CONFERENCE REPORT

Conference: 13th IWA World Congress on Anaerobic Digestion
Date: June 25 - 28 2013
Location: Santiago de Compostela, Spain
Proceedings: pw:\ Carollo\Documents\Carollo Internal Projects\Advanced Digestion Group\Papers & conference notes\IWA AD13 2013
Attendees: Toshio Shimada (DAL)
Paper(s) presented: Microbial community structure in two-phase (acid-methane) anaerobic digesters

Summary
The main focus of the conference was anaerobic digestion (AD) with an emphasis on resource recovery. More than 670 papers were presented in this conference. Plenary presentations were given by leading experts in anaerobic digestion. Podium presentations were given in three parallel tracks and grouped in the following categories:

- Co-digestion
- Biomolecular tools
- Biorefinery
- Solid Waste Treatment
- Microbial Population Dynamics
- Energy Recovery
- New Biomasses
- Biodegradation
- Environment and Economics
- Modeling and Control
- Anaerobic Membrane Bioreactors
- Pre-Treatment
- Innovative Technologies
- Anammox
- Full-scale Implementation
- Post-Treatment
- Inhibition
- Industrial
- Sewage
- Methodology and Kinetics

The conference program and proceedings with the full papers presented in this conference are available in ProjectWise at:

pw:\ Carollo\Documents\Carollo Internal Projects\Advanced Digestion Group\Papers & conference notes\IWA AD13 2013 and pw:\Carollo Documents\Carollo Internal Projects\Research Group\Specialty Conferences\IWA Anaerobic Digestion\AD13

The following are highlights from the presentations that I attended during the conference:

Plenary Sessions
- Willy Verstraete (Ghent University, Belgium) presented his vision for the future of the AD technology. AD will become the central process in municipal WWTPs by producing a whole
array of useful product, such as biogas, polymer, proteins. AD is a mature technology and advances in this field are remarkable. Latest advances include anaerobic MBR technology for industrial and domestic wastewater, treatment of saline sewage, and the combination of physical/chemical pretreatment processes with AD to increase gas production. The combination of AD-composting is the best available technology for municipal solids waste.

- Lutgarde Raskin (University of Michigan) discussed the advances on environmental microbiology in the AD field. Microbial resource management as the design and operation of bioreactors to develop microbial communities that can accommodate a desired process (e.g., meet water quality standards, increase biogas production). The application of molecular microbiology tools has increased our capabilities to rationally practice microbial resource management. New technologies, such as high throughput DNA sequencing, metagenomics, and metatranscriptomics, which are much more powerful and efficient than conventional methods, are beginning to be applied to AD systems.

- Jos Paques (Paques Holding B.V., The Neatherlands) discussed how to advance AD technologies from concept to industrial application. Breakthroughs in water/wastewater technologies are desperately needed because more than 900 million people lack clean water, 2.6 billion people lack sanitation, and the world’s energy demand is expected to increase by 50% over the next 25 years. To be successful, technology must be combined with entrepreneurship. Paques invests heavily in research and development to produce marketable AD processes.

Keynote Presentations

- Vincent O’Flaherty (National University of Ireland) studied the effects of temperature (7, 15, and 37 deg C) on laboratory-scale expanded granular sludge bed (EGSB) reactors and used metaproteomics in conjunction with 16S rRNA gene phylogenetic approaches to study the bacterial and archaeal composition. The methanogens expressed different proteins when exposed to different temperatures. At 15 deg C, methanogens had minimal growth but showed high levels of cell viability and activity.

- Damien Batstone (University of Queensland) presented an update on AD modeling. AD modeling has reached a steady and broad application base with approximately 150 publications per year. Key challenges that need to be overcome are input/substrate characterization, physicochemical modeling (i.e., phosphorus and sulfur), and multidimensional modeling.

- Fernando Fernandez-Polanco (University of Valladolid) presented results from a thermal hydrolysis study. Waste activated sludge (WAS) was pretreated in a continuous flow thermal hydrolysis prototype, blended with primary sludge and fed to continuously fed anaerobic digesters (SRT= 20 days, ORL= 1.9 kgVS/m3/day). Thermal hydrolysis resulted increased the gas production by 23% and improved the cake dewaterability by 30%.

