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BIOGAS – A SUSTAINABLE ENERGY SOLUTION FROM AGRO-INDUSTRIAL WASTES

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Overview

The fossil fuels are limited and nonrenewable resources; the use of biomass for energy production seems to be a solution to provide energy and reduce the dioxide carbon emissions. The food-processing industry generates large quantities of residues, which may represent sustainable and rich sources of bioactive compounds. Agro-industrial residues provide an enormous potential for sustainable products and bioenergy.

Biogas originates from bacteria in the process of bio-degradation of organic material under anaerobic conditions. The natural generation of biogas is an important part of the biogeochemical carbon cycle. Methanogens are the last link in a chain of micro-organisms which degrade organic material and return the decomposition products to the environment.

Biogas is produced through an anaerobic digestion by anaerobic bacteria with four steps identified as: hydrolysis, acidification, production of acetate and production of methane using a microorganism consortium. The final product is a gas mixture composed mainly of methane and carbon dioxide and traces of hydrogen sulfide, ammonia, hydrogen, and carbon monoxide.

Anaerobic digestion has demonstrated to be a flexible technology with a variety of reactor designs adapted to many situations, transforming liquid and solid residual organic matter to valuable intermediates such as carboxylates, which can be recovered, and finally to biogas, which can be used for the production of heat and electricity or upgraded to biomethane. [1].

Anaerobic Fermentation

Knowledge of the fundamental processes involved in methane fermentation is necessary for planning, building and operating biogas plants. Anaerobic fermentation involves the activities of three different bacterial communities. The process of biogas-production depends on various parameters.

Biogas microbes consist of a large group of complex and differently acting microbe species, notably the methane-producing bacteria. The whole biogas-process can be divided into three steps: hydrolysis, acidification, and methane formation. Three types of bacteria are involved.

Hydrolysis – the organic matter is enzymolyzed externally by extracellular enzymes of microorganisms.

Acidification – acid-producing bacteria, involved in the second step, convert the intermediates of fermenting bacteria into acetic acid (CH_3COOH), hydrogen (H_2) and carbon dioxide (CO_2). These bacteria are facultatively anaerobic and can grow under acid conditions. To produce acetic acid, they need oxygen and carbon. For this, they use the oxygen solved in the solution or bounded-oxygen. Hereby, the acid-producing bacteria create an anaerobic condition which is essential for the methane producing microorganisms. Moreover, they reduce the compounds with a low molecular weight into alcohols, organic acids, amino acids, carbon dioxide, hydrogen sulphide and traces of methane. From a chemical standpoint, this process is partially endergonic.

Methanogenesis – Methane-producing bacteria decompose compounds with a low molecular weight. Under natural conditions, methane producing microorganisms occur to the extent that anaerobic conditions are provided. They are obligatory anaerobic and very sensitive to environmental changes. In contrast to the acidogenic and acetogenic bacteria, the methanogenic bacteria belong to the archaebacter genus, the main difference lies in the makeup of the bacteria's cell walls.

Symbiosis of Bacteria

Methane- and acid-producing bacteria act in a symbiotic way. On the one hand, acid-producing bacteria create an atmosphere with ideal parameters for methane-producing bacteria. On the other hand, methane-producing microorganisms use the intermediates of the acid-producing bacteria. Without consuming them, toxic conditions for the acid-producing microorganisms would develop. In practical fermentation processes the metabolic actions of various bacteria all act in concert. No single bacteria is able to produce fermentation products alone.

