DISINTEGRATION OF SLUDGE - A WAY OF OPTIMIZING ANAEROBIC DIGESTION

Anna Maria Sundin
Käppala Association, Lidingö, Sweden
annamaria.sundin@kappala.se +46(0)8 766 67 11

ABSTRACT

The recent years there has been an increasing interest in optimizing the anaerobic digestion at wastewater treatment plants since the energy produced in the biogas has become more valuable, and the cost for sludge disposal more expensive. The Käppala Wastewater Treatment Plant is designed for a load of 700 000 p.e, receiving wastewater from eleven municipalities in Stockholm. The gas production at Käppala has increased by 50% since 2001, 6,1 million Nm³ biogas was produced during 2007. In addition to measures taken to improve the operation of the digesters, different methods for pre-treatment of sludge have been tested. However, the tested methods have shown not to be economically feasible. A breakthrough was made during 2007-2008 when a mechanical disintegration used for treating screenings from the mechanical treatment at Käppala WWTP was tested for pre-treatment of sludge. Full-scale batch tests has been made and evaluated in laboratory scale digestion. Significant increase in specific methane production was observed in the case of biological excess sludge and digested sludge, resulting in a 7% increase of the total gas production. A cost-benefit analysis has been done of the system, showing a break-even below 5% increase of the gas production. This would be equivalent to a pay-back time of approximately one year.

KEY WORDS

Anaerobic digestion, mechanical pre-treatment, disintegration, sludge, biogas potential, wastewater treatment, cost-benefit analysis

INTRODUCTION

During the past two years an increased interest in optimizing the energy balance over the wastewater treatments plants in Sweden has aroused due to increasing energy costs. One part of this is decreasing the use of electric power in the plant by optimizing the treatment processes. A second aspect is to regain the heat in the effluent, treated wastewater with heat pumps. The third, but not last effort is to optimize the usage of the organic matter in the influent wastewater, producing as much biogas as possible in the anaerobic digester. The energy in the biogas can be used for heating, electricity production or as car fuel, replacing other fossil fuels.

A way of improving the biogas potential of the organic matter is to have a pre-treatment of the sludge before the digester. There are different methods to do this, such as chemical, mechanical, ultrasonic, thermal or biological pre-treatment using enzymes (Drawnel, 2008). In a full scale application the profits made having a more efficient digestion process must be put against the investment and operational cost for the system.

Käppala Wastewater Treatment Plant

The Käppala Wastewater Treatment Plant takes sewage from eleven municipalities north and southeast of Stockholm. Sewage from approximately 530,000 p.e. is treated in the plant situated in Lidingö, a suburb of Stockholm, the capital of Sweden. The plant is situated in a rock to save space for housing areas. The Käppala Association is responsible for running the plant and a tunnel system of about 65 km.

The treatment comprises of mechanical, biological and chemical treatment and a final filtration stage, see Figure 1. The biological step is an activated sludge process with UCT-configuration, with the possibility to run a combined biological phosphorus and nitrogen removal. The primary sludge and the biological excess sludge is digested and then dewatered on belt filter presses. Since May 2006 the digested sludge is treated with the KemiCond™ process before dewatering, with the intention to increase the dry solid content. The total amount of sludge is 40 000 tons, or 8 000 tonnes of dry solids per year. Since July 2008 the
sludge is certified according to the Swedish ReVAQ-system assuring a high quality of the sludge so it can be used on farmland. Since August 2008, 90% of the sludge from Käppala WWTP has been used on farmland as fertilizer.

