FINAL PUBLISHABLE REPORT

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TITLE :

3A-BIOGAS –

Three step fermentation of solid state biowaste for biogas production and sanitation

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Introduction

Most of the organic material containing high dry matter percentage is treated in an aerobic way like composting. Regarding process energy balance in this biological treatment at least mechanical power has to be added for periodic turning of the substrates. Secondly it is impossible to use the energy accruing during the process.

Treating such substrates in conventional liquid biogas plants high volumes of water are necessary, which remain in most cases as wastewater subsequently. In relation to the quantities of feed material, high plant and process energy costs are incurred for material conveyance and maintaining temperatures. Process

The development of the new 3A-biogas batch-process for solid state biowaste can reach the best available synergies of composting and fermentation technology. It combines biogas- and compost-production including sanitation of the compost. The 3A process itself was patented in 1988 by Dr. Ing. Heinz Steffen as a discontinuous procedure.

The biological decomposition takes place during three operating phases (aerobic, anaerobic, aerobic) in a closed domain without intermediate movement of substrates. The procedure was improved in 1996 by the patented crosswise percolation-water feed. Using the experience gathered in extensive laboratory experiments, the new 3A-biogas batch system has to be up-scaled to prototype size in the project.

The 3A-biogas process

The development of the new 3A-biogas batch-process for solid state biowaste can reach the best available synergies of composting and fermentation technology. It combines biogas production, sanitation and anaerobic digestion in three phases: 1. aerobic, 2. anaerobic, 3. aerobic. The process generates biogas from solid state biomass (30-60% DM) and therefore uses the energy capacity of the biowaste. The end product of the 3A-biogas process is, after a final rotting phase outside the reactor container, compost. The innovative percolation water management avoids further wastewater. The aerobe bacteria activity during the aeration in the first process phase increases the temperature of the substrate. Therefore no external energy is needed to reach the operation temperature of 38°C. The in this phase beginning hydrolyses of the organic matter influences the biogas production in the anaerobic phase positively. After the aerobic treatment phase of 2 to 3 days, the air supply is stopped. The so created anaerobic condition is the basis for the biogas production. Within this phase the arising leachate is collected and spread again over the substrate (percolation water management). With this procedure, the water supply for the bacteria is ensured and the fresh substrate is inoculated with bacteria from former processes. With the crosswise percolation water management the substrate acidification in the first time of the anaerobic phase can be prevented as the percolate is in a stabile pH-range. In the third phase the substrate is aerated again. This ensures an odourless emptying of the reactors. The in this phase reached temperature of 70°C is sufficient to meet the sanitation requirements.

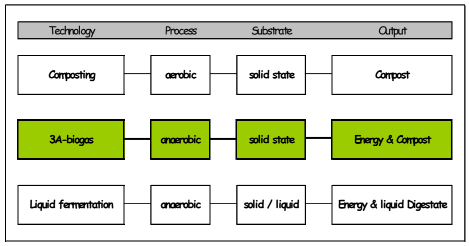

Figure 1: Treatment of organic substances

The 3A-biogas project

At the first project year, beginning on December 1st 2002, different basis investigations were realised. So a number of potential endusers of the 3A-biogas system were asked to describe their plant (biogas and composting) and to give some comments about their expectations and requirements for the new dry fermentation system. This results and the investigations of the legal requirements for sanitation in different European countries were the basis for the following process development. Further a partner realised laboratory scale tests of the 3A-biogas system. The results gathered there influenced the prototype scale tests in the second project year.

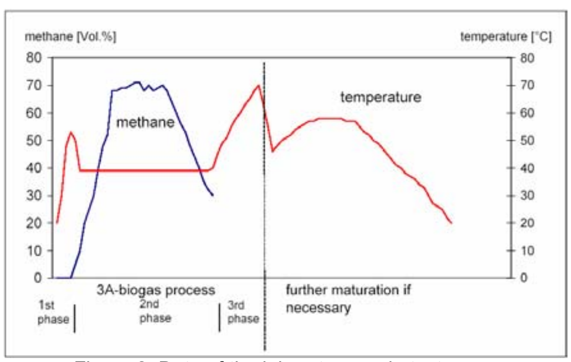

Figure 2: Data of the laboratory scale tests

After finalisation of the process development, which was supported by a computer based simulation program, the two prototype units were built at a partners site. Additionally, a control system for the prototypes was developed. The prototype units consists of one control container and one (in Spain) or two (in Austria) reactor container. In the control container all required components for the process are located. The reactors are special designed containers with an usable volume of about 25m^3. The filling of this reactors is done by a wheal loader from the top. For emptying the reactor container is lifted by a lorry and the substrate comes out at the second opening at the backside. The exhausted air from the aerobe process phases is treated by a bio-filter. This ensures that the whole process runs in a closed cycle and no odour emission occurs.