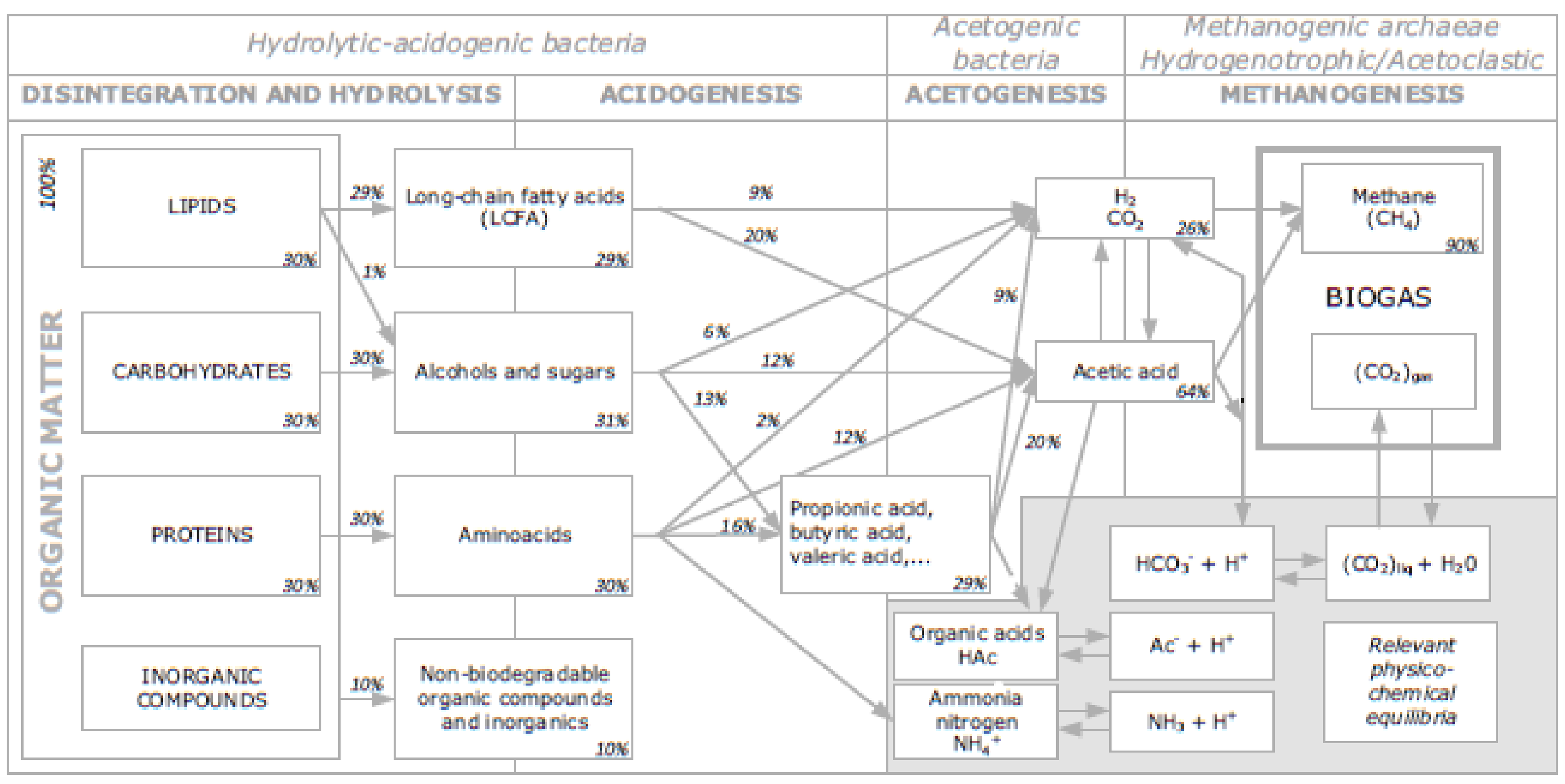

Fig. 1. Schematic representation of the anaerobic digestion process (Batstone et al., 2002)

Table 1. Composition of Biogas

Component	Content [%]
Methane, CH_4	50-75
Carbon dioxide, CO_2	25-50
Nitrogen, N_2	0-10
Hydrogen, H_2	0-1
Hydrogen sulphide, H_2S	0-3
Oxygen, O_2	0-2

Composition and Properties of Biogas

The composition of biogas varies depending upon the origin of the anaerobic digestion process. Landfill gas typically has methane concentrations around 50%. Advanced waste treatment technologies can produce biogas with 55-75% CH_4. The calorific value of biogas is about 6 kWh/m^3 - this corresponds to about half a liter of diesel oil. The net calorific value depends on the efficiency of the burners or appliances.

The main benefits that a biogas installation can provide are the following:

- ✓ Solve the problem of agricultural waste. Any organic waste is digestible. And it is converted into money.
- ✓ Control the CH_4 that is 27 times more polluting than CO_2, which in a normal way would have been released and now trapping it and converting it into energy.
- ✓ Prevention of the CO_2 production from other processes such as burning coal or oil that would have been necessary for that generation.
- ✓ The efficiency of the 350KWh biogas plants is greater than the photovoltaic one (1800 hours of annual production).
- ✓ From the waste we obtain monetary benefits and jobs in the biogas plant itself, improving the local economy.

References:

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