ProEcoPolyNet
Best practice Sheet
"3A Biogas"

RTD Project Identification

RTD Project Name: 3A Biogas
RTD Contract No.: ENK6-CT-2002-30026
Programme: FP5

Description of technology

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

The major part of solid state biowaste with a high proportion of dry substances is processed aerobically, typically by composting. The energy balance of this treatment is negative as mechanical energy is required to turn compost windrows and the energy (heat) produced is not harnessed. Treating solid bio waste in conventional biogas systems (anaerobic fermentation) consumes large quantities of process water and involves expensive mechanical and thermal process energy costs. The new 3A biogas batch process for solid bio waste achieves an optimum combination of the benefits of aerobic composting and anaerobic fermentation and includes sanitation of the compost. (see also **Fig. 1**)

The 3A biogas process is a combined composting and digestion process which is divided into three phases. The first phase is **aerobic**, the second is **anaerobic** and the third is **aerobic** again. These changes between aerobic and anaerobic conditions gave the 3A process its name. (see also **Fig. 2**)

An innovative perlocation liquid system allows direct fermentation of solid biomass (30-70% DS) without adding fluid. The process does not produce waste water. The products are only compost and biogas.

Operating principle

The 3A process combines biogas production, hygienisation and deodoration in three phases.

1. **aerobic**
   Substrate pretreatment: If necessary the substrate is interspersed with e.g. wood chips to reach a proper gas and water permeability.

   To start the 1st phase the input material is ventilated, so the substrate is aerated and the aerobic microbiological activity causes an increase in temperature. The temperature is controlled by regulating the ventilation. Temperatures up to 70 ℃ are reached. The 1st phase lasts up to 6 days depending on the input substrate.

   The 1st phase has the following effects on the substrate:

   - sanitation (reduction of pathogen)
   - heating of the substrate for the 2nd phase without energy input
   - reduction of lightly degradable substances to reduce the formation of acids.

2. **anaerobic**
   The 2nd phase of the 3A biogas process is the anaerobic phase, during which methane is produced. The reactor temperature is usually regulated on mesophile conditions (35 to 45 ℃). Within this temperature range methane forming microorganisms are quite resistant against changes of acidity. At thermophile conditions (45 to 55 ℃) the activity of microorganisms is higher but they will also react more sensitive to changes of acidity. The methane concentration in the bioreactor can continuously increase up to more than 70%. Depending on the energy content of the substrate one charge can be used for methane production for 25 up

to 40 days. The closed-circuit percolation liquid system allows direct fermentation of solid biomass without adding fluid. The process-related leakage is collected and stored in heated vessels. In regular intervalls it is sprayed over the substrate in the bioreactor. This procedure ensures the water supply for the bacteria and fresh substrates are inoculated with bacteria from former batches.

3. aerobic
To start the 3rd phase the substrate in the bioreactor is ventilated again and no more percolation water is added to the substrate. The aeration causes again an increase in temperature. If sanitation is necessary the temparure can be raised up to 70 ℃. During the 3rd phase the substrate is stabilised and it becomes quite inodorous. The second aerobic phase lasts ~10 days depending on the material and the requirements for maturity of the output compost.

Further composting: To reach compost with a further stage of maturity for special applications, the output material of the 3A biogas process can be composted in a conventional way inside (which reduces material throughput) or outside the fermentation reactors.

For details concerning temperature development and methane production during the three phases see **Fig. 3**.

Technical characteristics of installation

The 3A biogas plant consists of several biogas reactors being in different phases of the 3A prozess, which assures a continous production of biogas and facilitates the handling of sporadically available substrates.

The biogas reactors are cuboid, heat insolated boxes made of gas proof concrete. One of the four concrete walls is designed as a gas proof gate to make an easy charging and emptying possible. The covering is also made of heat insolatet, gas proof concrete or of a gas proof double diaphragm, which is also used as a biogas holder. In that case the gas reservoir also provides for the heat insolation of the bioreactor.

In the concrete bottom plate pipes for drainage and air ventilation are installed. The produced biogas and exhaust air are taken from the head space above the substrate by pipelines. The walls are equipped with temperature and pressure sensors necessary for automatic prozess monitoring and control. Pipes for irrigation with percolation liquid are attached to the covering.

The exhaust air that is formed in the first and third phase is purified by a biofilter to minimize bad smell. During the change from the aneraobic 2nd phase to the arobic 3rd phase an unusable gas /air mixture is produced, which is disposed of by a gas flare. This gas flare is also a legal safety equipment needed if the biogas utilisation drops out.