During the last couple of years the gas production has increased at Käppala WWTP, see Table 1. The aim is to improve digestion to increase the gas production and decrease the amount of sludge to be dewatered. During the year of 2007 6,2 million Nm$^3$ gas was produced, corresponding to 32 GWh heat energy produced in the gas burners. A major part, 27 GWh, of this energy was used as district heating in Lidingö giving the Association an income of about 660 000 € last year. However, Käppala association has evaluated the future usage of the gas, and come to the conclusion that it’s more beneficial to upgrade the gas to car fuel quality, both from an environmental and economical perspective. From the year 2010 the gas will be used as fuel in 100 busses in the Stockholm area, increasing the economical value of the gas by approximately 1 million euros per year.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas production (million Nm$^3$/year)</td>
<td>4.6</td>
<td>4.7</td>
<td>5.5</td>
<td>5.7</td>
<td>5.9</td>
<td>6.2</td>
</tr>
<tr>
<td>Produced heat in gas combustion (GWh)</td>
<td>22</td>
<td>23</td>
<td>26</td>
<td>28</td>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>Sludge to dewatering (tonnes dry solids/year)</td>
<td>7 200</td>
<td>7 400</td>
<td>7 500</td>
<td>7 800</td>
<td>7 700</td>
<td>7 700</td>
</tr>
</tbody>
</table>

One of the measures taken to improve the capacity of the digesters is the dewatering of the excess sludge which was improved in 2002 by replacing the old thickeners with centrifuges. This increased the DS concentration from 2 % to 6 %.

During the end of the 90’s and in the beginning of this century Käppala WWTP had immense problems with foaming in the digesters. The foaming was caused by abundant amounts of Microthrix parvicella produced in the biological step in combination with high gas production when digesting primary sludge with a high content of easily degradable organic matter. In the autumn of 2003 a system for disintegration of the biological excess sludge was tested. The sludge, including the Microthrix filaments, was supposed to be destroyed before the digestion (Sundin, 2006). The treatment had an effect on the sludge, and shortened the filamentous bacteria, but did not stop the foaming problems.
However, during the last couple of years ways of running the digesters more efficient have been found, with a much more stable process without foaming problems. Currently the digesters are run as shown in Figure 2, with primary sludge being pumped into the first digester and then, together with excess sludge, led to the second digester. In this way foaming is avoided since the gas production is lower in the second digester where the filamentous bacteria enter the system with the biological excess sludge. This operation mode is also very efficient out of a digestion perspective, since the retention time is longer for the primary sludge, compared to other modes of operation. The total residence time for the primary sludge is 28 days (17+11 days) and for the excess sludge 11 days. It is the primary sludge that has the highest biogas potential. (See Figure 2.) The degree of VS-degradation is approximately 60% over the whole system.

![Mass balance over the digesters at Käppala WWTP during 2007. DS: dry solids, VS: volatile solids; ΔVS: degree of degradation. Methane concentration biogas: 60%](image)

**Figure 2:** Mass balance over the digesters at Käppala WWTP during 2007. DS: dry solids, VS: volatile solids; ΔVS: degree of degradation. Methane concentration biogas: 60%

**METHODS**

**The disintegration equipment**

At Käppala WWTP the screenings from the step screens are collected and ground in a machine normally used in the paper industry. The grinder is called Krima Disperser System™ and is a product of Cellwood Machinery™. The ground screening material is diluted with water and is then pumped to the digester where it is digested together with the sewage sludge. This system has been used for treating the screenings at Käppala WWTP since 2004. It was installed as a result of new legislation that prohibits the depositing of organic waste starting at New Year 2004/2005.

The material enters the disperser in the infeed zone and then passes between two rotating discs with a gap of 0,20 mm (see Figure 3). The discs have teeth grounding the material helping the breakdown of the material passing through the system. The capacity of the Krima is 20 L/s.

www.european-biosolids.com

Organised by Aqua Enviro Technology Transfer
Käppala WWTP has also tested another machine from Cellwood, the Grubbens deflaker Labyrinta. This is a smaller equipment with lower investment and operational costs. The function is similar to the Krima disperser but the diameter of the rotor is smaller which gives a lower periphery velocity when treating the material. Another difference is that the gap between the discs is 1-2 mm which is wider than for the Krima (0,2 mm) (Cellwood, 2008). The deflaker is designed for treating materials in a liquid phase, while the Krima disperser could tear materials with high dry solids content. The capacity of the Grubbens deflaker is approximately 17 l/s.

