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MODERN TECHNOLOGIES OF ALGAE BIOMASS USED FOR OBTAINING ALTERNATIVE FUELS

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Abstract: Since classical fuel reserves are exhaustible, mankind is moving towards finding new sources of energy based on renewable, inexhaustible and environmentally friendly resources. Biogas and biodiesel are unconventional energy sources resulting from a natural controlled conversion process of biomass. In recent years, major research has been carried out on algal biomass conversion technologies in biogas and biodiesel. New types of digesters, power systems, storage facilities and a whole range of other equipment have been introduced and adapted.
Keywords: algae, biodiesel, biogas, technological equipment

1. INTRODUCTION

Implementation, development and scale-up of technologies for energy production are currently a challenge for scientists and a priority for energy system operators. Biomass of different origins is believed to be one of the main sources of renewable energy (McKendry P.. 2002, Goyal HB et al. 2008. Börjesson P. and Berglund M., 2006), some reports undermine this common opinion. Fargione et al. (2008) and Searchinger (Searchinger T. et al. 2008) have argued that irrational management of typical energy crops could in practice lead to increased greenhouse gas emissions, being emitted into the atmosphere. Some works also suggest that the intensive exploitation of arable land for growing crops for the production of biofuels can have a negative impact on global supply and food prices (Johansson D. and Azar CA. 2007).

Having in view the above issues, an urgent need arises for alternative sources of biomass for energy purposes that are both economical and environmentally friendly. Considering a very high photosynthetic efficacy, a rapid growth rate of biomass, resistance to various types of contamination and the ability to manage land that can not be used for other purposes, algae appear as a competition on typical energy crops (Mandal S et al . 2009; Smith V. et al., 2010). Green algae produce lipid substances - vegetable oils after the photosynthesis process. These oils can be used to produce biogas and diesel fuel.

2. MATERIAL AND METHODS

Alternative fuels (Table 1) are chemical substances (alcohols, ethers, esters. etc.) obtained through the use of various physicochemical and biological processes for the transformation of plant biomass represented by woody and herbaceous plants, forestry and agricultural waste of industrial and municipal waste, in products that can release by combustion a large amount of energy without generating major polluting effects.

Biomass represents the entire plant material or vegetation, either in the raw or processed state, from wild or cultivated plants, trees, shrubs or fast growing herbs, agricultural residues, wood residues, methane from the basins of city treatment plants (Naghiu et al. al.. 2005).

Table 1. Types of alternative fuels and their characteristics

Biofuel	Characteristics	Advantages
Farming biomass ethanol	- alcohol obtained by fermentation of grain crops and other plant sources	- high octane fuel and reduced emissions of greenhouse gases
Lignocellulosic biomass ethanol	- lignocellulosic biomass alcohol obtained by converting the fermentable sugars followed by fermentation to ethanol their	- high octane fuel and reduced emissions of greenhouse gases - do not use food or feed commodity
Biogas	- gas mixture of the predominant methane produced by anaerobic fermentation of manure or other waste or agricultural products, domestic and industrial	- raw material is unworthy - Important role in waste management - can be a source of energy in rural communities or poor areas of the globe
Biodiesel	- a diesel-like fuel obtained from vegetable oils	- reduce the emissions - engine is lubricated
Renewable diesel	- a diesel-like fuel obtained from vegetable fat and oil	- meet the standards for diesel with very low sulphur and animal fats added
Biobutanol	- alcohol fuel, like ethanol	- easier to carry, less corrosive than ethanol in pipelines

Biodiesel appears to be one of the fuels of the future, mainly due to the abundance of natural raw materials from which it can be produced. In this context, we do not wonder that biodiesel can also be produced fresh from marine algae. The greatest advantage of algae is that it can get 30 times more biodiesel per hectare than corn or soy. Since algae grow in salt water (the most abundant substance on Earth), it is understandable why

marine algae can become an alternative to oil. The discussion must begin with the source of raw material. It is not yet known what plant species we will rely on in the future as a source of fuel, so the big companies in the field are considering more options.

The future will show which of the experienced plants will prove to be the most appropriate. The selected algae species are those able to synthesize large amounts of lipids (fatty substances). But why? Because it is precisely these substances that can be obtained through a chemical process called transesterification, the precious fuel that we will feed tomorrow cars, motorcycles, scooters, chainsaws that work today with diesel. In theory, it's pretty simple.

