

ORION – A Global Approach to Waste Management

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Abstract: In the ORION project supported by the European Commission, 20 partners work together to manage organic waste from agro-food industries. The goal is to develop a small, automatic and user-friendly digestion machine to facilitate the domestic on-site treatment of a wide range of organic waste from around 100 and up to 5000 tonnes per year at low cost and with limited maintenance. Simon Crelier at the HES-SO Valais/Wallis is part of the network.

Keywords: Anaerobic digestion machine · Biomethanation microbial process · Energy from biomass · Renewable energy · Valorisation of waste

Small- to medium-sized agro-food industries in Europe have to manage roughly the weight of 100,000 freight trains of organic waste each year. This is a very difficult task, as there is a growing body of legislation within the EU which generates costs for SMEs and requires them to comply with stringent hygiene regulations. It is therefore high time for the European Union to tackle the problem.

An Action Plan with Quantifiable Milestones



The ORION project aims at offering SMEs the opportunity to treat their organic waste themselves, in order to reduce their expenditure on storage, transport, landfill or incineration, while simultaneously increasing the hygienic conditions on-site. An important objective of the project is the valorisation of waste as biomass in order to produce energy while reducing the environmental burden, and to thereby improve the autonomy and profitability of the agro-food SMEs.

For the first time, the partners will use an anaerobic digestion machine on an SME scale, *i.e.* 1 m³ to 50 m³. The system features maximum effectiveness for a large range of organic wastes with average capital costs and moderate operating expenses. “Critical to the correct operation are parameters such as temperature, pH, volatile fatty acids (VFAs), methane (CH₄), carbon dioxide (CO₂) or ammonium (NH₄⁺)”, explains **Simon Crelier**, Head of the Biotechnology Unit at the Institute of Life Technologies in Sion.

The project is organised in working packages with research and industrial groups from all over Europe active in the design, planning and construction of the prototype compounds. For example, to achieve the desired high reliability, advanced control tools and sensors have been developed, including a range of sensors for online, remote monitoring. New knowledge has to



UAS professor Simon Crelier, who teaches downstream processing and enzyme technology, presents the 20-litre stirred glass reactors with temperature control for anaerobic digestion at the Biotechnology Unit of the Life Technologies Department. Photo: Elsbeth Heinzemann.

be acquired regarding the impact of nanostructured surfaces on bacterial growth and a higher throughput of waste in the digester. In addition, project partners have devised a dissemination and training strategy to attract a very large number of SMEs and offer them a personalised service. The innovations seek to facilitate the implementation of EU policies on waste management and the production of renewable energies. The focus will be on sectors such as fishery and aquaculture, hotels and restaurants, small agro-food industries and a core group of representative SMEs involved in the pilot design and testing of various waste qualities and quantities. They rely on an interdisciplinary group of research centres to achieve the project’s technical goals.

From Waste to Value

An important issue within the project concerns the highest possible added value to be obtained from waste. Professor Simon Crelier and his team at the HES-SO Valais/Wallis in Sion are actively contributing in this area. They are developing the basis for the management and optimisation of the biological process applying the principles of biomethanation. This process helps to convert organic material to biogas microbiologically and under anaerobic conditions. Three physiological groups of micro-organisms play a crucial role, namely fermenting bacteria, organic acid oxidising bacteria and methanogenic archaea. The process starts with the micro-organisms degrading the organic matter, ending with cascades of biochemical conversions to methane and carbon dioxide (Fig. 1). Syntrophic relationships between hydrogen producers and hydrogen scavengers are relevant for this procedure. In order to achieve an adequate process design, optimal configuration and effective evaluation of economic feasibility, it is important to determine the practical and theoretical methane potential.

The concept of anaerobic digestion through biomethanation investigated at the HES-SO allows a variety of putrescible

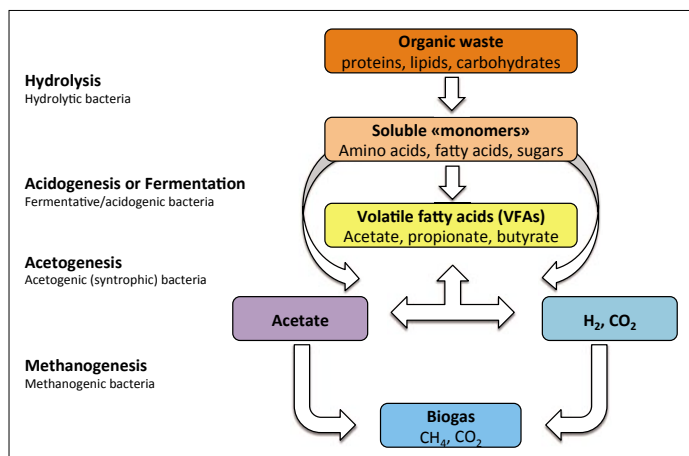


Fig. 1.

organic waste to be treated. A high proportion – depending on the substrate – is transformed into a mixture of methane and carbon dioxide, with the biogas serving as the energy source. “The process involves a complex microbial community whose members act in synergy”, says Simon Crelier. “This community’s fragile equilibrium is, however, stabilized thanks to positive feedback interactions between its members.”