The energy consumption has been measured for both the Krima disintegration and the Grubbens deflaker respectively. The power consumption of the Krima disperser was 80kW and for the Grubbens deflaker 30 kW. The specific energy consumption was 2 kWh/m$^3$ (0,03 kWh/kg DS) and 0,75 kWh/m$^3$ (0,02 kWh/kg DS) respectively.

Disintegration of sludge with the Krima disperser system

Käppala WWTP have tested to disintegrate sludge from the treatment plant with the Krima disperser, which is a new application of the Krima disperser system. The aim with the treatment is to increase the degradability of the sludge in the digester, giving an increased gas production and less sludge to deposit.

Disintegration of primary sludge and biological excess sludge in November 2007

A mechanical disintegration test was made in November 2007 where primary sludge and thickened excess sludge were treated separately. An overview of the experimental set up is presented in Figure 4. Sludge was collected and loaded in a tank lorry having two separate tanks, each with a volume of 8 m$^3$. The sludge was pumped into the Krima disperser system where it was disintegrated and then pumped into the second tank volume of the lorry. The treatment was repeated six times and samples were taken out after each cycle. Analyzed parameters and the methods used are presented in Table 2. The biogas potential of the sludge was analyzed in a laboratory scale batch digestion test before and after the treatment, see methodology below.
Figure 4: A generalized overview of the experimental set up of the sludge disintegration at Käppala WWTP

Table 2: Analyzed parameters and standard methods

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Standard method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry solids (%)</td>
<td>SS028113-1</td>
</tr>
<tr>
<td>Loss of ignition (%)</td>
<td>SS028113-1</td>
</tr>
<tr>
<td>COD (mg/l)</td>
<td>SS028142-2</td>
</tr>
<tr>
<td>pH</td>
<td>SS028122-2</td>
</tr>
<tr>
<td>Ammonia nitrogen (mg NH₃-N/l)</td>
<td>AN 30/87</td>
</tr>
</tbody>
</table>

Disintegration of primary sludge, biological excess sludge and digested sludge in May 2008

A new disintegration test was made in May 2008, as a development of the test made in November 2007. This time, disintegration of three different types of sludge was investigated, primary sludge, biological excess sludge and digested sludge, respectively. A more narrow spaced teeth disc was tested, to see if this would give a better grinding effect on the biological sludge, see Figure 5. In connection to the test of the Krima disperser another equipment from Cellwood machinery was tested to disintegrate the biological sludge, the so called Grubbens deflaker, designed for treating material in a liquid phase and with a lower power consumption than the Krima disperser.

Figure 5: Photo showing the difference between narrowed spaced (lower segment) and medium spaced discs (upper segment).

www.european-biosolids.com
Organised by Aqua Enviro Technology Transfer
The chemical analyses made where dry solids and loss of ignition of the sludges as well as the total and dissolved COD before and after the treatment. A microscopic investigation of the biological sludge was made before and after the disintegration. The biogas potential was analyzed before and after the treatment.

An uncertainty when evaluating the results from May 2008 is the fact that enzymes where added to the digesters during the period February – May 2008. This could have affected the results; however, the enzymes did not show any significant effect on the gas production or degree of degradation in full scale.

**Laboratory scale batch digestion test**

The biogas potential of the sludges before and after disintegration was analysed at JTI- the Swedish institute of Agricultural and Environmental engineering in Uppsala.

The inoculum was taken from the digester at Käppala WWTP and transported to JTI approximately one week before the tests to degas the sludge before the biogas potential tests were started.

