INFLUENCE OF ACTIVATED SLUDGE SRT ON ANAEROBIC EXCESS SLUDGE DIGESTION

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ABSTRACT

Investigations of different activated sludge samples were performed in order to evaluate the influence of aerobic activated sludge SRT on digester gas production during anaerobic sludge stabilisation. A decrease of anaerobic sludge degradation efficiency and in turn, a decrease of gas production could be confirmed as SRT was raised. Furthermore, simple test methods to predict digester gas production were tested which may be used for on site purposes.

KEYWORDS

Activated Sludge Plant, Sludge Stabilisation, Nutrient Removal Plant, Sludge Digestion, Digester Gas Production

INTRODUCTION

Anaerobic digestion is the most common method for sludge stabilization in medium size waste water treatment plants. Besides a high decomposition efficiency of organic matter, this method especially is favourable regarding the energetic balance of waste water treatment process.

Decomposition efficiency of anaerobic digestion may be described by several process factors, i. e.

- specific gas production vs. incoming or degraded organic matter
- organic solids removal efficiency ηVSS.

Recently, ever more activated sludge (AS) plants are extended for nitrification/denitrification. The technical modifications of AS plants for nutrient removal will influence anaerobic sludge stabilisation process mainly in two ways (Pöpel, 1993, ATV 1999):

1. SRT of AS systems is increased in order to grow and enrich nitrifiers within the system.
2. Pre-clarification volume is reduced in order to increase the organic content of the influent for denitrification purposes.

Both factors are supposed to lead to a decrease of both ηVSS and digester gas production during anaerobic sludge digestion.

While the influence of reduced primary sludge generation on gas production can easily be calculated (gas production per unit VSS removed remains fairly constant), the influence of the increased SRT has up to now only been estimated. Pöpel, 1993 and ATV, 1999 assume that VSS-removal efficiency remains constant. This would mean, gas production and VSS-degradation would only depend on the organic content of the excess sludge fed to the digester.

This might actually not be the case, because the prolonged SRT leads to a partial aerobic degradation of VSS, the remaining solids only being limited accessible to anaerobic degradation. This would mean, that digester gas production will decrease per unit of VSS in digester feed.

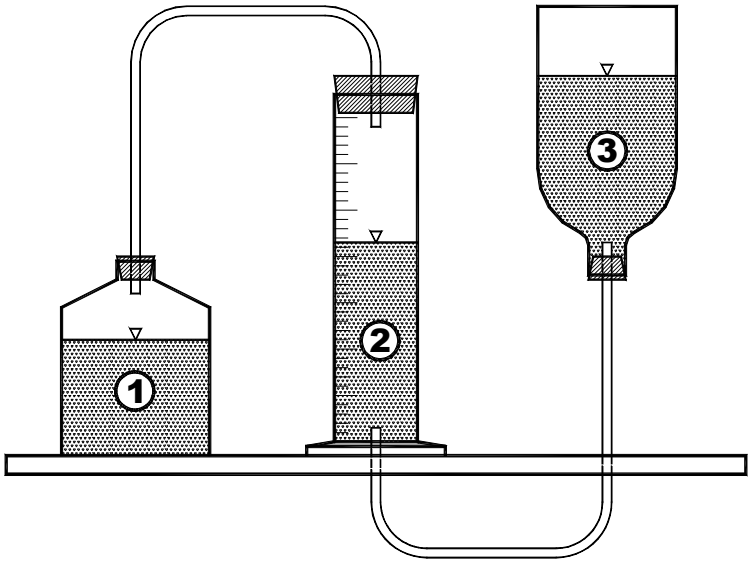
In a research project funded by the German state of Lower Saxony, investigations were carried out to quantity these effects.

METHODS

From 11 different AS plants, excess sludge samples were taken. At the same time, operation data of the WWTP were gathered to get information on important operating data like sludge loading rates, SRT etc. Actual SRT of the sludges investigated ranged from 6 to 26 days; one high loaded plant with only 0.7 days SRT was also included.

In the laboratory, sludge samples were analysed for SS, VSS and COD. After this the sludge was anaerobically digested in batch tests at a constant temperature of 35 °C. As an inoculum, digester effluent of the same WWTP was used if possible. For excess sludge from plants without anaerobic digestion, digested sludge from other WWTP was used. The tests were run for a period of 20 days, after which the anaerobic degradation was observed to be practically complete and which corresponds to the design detention time in many full scale mesophilic anaerobic digesters.

Gas production was measured by fluid displacement, using an alkaline solution to absorb the CO_2. The test set-up is shown in Fig. 1. The total digester gas production was calculated assuming a CH_4-content of 67 %, i.e. the measured results were divided by 0.67. Furthermore, the values were corrected to compensate temperature and pressure influence.



