

Słowa kluczowe: Osady ściekowe, aktywność metanogenna, fermentacja osadów ściekowych, energia odnawialna, odzysk energii.