Ghizlane El Ouai, student at HES-SO Valais/Wallis, prepares a new substrate for the 20-litre scale anaerobic digester. Photo: Elsbeth Heinzelmann.

In the biomethanation microbial process, hydrolytic enzymes are synthesised by fermenting bacteria utilising the hydrolysis products as substrates. Hydrogenotrophic methanogens maintain a low H_2 concentration, allowing more acetate to be produced by fermenting bacteria. This increases the fermentation yield and altogether provides directly methanisable acetate. Acetate depletion by acetate-consuming (acetoclastic) methanogens ensures thermodynamic feasibility of acetogen metabolism. The latter are therefore of necessity associated (syntrophically) to the former.

The Devil is in the Detail

The process does not always run smoothly, “but potential problems can be detected early by analysing the digestate and the gas being produced”, recalls the chemist, who has 10 years’ experience in the food industry. “They include accumulation of organic acids in the digestate, excessive ammonium content or



Student Ghizlane El Ouai and Professor Simon Crelier discuss substrate preparation and characterisation for organic waste management by a small-scale automated system of anaerobic digestion. Photo: Elsbeth Heinzelmann.

limiting, non-emulsified fats in the substrate, or accumulation of H_2 or H_2S in the gas. In fact, digester failures are very much like human diseases: the earlier they can be detected, the greater the chances that the evolution can be corrected and stability restored to the process”. Different options are available when it comes to correcting actions: for example, the digester can be put on a short “diet” to lower the levels of volatile fatty acids, the organic loading rate can be reduced or the substrate composition modified, trace elements can be added or iron salts can be used to prevent the release of H_2S (Fig. 2).

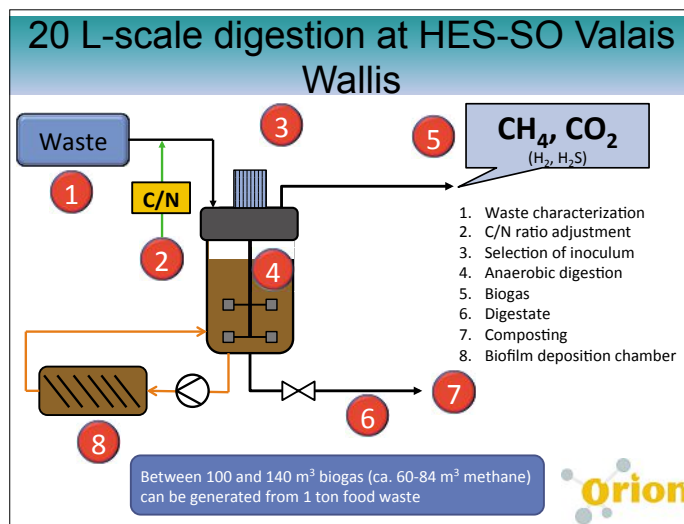


Fig. 2.

The expert in enzyme reaction engineering admits: “We consider it a challenge to optimise organic wastes as substrates for biomethanation and, if necessary, to combine them with co-substrates enabling us, for example, to correct the C/N ratio. Depending on the type of waste this parameter could be too low – resulting in a high ammonia concentration that is inhibitory to methanogens – or too high, resulting in N-limitation of the active biomass. In both cases this could lead to the whole system being blocked”.



Senior Research Assistant Rémy Dufresne carries out analytical measurements as part of the ORION project. Photo: Elsbeth Heinzlmann.



As the researchers found in their study, dried prunes, apricots, figs and walnuts – past their expiry date – serve as an excellent carbon-rich waste co-substrate for anaerobic digestion. Photo: Elsbeth Heinzlmann.

A Promising Approach to Valorisation

As the results show, the digestion residues contain biofertilising elements and often organic biopolymers such as lignin and lignocellulose which could be precursors of humus materials. Consequently, they represent a long-term addition to soil organic matter. Therefore the use of such residues – after appropriate aerobic stabilisation or in combination with compost – should be encouraged. The most efficient valorisation method is to co-compost with a waste management system that reproduces the natural biogeochemical cycles as closely as possible and reduces the environmental impact of the process. Today, Simon Crelier can draw a positive conclusion: “We will study the nature and composition of the digestates obtained from the different wastes treated in the ORION project in order to check whether we can use them for soil improvement and fertilisation. This will imply, in particular, the analysis of biofertilising elements, on the one hand, and for heavy metals, on the other.”

Developing renewable energy, especially energy from biomass, is a central aim of the EC’s energy policy. The Irish project managers from the DAITHI O’MURCHU Marine Research Station Ltd. think that ORION will have an impact on energy use since the system offers cost-effective and reliable

alternative to storage in cool areas, transport or incineration. The biogas produced will be directly used to heat the digester or to product hot water: organic waste can become a non-pollutant source of bio-energy.

Personal Details

Dr. Simon Crelier joined the Life Technologies Department of the HES-SO Valais in 2003, where he teaches downstream processing and enzyme technology. His research focus are isolation and characterization of biomolecules, enzyme technology, micro-reactors, biosorption, protein refolding and micro-encapsulation. The HES-SO Valais is partner of the biotechnet Switzerland.

Further information:

www.hes-so.ch

www.project-orion.eu

http://www.swissbiotech.org/ntn_swiss_biotech

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