2G.1 Activity and life time of commercial enzymes in excess sludge fluid and digester fluid, Anna Hansson, Linköping University

2G.2 Renewable energy and recycling of nutrients – biogas from horse manure, Åsa Hadin, University of Gävle

2G.3 Impacts of co-digestion waste vegetable oil with primary and waste activated sludge on microbial community and process performance, Jörgen Ejlertsson, Scandinavian Biogas Fuels AB

2G.4 Co-digestion of horse manure and cattle slurry, Henrik Olsson, JTI - Swedish Institute of Agricultural and Environmental Engineering

2G.5 Effects of sulfide on anaerobic digestion of primary and activated sewage sludge: A multi-approach study, Sepehr Shakeri Yekta, Linköping University

2G.1 Activity and life time of commercial enzymes in excess sludge fluid and digester fluid
Activity and life time of commercial enzymes in excess sludge fluid and digester fluid
Anna Hansson1,3, Bengt-Harald Jonsson 1,3 and Martin Karlsson1,2,3

1Molecular Biotechnology, Dept. Of Physics, Chemistry and Biology, Linköping University, SE-581 83 Linköping, Sweden
2Rational Enzyme Mining AB, Gjuterigatan 1B, SE-583 73 Linköping, Sweden
3Develop project 7 within Biogas Research Center (BRC) Linköping, Sweden

Annually, 9 million metric tons of sludge dry substance is produced at wastewater treatment plants (WWTP) in Europe. When treated by anaerobic digestion the degree of degradation is often low at approximately 50 %. The low degradation is caused by two major factors; a short hydraulic retention time and that the sludge recalcitrant to hydrolysis. Improved hydrolysis would result in increased degradation and thereby increased biogas production. A possible solution to improve the hydrolysis and thereby the degree of degradation is to add hydrolytic enzymes. Several earlier studies have been performed where hydrolytic enzymes have been added for evaluation of the effect on biogas production [1, 2]. Unfortunately, the result varies widely between different studies. In several cases an increased biogas production has been observed, whereas other studies have not verified these promising results. However, it is not clearly understood whether the added enzymes are active or has an appreciable life time in the sludge or digester environment. This project was therefore mainly designed to clarify what happens to the enzymes in these
In this study we have evaluated the activity and life time of added commercially available enzymes in excess sludge and digester fluid. In comparison to enzymes in reference solutions, the enzymes activity decreased in most cases significantly faster in substrate or digester fluids. Notably, in presence of protease inhibitors the activity remained for a longer period of time. Not surprisingly suggesting that the inactivation of exogenous enzymes is caused by degradation by proteolysis.


2G.2 Renewable energy and recycling of nutrients – biogas from horse manure

Åsa Hadin, Faculty of Engineering and Sustainable Development, Department of Building, Energy and Environmental engineering, University of Gävle

E-mail: aho@hig.se

Society’s energy demand and use of nutrients for food production cause environmental impact. At the same time renewable materials seen as problems can be used as renewable energy and/or as fertilizers. The increasing number of horses in Sweden results in an increase in the amount of horse manure. Storing and handling of horse manure has negative environmental impact to air, soil and water. Using horse manure as a renewable energy source and for nutrient recycling can reduce environmental impact and also contribute to fulfilling the national and regional environmental objectives.

The aim of the project is to investigate, with interviews and literature reviews, how horse manure can contribute to a more sustainable society by energy recovery and recycling of nutrients. Environmental and technical aspects identified in the project are handling and amount of horse manure, conditions for spreading bio-fertilizer and technologies for producing biogas from materials with high content of total solids. Information about the current situation on horse manure gives a base for the analysis about prerequisites on biogas from horse manure. Finding proper off-set for digestate from digested horse manure in agriculture is a key issue. Studied information and research about different biogas technologies give examples on solid state anaerobic digestion, digestion in liquid anaerobic digestion plants and co-digestion.

These aspects are parts of the analysis about possibilities and obstacles for biogas production from horse manure. Continued studies on the prerequisites for biogas from horse manure will take into account legal requirements, economic aspects on
biogas technologies, handling of manure and bio-fertilizer, sanitisation, pretreatment, localisation and transport aspects.

2G.3 Impacts of co-digestion waste vegetable oil with primary and waste activated sludge on microbial community and process performance

Ryan Ziels2,4, Pascal Ojong1,4, Karl Gustavsson1,4, Annika Björn1,4, Anna Karlsson3,4,*, Sepehr Shakeri Yekta1,4, Bo H. Svensson1,4, and Jörgen Ejlertsson3,4

1Department of Thematic Studies - Water and Environmental Studies, Linköping University, Sweden
2Department of Civil and Environmental Engineering, University of Washington, Seattle, USA
3Scandinavian Fuels AB, Holländargatan 21A, Stockholm, Sweden
4Biogas Research Center, Linköping University, Sweden
* Corresponding author