- Perry McCarthy (Stanford University) presented results for a pilot-scale fluidized media anaerobic MBR treating domestic wastewater at ambient temperatures. The system included two reactors in series: an anaerobic fluidized bed reactor followed by a similar reactor with submerged membranes. Membrane fouling was prevented by scouring action of fluidized media against membranes and a membrane flux of 9 liters/m2/hr has been achieved. The power consumption was less than 0.1 kWh/m3/day. After a 4 month startup, COD removal efficiency of 86% was achieved at temperatures ranging from 10 to 15 deg C. Biosolids production was 0.03 g/g COD removed.
Platform Presentations

- **Girault et al.** *Impact of interactions between substrates on the methane production of codigestion systems.* To design co-digestion systems, most of the designers consider that the methane production will be equal to 80% of the weighted sum of the biochemical methanogenic potentials (BMPs) of substrates. However, interactions between substrates can influence the methane production and are generally not taken into account. The effect of interactions between substrates (synergies or antagonisms) on the BMP value of mixtures of substrates was investigated. No antagonism was identified. Significant synergies were highlighted. These interactions can be due to enzymatic activation phenomena.

- **Nikolausz et al.** *Stable isotope fingerprinting of biogas for the assessment of methanogenesis in anaerobic digesters.* Molecular methods are time-consuming and costly. Determination of stable isotope characteristics of the biogas allows an alternative rough estimation of the predominant methanogenic pathway. The isotope signature of methane and CO₂ can be used to analyze methanogenic pathways, since methane formation from H₂ and CO₂ results in larger isotope fractionation than aceticlastic methanogenesis. This study assessed the predominant methanogenic pathways in laboratory-scale anaerobic by means of analysis of mcrA transcripts with the isotope monitoring of the biogas. The ability of stable isotope fingerprinting to follow short-term activity changes was demonstrated by the shift in delta values shortly after substrate feeding.

- **Salvador et al.** *Metaproteomics of anaerobic microbial communities degrading long-chain fatty acids.* This work studied the syntrophic degradation of long chain fatty acids (stearate and oleate) was studied. A comparative metaproteomics approach, in which proteins were analyzed by LC-MS/MS, was combined with 16S rRNA gene pyrosequencing. Metaproteomics results were similar and comparable distributions of COG functional categories were found for both samples. Archaeal proteomes were much better identified than bacterial ones, with five times more proteins retrieved.

- **Bocher and Zitomer.** *Relating Methanogen Community Structure and Anaerobic Digester Function.* Specific methanogenic activity (SMA) of anaerobic biomass samples was determined to quantify digester functionality, and community structure was characterized using DGGE banding patterns for the mcrA gene. Quantitative structure-activity relationships (QSARs) were established between methanogen community structure and SMA values using multiple linear regression.

- **Ho et al.** *Effects of temperature on the methanogenic pathways and microbial community of the high-rate methanogenesis system.* This study investigated the effect of elevated temperatures on methanogenesis. Stable anaerobic digestion was achieved at 3 and 4-day HRT at 55 and 60 deg C, respectively. The methanogenic community was dominated by *Methanosarcinaceae*, which are capable of switching between aceticlastic and hydrogenotrophic methanogenesis. Stable isotopic signatures method showed a strong contribution of non-aceticlastic methanogenesis of more than 50% to the total methane production, and increasing to nearly 90% at 65 deg C, demonstrating the significance of syntrophic acetate-oxidation mechanism in thermophilic high rate methanogenesis.

- **Conteau et al.** *Cow and termite digestion mimicking: from animal digestive tracts to lab-scale pilots.* This work analyzed natural innovation in animal digestive tracts to improve AD processes. Cow and termite digestive systems can be divided into elementary steps and translated in terms of process engineering: cutting and grinding compartments; CSTR or plug flow reactor; chemical, enzymatic or biological reactors and press filter. The key
elements of these two systems were optimized and then put together into two lab-scale semi-continuous pilots fed with WAS. The performance of both these systems was considerably higher than lab references and conventional WWTP digesters.