Size and number of bioreactors are variable and should be adapted to availability and amount of input material. Because of the modular concept of the plant it is comparatively easy to react to changes in the availability of input material by extension or partly closing.

Location and use

► *Location*

- The 3A biogas process is highly appropriate for liquid fermentation plants or wastewater treatment plants with digestion, that need a second treatment line for solid input substrates. Especially biogas plants with a high amount of dry or sandy input materials benefit from the advantages of 3A biogas.

- Furthermore the 3A biogas treatment is an ecological and economical alternative to common composting plants.

- Another operational possibility for the 3A biogas process is the treatment of municipal solid waste in order to reduce the volume, water content, organic content and heating value.

► *Use*

- The produced biogas can be used in CHP generation plants and gas turbines or purified for the use in fuels cells or for the feed-in to a public gas distribution system etc…

The produced compost is suitable for fertilisation and soil improvement.

State of Development/Market implementation

► *Prototype and Field tested*

After laboratory trials a 3A biogas batch system was scaled up to industrial requirements within the framework of the 3A biogas project. Two prototypes with a capacity of 25-40 m^3 were constructed and installed in Weibern (A) and Léon (E). The 12-month testing of the prototypes showed, that the 3A biogas process is suitable for the profitable production of high quality biogas (75% methane) from solid state biowastes.

► *Serial production*

The 3A process is virtually ready for marketing. Using the results of the 3A biogas project a biogas plant with a capacity of 250 kW_{el} using straw containing poultry manure and grass silage as substrates was designed. The produced heat was intended to be used for heating a hen-coop. Because of a strong opposition among abutters, increasing prices of the input materials and difficult negotiations concerning the feed-in tariff for the produced electricity the project has not been implemented yet.

Considering the increasing prices of raw materials for biogas plants it is likely that the 3A prozess will be applied primarily as an ecological and ecomomical alternative to common composting plants.

several enquiries concerning the implemetation of the 3A prozess by composting plants using biowaste as substrate.

Capital investment

Each (3A) biogas plant is designed and constructed with regards to the individual needs of the particular operator. That is why, biogas plants differ in size and specification. As a matter of course different plants show varying values of installation and investment costs.

So the calculation quoted below is just an example for an indivudual 3A biogas plant, that was recently designed by Müller Abfallprodukte GmbH. The plant comprises four bioreactors, each with a size of 6 x 25 m. The plant is intended to process 8000 t of organic waste (bio waste, waste from the food industry,…) per year. The investment costs (including plant engineering and construction, process measurement and control, gas installations and other peripheral devices) are named with 1,4 Mio €. Installations for biogas application (CHP, transformer,…) were not considered.

Operational data

Referring to the above-mentioned biogas plant with a biowaste consumption of 8000 t/a a biogas output of 720000 m^3/a and an electricity output of 1,5 Mio kWh/a can be achieved.

Benefits and obstacles

► The 3A biogas process for solid bio waste

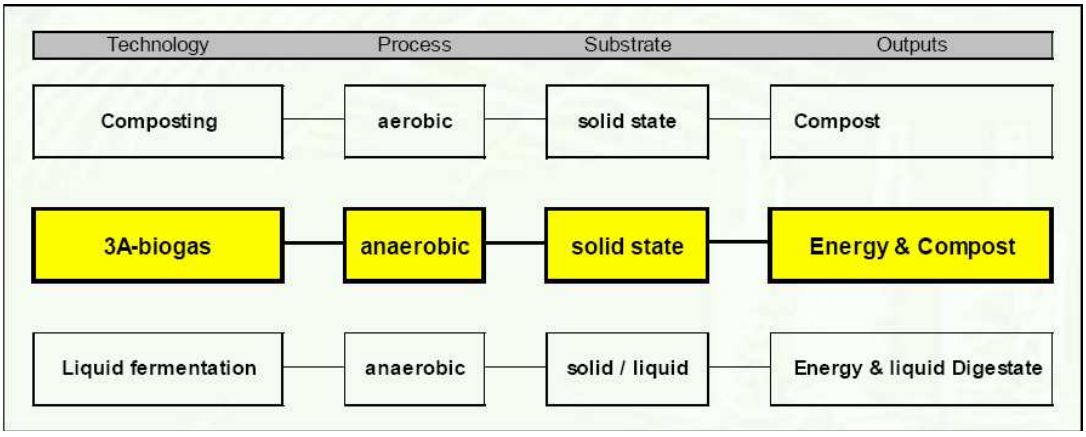

Fig. 1 *3A biogas in comparison to common treatments*

At the moment the coordinator of the project (Müller Abfallprodukte GmbH) works on

achieves an optimum combination of the

benefits of composting and anaerobic fermentation.