Legend:
1. Reaction vessel V_{sludge} = 600 – 800 ml
2. Gas storage and sampling
3: Displacement fluid balancing vessel

Fig. 1. Test set-up of batch anaerobic fermentation tests

Furthermore, two simple tests were carried out with each of the sludge samples:

- Measurement of AS endogenic respiration rate after 1 day aeration at 20° C using the method described by Svardal (1997).
- Measurement of organic acid production after 7 days. The raw excess sludge was put into a closed vessel at 20° C, agitated manually once a day and fatty acids produced (measured as volatile HAc equivalents) were measured after 7 days.

The purpose of these tests was to check whether they are appropriate as a simple method to estimate the digester gas potential of excess activated sludge.

RESULTS

Influence of activated sludge SRT on digester gas production

In Fig. 2, results of specific gas production per unit of raw sludge VSS added to the digester (q_G, Nml/gVSS feed) versus sludge age are shown. A clear dependency can be seen. Even if the value of the single high loaded system (SRT = 0.7 d) is neglected, (because all other plants were operated at SRT between 6 and 26 d), a decrease from 300 Nml/g to 250 Nml/g at SRT = 5 d and 27 d, respectively, was observed. In terms of solids degradation efficiency ηVSS, this corresponds to a decrease from about 40 (5 d) to about 30 % (27 d) at a given specific digester gas production of 750 Nml/g$VSS_{degraded}$.

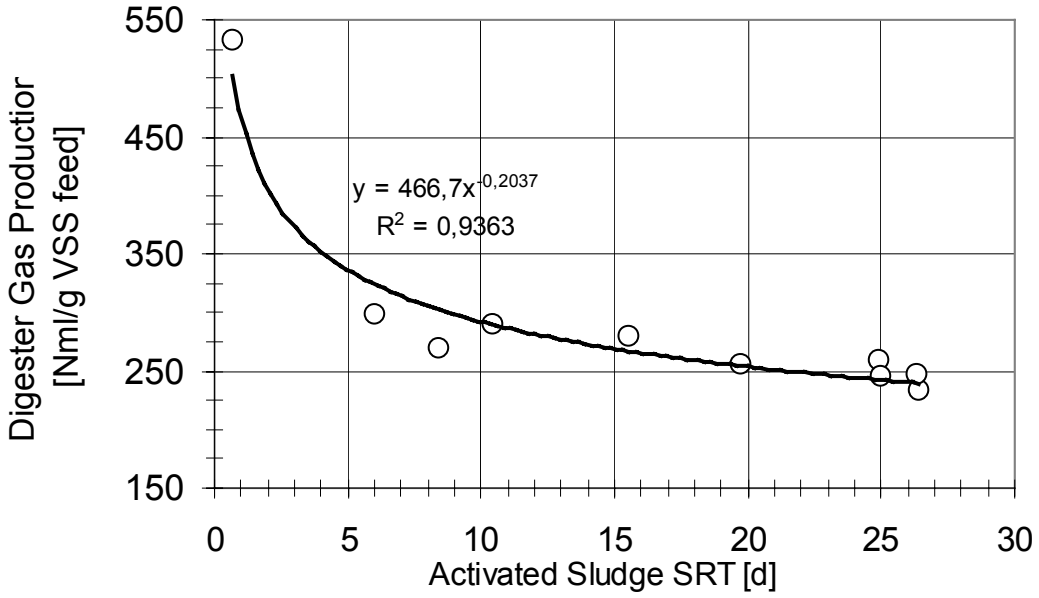


Fig. 2. Results of batch test digester gas production vs. activated sludge SRT

The calculated regression indicates a good fit of data ($R^2 = 0{,}936$):

$$q_G = 467 \times SRT^{-0{,}2037}$$

Endogenic AS respiration rate and digester gas production

Results of endogenic respiration rate were clearly dependent on SRT of the AS plants. Accordingly, a good dependency of specific gas production q_G on respiration rate was found, as shown in Fig. 3.