- **Garcia-Gen et al.** *ADM1 application to anaerobic co-digestion: generalized implementation of fermentable soluble substrates.* A general methodology for implementation of fermentable soluble substrates on the IWA ADM1 was proposed such that the model application can be extended for anaerobic co-digestion of multiple and diverse substrates. Fermentation stoichiometry of soluble substrates such as ethanol, glycerol or lactate, not originally described by the ADM1, is channelled through mass- and electronbalanced sugar fermentation equivalent reactions. All fermentable substrates are degraded by a single generic group of biomass fermenters (Xfer) in substitution of the original sugar fermenters (Xsu) in ADM1 and thus no additional microbial group states are required. The ADM1 sugar fermentation kinetics is modified with a competitive term to account for the multiple substrates competing for one biomass group. A pilot scale model validation was successfully conducted at a fully instrumented pilot plant treating a blend of three soluble substrates (pig manure, wine and gelatine) at mesophilic conditions. Only the acetoclastic ammonia inhibition had to be modified respect to standard ADM1 parameters to obtain consistent model prediction of gas and liquid characteristics.

- **Bartacek et al.** *Removal of hydrogen sulphide from biogas by microaeration in UASB reactor.* Microaeration was used to remove H2S from biogas in a lab-scale UASB reactor treating sulfate-rich wastewater. Air was dosed into the recycle of the reactor. The H2S levels in the microaerobic reactor were 70% lower than the anaerobic reactor. No significant negative effect of microaeration on the methanogenic activity of granular sludge was observed.

**Short Presentations**

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- **Ge et al.** *Evaluation of anaerobic digestion processes for short sludge-age WAS.* Extended sludge age WAS (normally > 10 days) has poor degradability. There is little information on the properties of short sludge-age WAS. The anaerobic digestibility of WAS with an age of 2-4 days was evaluated under three different anaerobic (conventional mesophilic, thermophilic, and TPAD). Degradability extent was strongly linked to sludge age being 85% (2 days), 73% (3 days), and 63% (4 days). Extent was not influenced by digestion temperature. The rate of degradation for 3 and 4 day material was strongly enhanced (by 45%) at thermophilic conditions. This indicates that longer sludge age material is more
amendable to pre-treatment than short age material, but that under normal (non accumulation) conditions of 3 days or greater, there is a substantial kinetic advantage in operating at thermophilic conditions.

- Tandukar et al. *Anaerobic co-digestion of municipal sludge with FOG enhances the destruction of sludge solids*. This study investigated the effects co-digestion of a sludge-mix of primary sludge (PS)/thickened WAS (TWAS) with concentrated fat-oil-grease (FOG) over range of FOG/sludge-mix volumetric feed ratios. The biodegradability of PS, TWAS, sludge-mix, and FOG was 43.0, 38.6, 41.8, and 97.7%, respectively. Batch co-digestion of sludge-mix and FOG at different COD ratios resulted in an enhanced degradation of the sludge-mix COD to as much as 10.9% when the feed FOG COD was 18.5% of the total waste COD loading. Gas production was linearly correlated to the COD of the feed.

- Buffiere et al. *Kinetics of primary sludge digestion at various temperatures*. Anaerobic digestion is now commonly used for sludge treatment. Lab-scale digesters were operated at temperatures between 28 and 55 deg C. Methane production rate increased with temperature. The maximal methane production rate was obtained at 49 deg C.

- Miot et al. *Case Study of Anaerobic Digester Foaming in Egg Shaped Digesters*. Egg-shaped anaerobic digester foaming has been a consistent problem for the Oceanside Water Pollution Control Plant. Seasonal intermittent foaming events have been correlated to the presence of nocardioforms. Changing the mixing regime from continuous to intermittent resulted in fewer and shorter foaming events.

- Rodriguez-Roda et al. *Anaerobic digester foaming: occurrence and control in Spain*. Out of 38 wastewater treatment plants that were surveyed, 23 plants reported incidence of AD foaming. The frequency of foaming ranged from seasonal (7 plants), intermittent (13 plants), and persistent (3 plants). The foaming causes included feed characteristics and operating factors. The most common control technologies included defoamers, uniform sludge feeding, and optimized mixing. At one plant, the main cause of foaming was high gas production with insufficient surface area for gas to escape the liquid volume. This was mitigated by controlling the percentage of PS and WAS.