The biogas potential for each sludge type was monitored in a laboratory scale batch digestion test in 1 L bottles at 37°C with inoculum from Käppala WWTP. (See Figure 6.) The loading used in the tests corresponds to 5 g VS/L reactor volume (total sludge volume 600 mL, out of 440 mL inoculum). The bottles were placed on a shaking table in a room with a constant temperature of 37°C to insure a gentle mixing and heating of the sludge. A triplicate digestion test was made for each sludge. The batch digestion test was carried out for at least 30 days.

The dry solids content (DS) and the loss of ignition where analysed for all sludges and the inoculum.

The gas production was calculated by digital pressure measurement in each bottle. The equipment used for this was a digital pressure meter (GMH 3110) with a pressure sensor (GMSD 2BR; -1000 to 2000 mbar). The pressure was then converted to normalized gas volume (0 degrees Celsius, and 1 atmosphere of pressure).

Gas samples where taken out and analysed using gas chromatography (PerkinElmer ARNEL, Clarus 500, and column: 7’ HayeSep N 60/80, 1/8” SF; FID detector 250 ºC; carrier gas: Helium, flow 31 mL/min ; injector temperature: 60 ºC; injection made by a Headspacesampler Turbo Matrix 110).

**Figure 6:** Equipment used for the batch laboratory scale digestion tests at JTI in Uppsala (Drawnel, 2008)

www.european-biosolids.com
Organised by Aqua Enviro Technology Transfer
RESULTS AND DISCUSSION

Laboratory scale batch digestion test and chemical analysis

Disintegration of primary sludge and biological excess sludge in November 2007

The mechanical disintegration of the biological sludge resulted in a significant increase of the methane gas production, the specific gas production of the untreated reference sludge was 62 NmL/g VS compared to 230 NmL/g VS for the treated sludge, see Figure 7. It is notable that the gas production stopped for the reference sludge after 20 days, whereas the treated sludge continued to produce gas for more than 50 days. The results show that one treatment cycle is enough to get the effect on the gas production. It should be stated that the reference gas production is comparable low, in 2004 a batch digestion test was made with biological excess sludge from Käppala WWTP, giving a specific methane production of 120 NmL/g VS after 11 days (Leksell, 2004), this is more comparable to the full scale experience from Käppala WWTP where the specific gas production in the second digester with biological excess sludge was 0.10 Nm³ CH₄/kg VS as an average 2007, and with an average residence time of 11 days (see Figure 2).

It could be concluded that the mechanical disintegration of the sludge both has a kinetic effect with a higher velocity on the initial gas production, as well as an effect on the specific methane potential of the sludge, resulting in a higher level of the gas produced from the substrate.

Figure 7: Specific methane production of untreated and treated biological excess sludge (DS content 6%, VS content 4.2%). Treatment with the Krima disperser medium spaced disc for up to six cycles.

The untreated primary sludge has a higher specific gas production than the biological sludge since it has a higher content of fat and other easily degradable compounds. The disintegration of primary sludge resulted in a 10% increase of the specific methane production after one cycle (261 ± 14 NmL/g VS), however the gas production after 6 cycles was the same as the reference sludge (235 ± 11 NmL/g VS), see Figure 8. This result is puzzling, and could probably be explained by the high standard deviation for the specific experiment, that is, the difference between the samples is in between the margin of error.
During the disintegration test with the Krima samples were taken out after each cycle. These samples were analysed with respect to a number of parameters to find out whether the change in chemical composition of the sludge could be correlated to the biogas potential of the sludge before and after the treatment. The dissolved COD increased significantly for both the biological sludge and the primary sludge. (See Figure 9.) The diagram suggests that an increased number of treatment cycles would have an increased effect on the chemical composition of the sludge. However, this has no effect on the final gas production, having in mind that the number of cycles did not affect the specific gas production of the biological sludge, and that the affect of the mechanical treatment had a marginal effect on the primary sludge. The explanation to this is that it is not only the dissolved COD that is transferred to methane, but also a part of the particulate COD. The energy content of municipal sludge is approximately 3.89 kWh/kg COD (Hultman et al., 2003), and the energy content of methane gas is 9.8 kWh/Nm$^3$. The increase in dissolved COD for the excess sludge in Figure 9 would correspond to an increased methane production of 1 Nm$^3$/m$^3$ sludge. The volatile solids is 46 kg/m$^3$ in the sample, corresponding to a potential methane production of 7.4 Nm$^3$ CH$_4$/m$^3$ untreated biological sludge, showing that the methane production of the dissolved COD only corresponds to a small fraction of the total gas production.