The flexible modular batch system provides three process phases (aerobic; anaerobic; aerobic = 3A) in one reactor.

► Adequate pore volumes of the organic input substrate and the proper use of a closed-circuit process water system avoids wastewater and enables 3A biogas to work without material conveyance and water addition during the whole process.

► If required sanitation is done within the process. (T up to 70°C for several days during the 1st and 3rd phase).

► The 3A biogas process uses mature, high quality and low maintenance technique of rugged design.

The valuable end products are biogas and top-quality compost - ready for fertilisation and soil improvement without any further treatment. No waste products are accumulated within the process.

Contact and further information

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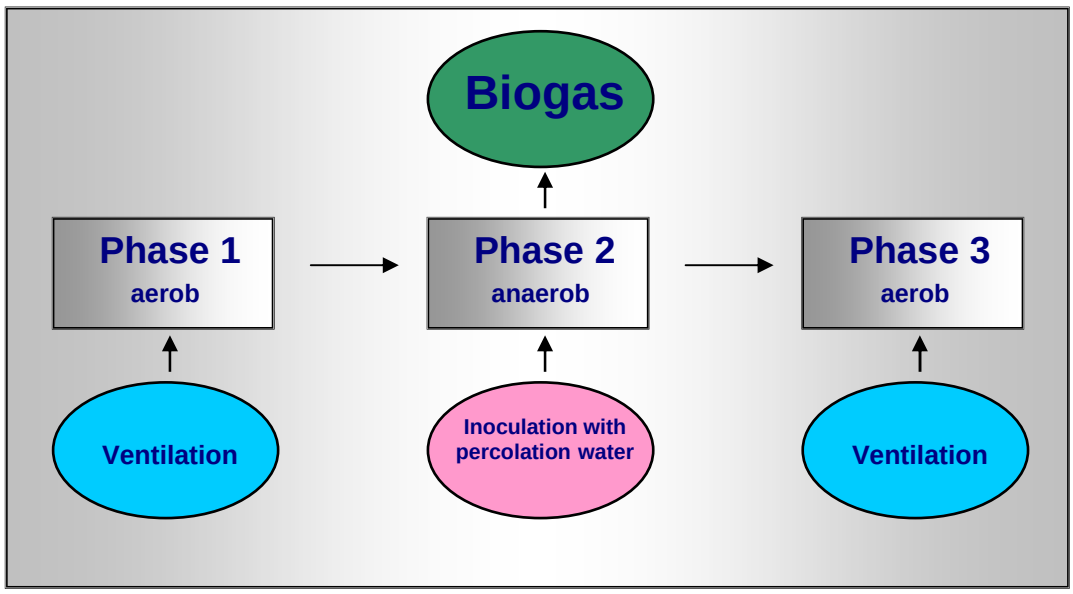

Fig. 2 *The 3A biogas process*

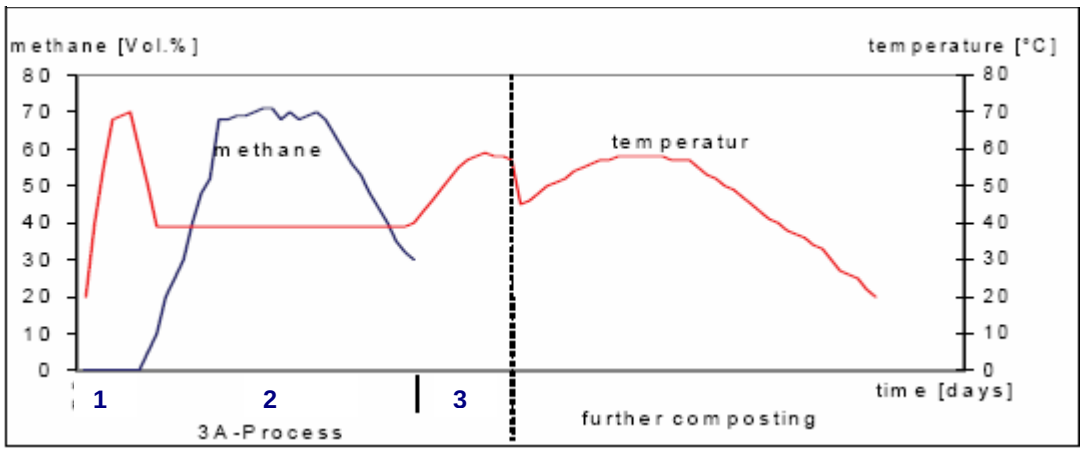

Fig. 3 *3A biogas process: Methane production and temperature development*
***1**…aerobic, **2**…anerobic, **3**…aerobic*