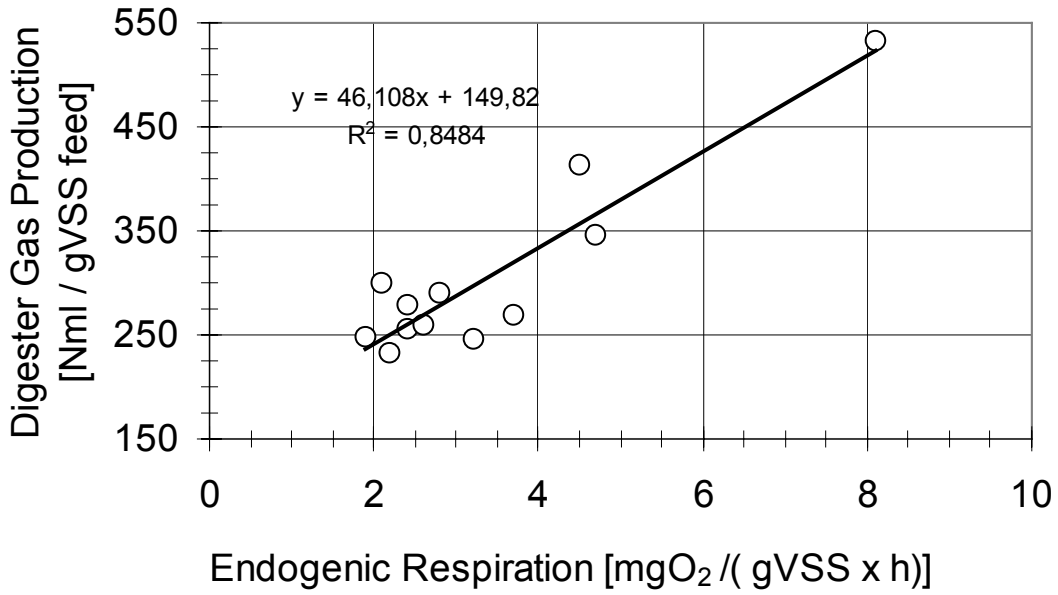


Fig. 3. Results of batch test digester gas production vs. activated sludge endogenic respiration rate

Acidification potential and digester gas production

Digester gas production and the amount of volatile fatty acids (VFA) should be closely linked to each other, since VFA are the main source of methane production. In our tests, this could be proven as shown in Fig. 4.

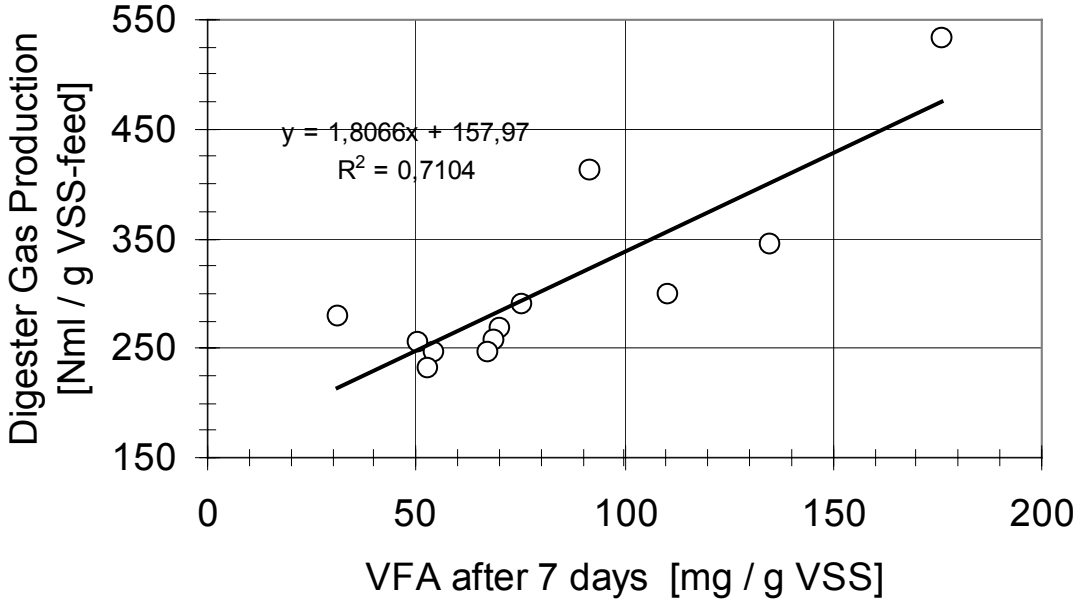


Fig. 4. Results of batch test digester gas production vs. VFA production after 7 days

CONCLUSIONS

From the results, the following conclusions can be drawn:

- As SRT of AS plants is increased in order to achieve nitrification, not only the amount of excess sludge production decreases due to endogenic decay. In addition, the remaining organic content is less degradable during anaerobic sludge digestion. This leads to a decrease in digester gas production, which in turn will influence total energy balances of full scale WWTP.

- Normally, in full scale plants a mixture of primary and secondary sludge is digested. Therefore it is not possible to determine gas production from excess sludge. Using simple measurements of endogenic respiration and/or acidification potential of excess sludge, good and practicable estimation methodes are available for on site purposes

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REFERENCES

ATV (1999):
Energy balances of waste water treatment plants (in German)
Status report of the German ATV FA 3.1

Kapp, H. (1998):
Influence of sludge digestion on energy balances of waste water treatment plants (in German)
Stuttgarter Berichte zur Siedlungswasserwirtschaft, Technical University of Stuttgart,
Vol. 149, 169 ff, R. Oldenbourg Verlag München

Mennerich, A: (2000):
Final report for the research project: “Energy and mass balances during anaerobic waste water sludge stabilisation, under preparation

Pöpel, H.-J. (1993):
Effects of waste water treatment and sludge treatment technologies on digester gas production (in German)
Schriftenreihe WAR, Technical University of Darmstadt...

Svardal, K. (1997):
Setup and interpretation of respiration measurements of activated sludge systems (in German)
Wiener Mitteilungen, Vol. 141, Technical University of Vienna, Institut für Wassergüte und Abfallwirtschaft