In May and June 2004 the plants were delivered to their destinations in Weibern (Austria) and León (Spain). After the final manufacturing on the test locations both plans will investigate different substrates and mixtures on their usability in the 3A-biogas system.

The expected results from the testing phase (May till December 2004), are the biogas quality and quantity of specific substrates (organic wastes; energy crops, solid state cow manure) as well as information regarding the optimisation of the process itself. Up to now, the results of the laboratory scale tests of different materials, supports the testing phase in the prototype units.

Figure 3: View on the 3A-biogas testing plant

The combination of the biogas and composting process, like it is realised by 3A-biogas, influences the process in a number of positive aspects. Regarding the reduced water amount of the substrate, the volume of the reactor can be reduced significantly. Further more the dryer substrate consistence allows a treatment of the end product to compost, which can be used as a high quality fertiliser. Based on the equal biogas yield (investigated in the laboratory tests) 3A-biogas will be an interesting alternative or combination to existing composting and biogas plants.

<u>Expected impact and exploitation</u>

3A-biogas is mainly addressing the communal and agricultural waste treatment industry where both biodegradable wastes and organic residues for the production of biogas are available. Often there are already conventional liquid biogas plants with an existing utilisation for the produced biogas. The additional installation of a 3A-biogas system as a second treatment line for dry input substrates will lead to several synergies for end users and optimal completion.

The potential for biogas plants in the agriculture and food sector, e.g. in Germany, was estimated by Weiland to be 30.000 – 40.000 plants in total with an annual increase of 150 – 200. In the year 2000 just 1000 plants were already installed, but their number is strongly increasing. The estimated potential of energy produced on the basis of biogas for all EU Member States is 753 PJ. Only little of this potential is currently used. A considerable fraction of today’s unused potential will match the advantages of 3A-biogas. All countries with agricultural overproduction or a backlog in redevelopment of the environmental situation can be seen as promising future markets for biogas and as well for 3A-biogas plants. 3A-biogas plants will be able to work financially viable at small to medium scale application up to 3000 m3/a.

Furthermore potential customers are the agro- and food sector, the MSW industry and the biowaste treatment sector.

Testing phase

The first months of the testing phase were nearly interrupted daily by wrong delivered or faulty components. After all parts were repaired or changed the real testing phase could start. As at the location of the Austrian prototype unit biowaste is available in big amounts, it was decided to investigate in the first test runs this substrates. For the test runs it was necessary to mix up the substrate with structure materials to create pore volumes where the percolation water and the biogas can flow through. The substrate mixing was achieved with a common compost turning machine. Before the test run could start it was necessary to prepare the first percolation water. As the 3A-biogas process combines aerobic as well as anaerobic treatment phases both kinds of bacteria have to be in the percolation water. Therefore the water was created of a mixture of waste water of a fermentation plant and compost.

The first aerobe process phase worked out as expected very well. In the anaerobe treatment phase the Methane concentration increased in the first cycles very slow. In the following cycles the CH_4 concentration was faster in the usable range and higher amounts of biogas could be used.

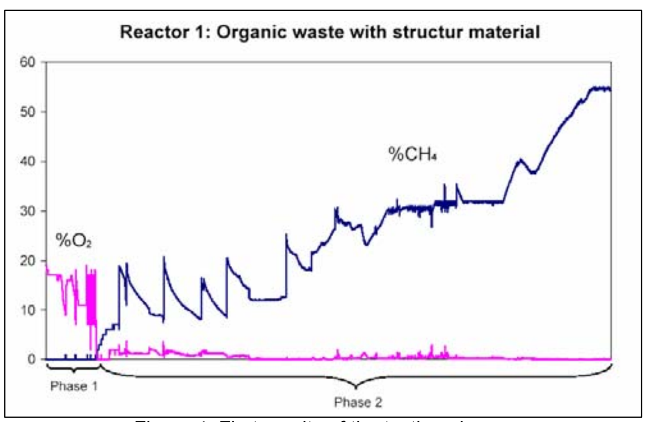

Figure 4: First results of the testing phase

It seems that the anaerobe bacteria in the percolation water needs some time to confirm to the used substrate. For the further commercial 3A-biogas plants this could mean that the input substrate has to be as equal as possible during the whole year to ensure a stabile biogas production.

Conclusion

The results of the laboratory tests and the first results of the prototype unit show that the 3A-biogas system works very well. The important fact in the remaining time of the project and afterwards is to optimise the system and to find optimal material mixtures to ensure an economic efficiency.

All the during the testing phase gathered information, all the different material preparations and as well all the problems we had will be implemented in a new 3A-biogas plant and offered for potential customers. Besides this batch process, investigations will go ahead to develop in future a continuos 3A-biogas dry fermentation system.