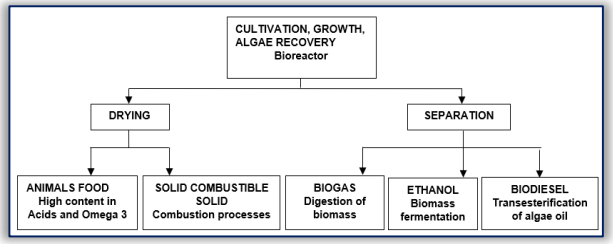

Figure1 – The process of transforming algae into biofuels

Green algae produce lipid substances - vegetable oils after the photosynthesis process. These oils can be used to produce biodiesel fuel for the supply of any diesel engine. At the current level of consumption, oil reserves may end soon enough; as the reserves will drop, the price will grow alarmingly and anyway, the oil industry is extremely polluting, contributing to global warming.

The oil crisis is near and new sources of raw materials need to be found to get fuel. Researchers look for algae more than other terrestrial plants! This is explained by the fact that they have some great advantages. First of all, their vital needs are smaller and easier to satisfy. They only need water, sun and carbon dioxide and they are easier to buy and create fewer problems than the pesticides and pesticides that are growing today in terrestrial plants (Vadineanu A.). The process of algae transformation in biofuels which are growing today in the terrestrial plants (Vadineanu A.), is shown in figure 1. Biogas is a gas composed mainly of methane and carbon dioxide in varying proportions, resulting from anaerobic fermentation (without air, without oxygen) of organic matter. Biogas emanates from the substrate, from waste, organic, vegetal, animal, household waste, under the action of methanogenic bacteria.

Biogas production technology is one of the oldest and most known natural processes of "swamp gas" emission. It allows the creation of alternative energy sources and is the object of study of many scientific schools in the world. As a result, biogas technology is widely applied in a number of industrial countries in Europe and America.

The Southeast Asian example shows that thousands and thousands of different capacity biogas plants are already operating using standard technology. However, the biomethane content of the biogas does not exceed 60 ± 5% and the process is characterized by the long duration of fermentation - from 3 to 10 days, the degree of transformation of organic substances from biomass being only 40-60%. The resulting waste water contains high concentrations of pollutants, making it necessary to treat them under aerobic conditions (Cleseri LS., 1992).

The production of biogas by anaerobic digestion (AD) is considered to be the optimal treatment for animal manure as well as for a wide variety of organic waste suitable for this purpose, as such substrates are converted into recoverable energy and organic fertilizer for agriculture. At the same time, the elimination of the organic fraction from the total amount of waste increases both the energy conversion efficiency by incinerating the remaining waste and the stability of the waste dumps.

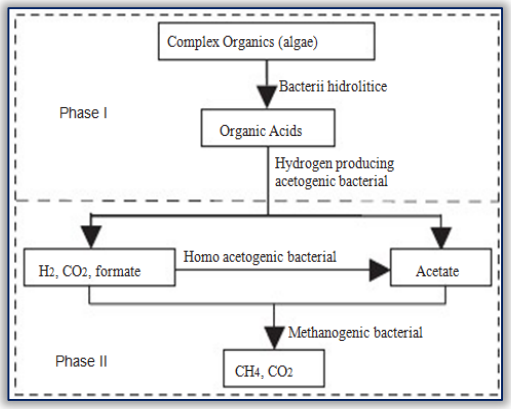

Figure 2 - Biogas production process

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Anaerobic Digestion (AD) is a microbiological process of decomposition of organic matter, in the absence of oxygen, encountered in many natural environments and nowadays widely applied for the production of biogas in air-tight tank-type reactors, commonly called digesters.

A wide variety of microrganisms are involved in the anaerobic process, resulting in two final products: biogas and digestate. The process of producing biogas and the two phases of the anaerobic digestion system are presented below in Figure 2 (Olguin EJ.).

3. TECHNOLOGIES AND EQUIPMENT FOR BIOGAS PRODUCTION

Biogas technology has its own traditions in India, China, USA, Canada, Japan, and has become interesting in Europe, namely Denmark, UK and in Romania since 1975. The raw material, biomass can also be obtained by growing fast-growing plants in the so called energy plantations that can be: land plantations, plantations at sea, algae and other marine plants. From the point of view of the fermenter's feed (loading), the technical equipment within the technologies can be classified as follows:

— with discontinuous power supply (characteristic of small capacity equipment for household use and medium capacity of farms);
— with continuous feed for industrial installations (Vintila M.. 1989).