The conclusion from this experiment is that it is not possible to use chemical analysis of the sludge to correlate to the potential increase of the biogas production.

Also the ammonia increased with the number of treatment cycles, and the same conclusion must be made there. For more data from the test, see Drawnel (2008).
In May 2008 the disintegration test with biological excess sludge was made with two different kinds of rotating discs with the aim to increase the effect of the Krima using a narrow spaced disc instead of medium space normally used for treating screenings. The results are shown in Figure 10, where it can be concluded that the biogas potential increased due to the disintegration, but the narrow spaced discs did not give any extra effect. After 11 days the methane potential was 150 mL/gVS for the untreated sludge, compared to 200 mL/gVS for the treated sludge, corresponding to an increase of 33%, see figure 10. This increase is the same during the whole batch test. The reference gas production was more reasonable than the results in November 2007, where the reference sludge had an unreasonable low gas production that stopped after 11 days. In May 2008 the reference sludge produced gas for the whole measurement period, over 60 days. The accumulated methane potential was 240 mL/gVS, compared to the batch test made in 2004 where the gas production stopped at 160 mL/gVS after 40 days (Leksell, 2005). The increased reference production in May 2008 could be an effect of the enzyme dosage to the digesters at Käppala WWTP during spring 2008. This could also have affected the level of the gas production from the treated sludge, which was higher than in November 2007.

Figure 10: Specific methane production of biological excess sludge (DS content 5.7%, VS content 3.7%) treated with the Krima disperser narrow spaced disc and medium spaced disc respectively

The treatment with the Grubbens deflaker gave the same effect on the specific methane potential as the treatment with the Krima disperser. (See Figure 11.) The second cycle gave a marginally effect on the gas production, compared to the effect of one treatment cycle.

Figure 11: Specific methane production of biological excess sludge (DS content 6%, VS content 3.9%) treated with the Grubbens deflaker system

www.european-biosolids.com
Organised by Aqua Enviro Technology Transfer
A microscopic study was made to see the effect of the treatment on the filamentous bacteria in the biological excess sludge. No significant effect on the filament length could be seen with either Krima disperser or the Grubbens deflaker.

The disintegration of primary sludge resulted in a lower methane potential than before the treatment, see Figure 12. This is a surprising result, but could be explained by the fact that the primary sludge is so easily degradable that some of the substrate has been degraded on the way to Uppsala (approximately 1.5 hours away). The gas potential after 20 days was higher than in earlier laboratory batch tests with primary sludge, 387 mL CH₄/gVS compared to 230 mL/gVS in November 2007 and 310 mL/gVS in autumn 2004 (Leksell, 2005).

The conclusion from the disintegration test of primary sludge is that the disintegration does not have an effect since the primary sludge itself is so easily degradable, and is degraded anyway.

![Figure 12: Specific methane production of primary sludge (DS content 6.9%, VS content 5.8%) treated with the Krima disintegration system (medium spaced discs)](image1)

A test with disintegration of digested sludge was performed to investigate whether this could increase the degradability of the sludge that has not already been degraded in the digester. The results are shown in Figure 13, where it can be seen that the gas potential from the digested sludge is significantly lower than the biological sludge and the primary sludge. After 13 days the accumulated methane production was 68 NmL/gVS for the treated sludge compared to 55 NmL/gVS for the reference, however the difference had disappeared after 48 days of digestion when both sludges had a biogas potential of 94 NmL CH₄/gVS.

