WEEG NEWSLETTER November 2018

The newsletter is published monthly by the University of Southampton's Water and Environmental Engineering Group WEEG, and reports things of interest in this field worldwide, as well as ongoing undergraduate student and research work in WEEG itself.

We believe that water and energy are the most important topics worldwide for the next decades. Our work covers river and coastal engineering, water and wastewater and energy related to water.

Editorial: today's topic is anaerobic digestion (AD), or rather emerging developments in this area that may also lead to carbon capture

Environmental Engineering: *Biomethanisation of CO_2 in AD*

In anaerobic digestion of biowastes, complex organic molecules are hydrolysed into simpler compounds. The final step of conversion into methane is done by a group of microbes called *Archaea*, which look very much like bacteria - tiny single-celled organisms. *Archaea* first appeared on Earth even before bacteria, and are more different from them than we are from plants or fungi. They can live in extreme conditions and on unusual substrates, and on another occasion we may say more about the fascinating things they can do...

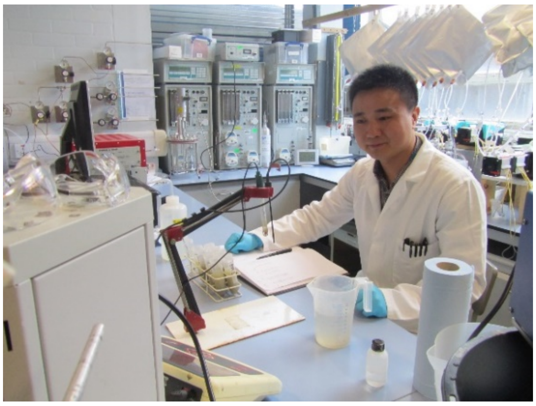

Fig. 1: Dr Bing Tao working on lab-scale digesters

In AD, one important group of *Archaea* are the acetoclastic methanogens, which can split acetic acid directly into methane (CH_4) and carbon dioxide (CO_2). In a normal digester, this is the main route to biogas production. Another group is the hydrogenotrophic methanogens, which can convert hydrogen (H_2) and CO_2 into CH_4 and water (H_2O).

CO_2 is naturally present in biogas from organic wastes - usually at around 40-50%, depending on the feedstock. In a well-functioning digester the amount of H_2 is very small, as it is rapidly scavenged and converted to methane. If a digester of this type is fed with H_2, however, the hydrogenotrophic population increases and both the proportion and the absolute amount of CH_4 in the biogas also increase.

This is potentially very attractive, since biogas needs to be upgraded for many purposes - e.g. for gas grid injection, or to make compression and storage more economic. Conventional upgrading relies on stripping out the CO_2 by physico-chemical means; but biomethanisation actually increases the methane yield from a given input of carbon.

In practical terms there are two main system configurations: in situ where H_2 is added directly to a digester fed on organic waste; and ex situ where H_2 and CO_2 are fed directly to a bioreactor. In an ex situ process the CO_2 could come from a range of sources such as biogas, fermentation (e.g. brewing), combustion or atmospheric carbon - although not all of these are feasible at present.

In situ conversion is of interest to the water industry, which already has many digesters and even upgrades biogas for grid injection at some UK sites. In a conventional digester with H_2 addition, a biomethane production rate of 4 m^3 per m^3 of digester per day is a reasonable target and a good improvement on typical rates in commercial plant. If the technology can be made simple and cheap enough, it could also be used in applications such as on-farm digestion of animal slurries.

Ex situ conversion has huge potential as it could handle much higher rates of gas input. If we think of the big CO_2-producing industries, such as incineration, cement production or power generation, we are talking of hundreds or thousands of <u>tonnes</u> of gas per day at a single plant. The systems must be able to handle this. So this is an exciting time to be involved in the design of advanced reactor configurations - and in working out what these strange organisms, from so early in the Earth's history, require and how they can be used.

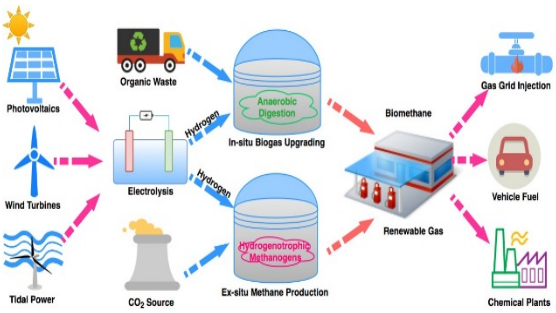

Fig. 2: Potential routes from renewable electricity to products via biomethanisation - flowchart.

Biomethane is not the only potential end product: other possibilities are now emerging. The value of methane as a fuel gas is relatively low, but it is also an energy source for other microbial systems. It is used commercially for production of high quality single cell protein as an animal feed in a protein-hungry world. In the next few years, rapid growth in our understanding of microbiology and of the systems needed for scale-up will open up routes to new materials, such as bioplastics and liquid fuels.

Southampton is leading a consortium project on biomethanisation of CO_2 funded by EPSRC with partners at the Universities of York and Sheffield and industry supporters Lutra Ltd, ITM Power, FERA and United Utilities.

Contact: Prof Charles Banks, cjb@soton.ac.uk

3rd year student project: *Rainwater Harvesting and Utilisation in the UK*

In cities, rainwater is usually drained off as quickly as possible. The collection or harvesting of rainwater could however provide a source of fresh water, e.g. to reduce the demand on our water supply systems. Fig. 3 shows a typical below-ground garden rainwater harvesting (RWH) system which could be used by households in the UK, in both rural and urban areas.

Fig. 3: Garden Rainwater Harvesting System

Oliver Wiltshire is a 3rd year Civil Engineering student, who is doing a self-proposed individual project on rainwater harvesting (RWH) and utilisation in the UK. Previous analysis shows that RWH is feasible in more than half the UK's area. The project is thus looking at the current state of RWH in the UK, available products on the market and uptake, public acceptance for either potable or non-potable water use, and comparison and evaluation of RWH use in different scenarios.

Contact: Dr Yongqiang Liu, Y.Liu@soton.ac.uk

4th year Group Design Project: *Supercritical stream wheel for hydro-powered irrigation*

Many irrigation systems have supercritical flow channels to reduce the energy of the flow. Here the water flows very fast, at 3-6 m/s (Fig. 4), and contains quite a bit of energy.

Unfortunately, there is not much available in terms of technology to use the energy whilst maintaining the flow regime. This is important since we cannot allow the channels to flood.

Fig. 4: Supercritical flow channel, v = 5.5 m/s

In this project, the students aim to develop, design and build a stream wheel for supercritical flow to drive a piston pump. This will allow the use of water saving irrigation systems, and irrigation of fields 50 to 60 m above canal level.

Contact: Dr Gerald Muller, g.muller@soton.ac.uk

New NIBBs announced

Southampton will lead a new 5-year BBSRC Network in Environmental Biotechnology - see post 161 on the Enviro Lab Facebook page

Jobs in water engineering:

This gives you an idea of the type of work you can do when working in industry.

Civil and Environmental Engineering at Southampton University:

WEEG: the Civil and Environmental Engineering pathway offers the chance to deepen your knowledge in water-related areas, and gives you a better preparation for environmental engineering projects.

Contact: Dr Sonia Heaven, s.heaven@soton.ac.uk, Bldg. 7, Room 5004

Further information:

We have two Facebook pages, which provide a logbook of our laboratory activities:

www.facebook.com/Hydraulicslaboratory/

www.facebook.com/environmental.lab.university.of.southampton/

Brought to you by:

UNIVERSITY OF Southampton