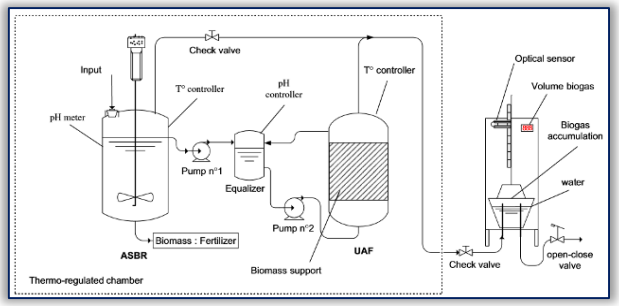

Figure 3 - Schematic design of a two-phase anaerobic digestion system

4. EXAMPLES OF BIOGAS PLANTS USED IN ROMANIA

— Low capacity plants

The installation shown in FIGURE has a capacity of 14 m3. And was designed by a team from the faculty of Hydrotechnics of Iasi Polytechnic Institute and it was made in rural households from the counties of Iasi, Botosani and Suceava.

The plant is composed of a feed chamber, a fermentation tank, a gas meter and an exhaust chamber.

From the base of the outer wall of the supply chamber to the base of the evacuation chamber, a 1.1 m level difference is made which allows the gravitational displacement of the fermentation material (the floor of the feed chamber and the fermenter are formed in a tilted plane). The supply and evacuation chambers are in the form of openings with wooden caps and access to metallic steps.

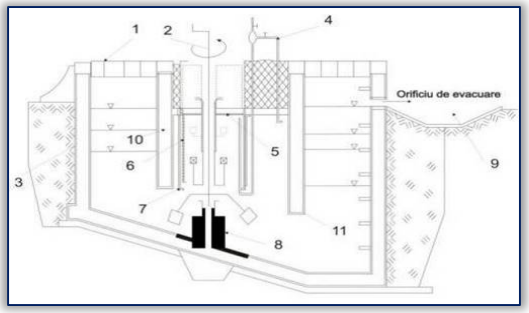

Figure 4 – Small capacity biogas installation: 1 – wooden floor; 2 – stirrer; 3 – outer wall; 4 – gas outlet pipe; 5 – ballast on the wooden floor; 6 – plate bell (gas meter); 7 – exhaust pipe; 8 – bronze nut; 9 – exhaust duct; 10 – the inner wall of the feed chamber; 11 – the inner wall of the evacuation chamber

The plant operates at ambient temperature and the insulation is done with a layer of straw and manure. Biogas production stagnates if the temperature in the fermenter drops below 8-10°C.

To accelerate the fermentation process, a blade shaker is provided which acts on the bottom of the fermenter. The shaker is manually operated by a crank.

Fuel gas capture is done through two wells, one under the bell and the other in the fermenter's shelter where the gases from the biomass flowing to the exhaust pipe are stored. Under normal operating conditions, the plant can supply about 3 cubic meters of gas per day.

In this field, the researchers from INMA Bucharest designed and built a biogas pilot plant, Figure5 (for experimenting with biogas technologies from animal manure, agricultural biomass, algal biomass).

The pilot plant for biogas production consists of two bioreactors for fermentation, stirring system, agitator drive motor - frequency inverter system. 4 pH sensors, 6 temperature sensors, heating system, photovoltaic panel system, solar panels, pH correction solution, storage tank, biogas flowmeters, low pressure transducers, biogas-powered generator, portable gas analyzer. The total capacity of the pilot plant is 5 m3.

With the help of the pilot station you can experiment with different biogas-producing innovative recipes, as well as conducting the fermentation process either mesophilic or thermophilic.

Within the INMA research is being carried out on an innovative technology for obtaining algal biomass as a source of raw material for the production of alternative biofuels. In this biogas technology, the MGA pilot station will be used.

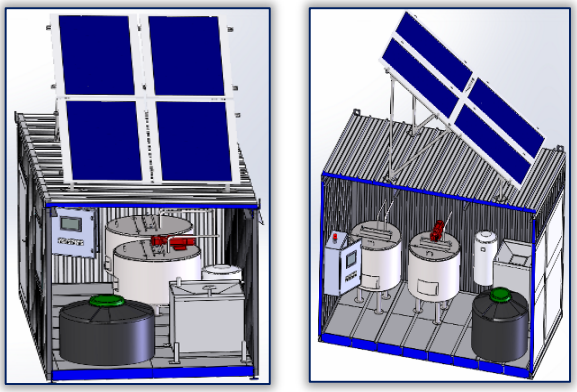

Figure 5 - MGA- Pilot plant for obtaining bioenergy through dry and wet advanced methanogenesis

— Medium capacity facility

Such a facility was designed by a team of the Institute of Food Chemistry in Bucharest. The scheme of the installation is shown in Figure 6. The capacity of the fermenter is 25-50 m^3, the plant having two main components: the fermentation tank, the cylindrical vertical shaft, thermally insulated and a multifunctional bell, which can be slid vertically into the fermentation tank. The fermentation cuvette is semi-planted, so that at least 1.5 m of its height is above the ground. There are four metal stops inside the bowl, which limit the lower position of the bell.