![Figure 13: Specific methane production of digested sludge (DS content 3%, VS content 1.8%) treated with the Krima disintegration system (Medium spaced discs)](image2)
Cost-benefit analysis for a full scale application

The investment and operational cost of the systems has been compared to the profits made having a more efficient digesting process, resulting in more gas and less sludge. The result is presented in Figure 14, showing that the break-even for both systems is below 5% increase of the total gas production. The driving forces in the result are high cost for sludge disposal (approximately 47 €/ton sludge) and the income of the gas upgraded to car fuel quality (0.05 €/kWh). The Grubbens deflaker system has a pay-back time of less than one year compared to just over one year for the Krima disperser. The Grubbens deflaker is more beneficial due to lower investment cost and lower energy consumption.

Figure 14: Cost-benefit analysis for the Krima disintegration system and the Grubbens deflaker respectively.

To summarise the results from the different experiments with mechanical disintegration a summary has been made in Table 3. The specific gas production after 11 days has been compared, since this corresponds to the residence time in the second digester where the biological sludge is treated. Looking at the effect of the disintegration a 33% increase of the methane production can be seen for the biological sludge. In full scale approximately 20% of the gas is produced from the biological excess sludge, and the rest, approximately 80% from the primary sludge. Thus the 33% increase of the gas production gives a 7% increase in total gas production.

Table 3: Summary of the specific gas production from biological excess sludge at Käppala WWTP

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Specific gas production after 11 days (Nm³ CH₄/ton VS)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reference</td>
<td>Disintegration</td>
</tr>
<tr>
<td>Autumn 2004</td>
<td>120</td>
<td>160</td>
</tr>
<tr>
<td>November 2007</td>
<td>60*</td>
<td>160</td>
</tr>
<tr>
<td>May 2008</td>
<td>150</td>
<td>200</td>
</tr>
<tr>
<td>May 2008</td>
<td>150</td>
<td>200</td>
</tr>
</tbody>
</table>

*Unreasonably low value, the reference value from autumn 2004 is used to estimate the effect of the disintegration
The disintegration of the digested sludge gave a specific methane potential of 60 Nm$^3$/ton VS after 11 days. The mass balance in Figure 2 shows that the amount of volatile solids not digested out from R200 was 15 tonnes VS/day. Hypothetically, mechanical disintegration of this sludge would result in an increase of 9% on the total gas production. In practice the disintegration would take place in the recirculation flow of the second digester.

The conclusion is that the most beneficial way of using the mechanical disintegration is to treat the part of the organic material in the sludge, which is difficult to degrade in the anaerobic digestion process. One way is to treat the biological excess sludge before it is pumped into the digester; another application is to treat the sludge in the second digester to disintegrate the organic material, which has not already been degraded. The interpretation of the results from the experiments made in 2007-2008 is that the effect on the gas production is approximately the same for the two applications, 7 and 9% respectively. This means that it would be economically feasible to invest in a mechanical disintegration in the form of either a Krima disperser, or a Grubbens deflaker.

Unfortunately the enzyme addition in spring 2008 makes it more difficult to evaluate the exact effect of the mechanical disintegration on the gas production but the overall conclusion from the experiments made during 2007-2008 shows a significant effect of the treatment of the biological sludge. When it comes to the disintegration of the digested sludge one hypothesis could be that the effect would have been greater if there had not been an enzyme addition, since the enzymes are supposed to give a higher degradation in the digesters, leaving less organic matter left after the digester.

**Operational strategies and future developments**

The batch digestion tests of the biological sludge indicate that an increased residence time of the mechanically treated biological sludge would result in a even higher gas production. This should be kept in mind looking at future optimization of the digesters at Käppala WWTP. In five years time Käppala will have built a new digester volume due to the redundancy problems of having only two digesters. This would result in an increased hydraulic retention time.