The objective of this research was to study the impacts of co-digesting waste vegetable oil (WVO) with primary sludge (PS) and waste activated sludge (WAS) on microbial community dynamics and process performance in mesophilic laboratory-scale biogas reactors. Microbial community analysis included quantitative PCR on the 16S rRNA gene targeting the methanogenic orders Methanomicrobiales, Methanobacteriales, Methanococcales, the methanogenic families Methanosetaeacea and Methanosarcinacea, as well as the syntrophic beta-oxidizing bacterial genera Syntrophomonas and Syntrophus. Co-digestion of WVO was achieved up to a maximum organic loading rate (OLR) of 1.5 g-VS-fat/L-d (52% of influent VS). The co-digestion of WVO resulted in a significant increase in hydrogen- and acetate-utilizing methanogenic groups. Syntrophomonas gene counts in the WVO co-digestion reactor increased significantly, suggesting their involvement in long-chain fatty acid (LCFA) degradation. Batch degradation capacity tests revealed that the increased abundance of beta-oxidizing syntrophic bacteria and methanogenic archaea in the WVO co-digestion reactor corresponded to significant increases in degradation kinetics of acetate and oleic acid relative to the control reactor. Therefore, co-digesting WVO with PS and WAS led to an adaptation of the microbial population with higher degradation kinetics for intermediate metabolites. Yet, incomplete removal of the WVO was observed at the maximum OLR despite the increased capacity of the microbial population, as indicated by a reduced methane yield of 70% and LCFA accumulation to over 2.0 g/L.

2G.4 Co-digestion of horse manure and cattle slurry

Henrik Olsson*, Johan Andersson, Mats Edström and Gustav Rogstrand
Key words: Biogas production, Co-digestion, new substrates, horse manure

Horse manure is a waste problem for municipalities and horse owners. One way to turn this waste problem into a potential recourse would be to co-digest horse manure with cattle slurry. This would contribute to production of biogas and close the nutrient cycle. Co-digestion of liquid manure with solid substrates makes it possible to increase the organic loading rate (OLR) and by that use the digester volume more efficient. The objectives of this study was to demonstrate that it is technical possible to Co-digest liquid manure and horse manure in proportions where 50 % of the biogas is produced from horse manure without adding fresh water to the process.

The project began with conducting batch trials of horse manure with four different bedding materials. Batch trails was conducted to quantify how the choice of bedding material affects the biogas potential. The technical aspects of co-digesting liquid manure with horse manure were studied in farm scale at the biogas plant at Sötåsens Agricultural College. 250 tons of horse manure with sawdust as primary bedding was co-digested with liquid manure from 60 dairy cows.

The horse manure contained less amounts of impurities such as sand, gravel and bigger objects compared to the deep litter at Sötåsen and was easier to convert into slurry. The biogas potential trails showed that the biogas potential from horse manure depends on chosen bedding material. Horse manure with straw as bedding material had methane forming potential of more than 200 Nm3/ton volatile solids (VS). Sawdust and peat bedding gave manure with a methane potential less than 100 Nm3/ton VS. Approximately 50 % of the digested horse manure needs to have straw as bedding material if the horse manure shall contribute to 50 % of the biogas production.

The authors like to thank The Swedish Horse Council Foundation and the Swedish Board of Agriculture for the support that made this project possible. Further JTI wants to thank Sötåsens Agricultural Colleges and Hushållningssällskapet Skaraborg for good collaboration.

2G.5 Effects of sulfide on anaerobic digestion of primary and activated sewage sludge: A multi-approach study

Sepehr Shakeri Yekta1,4,* , Magnus Willén1, Annika Björn1,4, Ryan Ziels2,4, Pascal Ojong1,4, Matilda Svedlund1, Anna Karlsson3,4, Jörgen Ejlertsson3,4, Bo H Svensson1,4

1Department of Thematic Studies-Water and Environmental Studies, Linköping University, SE-581 83, Sweden
The effects of sulfide on process performance, microbial community structure and degradation capacity of specific intermediates, trace metal speciation, and fluid characteristics during anaerobic digestion of Fe-rich primary and activated sludge were investigated. Concentration of sulfide was increased from 6 to 48mM in a lab-scale biogas reactor (R1) by addition of sodium sulfide. A second reactor (R2) operated as control without sulfide addition. The increase in sulfide caused a temporary decrease in biogas production and accumulation of acetate. This was attributed to a subsided capacity of the methanogenic community to degrade acetate due to decline in abundance of acetate-utilizing Methanosaeta (as analyzed by quantitative polymerase chain reaction). The biogas production resumed and the acetate was depleted potentially due to an adaptation of the methanogenic community to the higher sulfide level. Cobalt and Ni speciation suggested that the increase in sulfide concentration did not influence the solubility and potential bioavailability of these metals. This is likely due to an excess of Fe over S in the system, which in turn scavenges the free sulfide from the liquid leading to a sustained sulfide content of the biogas below 200 ppm during the whole experimental period. Furthermore, addition of sulfide increased the viscosity of the sludge in R1 as compared to R2.