The installation works in mesophilic mode, with the possibility of mounting an internal heat exchanger. Dilution of the material is done with warm water. Organic feed is through a tube that penetrates through the bell shaft and the exhaust of the fermented material is made with an exhaust pipe.

— High capacity installation

High-capacity biogas plants have been designed by the Institute of Studies and Design of Construction for Agriculture and Food Industry (ISPCAIA) based on the technology established by a research team from the Institute of Food Chemistry (IAA).

Many companies have been established in the country to assemble high-capacity biogas plants such as pulg-flow and superflow (http://biogaz-instalatii.ro/imari.html).

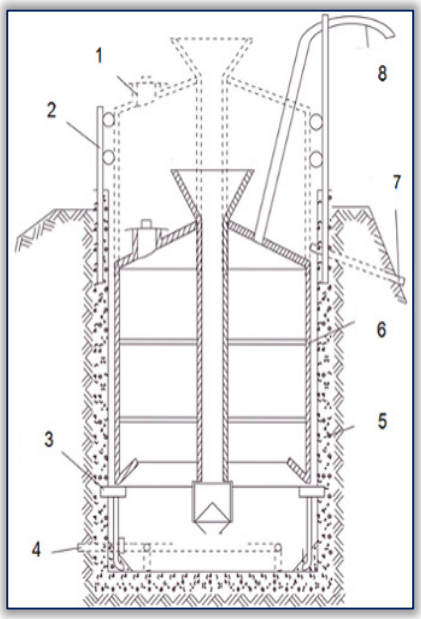

Figure 6 - Medium capacity biogas plant (25–50 m^3): 1–manhole; 2-bell guide support; 3-stopper bell; 4-connect hot water; 5-concrete wall; 6-metal bell; 7-exhaust pipe; 8-biogas hose

4. CONCLUSIONS

— The biogas and biodiesel production technology are ones of the oldest and most known natural processes. It allows the creation of alternative energy sources and is the object of study of many scientific papers in the world.

— Despite some limitations on the use of algal biomass for biofuel production processes, studies have led to their recognition as an alternative source of organic substrate. These organisms have many advantages in the production of biofuels compared to typical crops used as energy sources: they contain large quantities of polysaccharides and lipid substances and are devoid of lignocellulosic compounds that are hardly degradable; are characterized by an increased biomass rate; eliminate a small amount of carbon dioxide; are biodegradable, so they do not affect the environment.

— Biogas is obtained through the anaerobic digestion process (AD) in special plants, which, depending on the production capacity, can be classified in small, medium and large plants- by using the alternative biofuels obtained from reducing the consumption of fossil fuels.

Acknowledgement: The research work was funded by the NUCLEU Programme of the Ministry of Research and Innovation, through financing contract no. 8 N / 09.03.2016 –Act.Ad.2/2017 for the project " *PN 16 24 04 04 „Researches regarding to development of an innovative technology for obtaining advanced biofuels from non-food resources"/„*Cercetari privind dezvoltarea unei tehnologii inovative pentru obtinerea biocombustibililor avansati din bioresurse non-alimentare".

Note: This paper is based on the paper presented at ISB-INMA TEH' 2017 International Symposium (Agricultural and Mechanical Engineering), organized by University "POLITEHNICA" of Bucharest – Faculty of Biotechnical Systems Engineering, National Institute of Research-Development for Machines and Installations Designed to Agriculture and Food Industry – INMA Bucharest, Scientific Research and Technological Development in Plant Protection Institute (ICDPP), National Institute for Research and Development for Industrial Ecology – INCD ECOIND, Research and Development Institute for Processing and Marketing of the Horticultural Products "HORTING" and Hydraulics, Pneumatics Research Institute INOE 2000 IHP, University of Agronomic Sciences and Veterinary Medicine of Bucharest (UASVMB) – Faculty of Horticulture and Romanian Society of Horticulture (SRH), in Bucharest, ROMANIA, between 26 – 28 October, 2017.

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ISSN 1584 - 2665 (printed version); ISSN 2601 - 2332 (online); ISSN-L 1584 - 2665