The development of the sludge disintegration with the Grubbens deflaker and/or the Krima disintegration system will continue at Käppala WWTP. In future tests it would be interesting to look closer into how the viscosity of the sludge is affected by treatment. If the viscosity is lowered due to the treatment, a higher dry solid content of the sludge could be used without causing problems with pumping of the sludge, heat exchange or mixing in the digesters. A higher DS content of the sludge would result in a higher residence time of the sludge, and a more efficient use of the digester volume.

The combination of mechanical disintegration and addition of enzymes needs to be looked into in a more controlled and scientific way than in the experiment made in may 2008. This is also an idea for future experiments.

Full scale tests with disintegration of the biological sludge with the Grubbens deflaker would be a natural continuation of the experiments made in “pilot scale” and will carried out during the year of 2009.

**CONCLUSIONS**

1. It could be concluded that the mechanical disintegration of the biological sludge used in this project both has a kinetic effect with a higher velocity on the initial gas production, as well as an effect on the specific methane potential of the sludge, resulting in a higher level of the gas produced from the substrate.

2. The mechanical disintegration of biological excess sludge with the Krima disintegration system results in a 33% increase of the specific methane production. This corresponds to an increase of 7% on the total gas production.
3. One treatment cycle is enough to give the full effect of the pre treatment when treating 100% of the sludge flow. Narrow spaced discs did not show any increased effect on the treatment result.

4. The Grubbens deflaker system has the same effect on the biological excess sludge as the Krima but to a lower investment and operational cost.

5. The power consumption of the Krima disperser was 80kW and for the Grubbens deflaker 30 kW. The specific energy consumption was 2 kWh/m$^3$ (0.03 kWh/kg DS) and 0.75 kWh/m$^3$ (0.02 kWh/kg DS) respectively.

6. A microscopic study was made to see the effect of the treatment on the filamentous bacteria in the biological excess sludge. No significant effect on the filament length could be seen with either Krima disperser or the Grubbens deflaker.

7. A mechanical disintegration of the digested sludge would result in an increase of 9% on the total gas production. In practice the disintegration would take place in the recirculation flow of the second digester.

8. Break-even for both the Krima and the Grubbens system is below 5% increase of the total gas production. The driving forces in the result are high cost for sludge disposal (approximately 47 €/ton sludge) and the income of the gas upgraded to car fuel quality (0.05 €/kWh). The Grubbens deflaker system has a pay-back time of less than one year compared to just over one year for the Krima disperser. The Grubbens deflaker is more beneficial due to lower investment cost and lower energy consumption.

9. Over the years batch laboratory anaerobic digestion tests have shown to be a reliable method for measuring the specific gas potential of a substrate, showing good agreement with the mass balance over the full scale digestion.

10. An important conclusion from this project is that when evaluating different methods of pre-treatment of sludge it is not possible to use chemical analysis of the sludge to correlate to the potential increase of the biogas production.

11. The untreated primary sludge has a higher specific gas production than the biological sludge since it has a higher content of fat and other easily degradable compounds. The fact that the primary sludge is so easily degradable results in a negligible effect of the degradation after the mechanical disintegration.

12. The most beneficial way of using the mechanical disintegration is to treat the part of the organic material in the sludge, which is difficult to degrade in the anaerobic digestion process, either by treating the biological excess sludge, or the digested sludge.

ACKNOWLEDGEMENTS

This project has been carried out as a cooperation between Käppala association and Cellwood machinery. A special thanks to Peter Ek and Anders Holm at Cellwood and Gunnar Jansson at Käppala WWTP for excellent cooperation in the planning and performance of the disintegration tests, with the support of the operators, maintenance and laboratory staff at Käppala WWTP. The first part of the study was made as a part of a master’s thesis by Agnieszka Drawnel who should be acknowledged for her hard work with the thesis. A final thanks to Mikael Hansson at JTI for supporting the author with data for this article.

www.european-biosolids.com
Organised by Aqua Enviro Technology Transfer
REFERENCES


