USE OF GEOTHERMAL ENERGY SOURCES FOR ORGANIC WASTE MANAGEMENT

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ABSTRACT

A novel system for organic waste processing coupled to food production was conceived and constructed during the project INTERREG IV Greece-Bulgaria 2007-2013 *«Fostering the use of low temperature geothermal sources through the development of operational exploitation guidelines and green energy solutions of enterprising»*. Organic waste biomass is digested using geothermal energy and converted into biogas and mineralized organic nutrients (liquid and solid fertilizer). The biogas (CO_2) and the nutrients are used for enhanced food production in geothermal greenhouses. Enrichment of greenhouses with CO_2 is commonly applied around the world during the winter season and/or when sunlight is limited. Geothermal greenhouses can benefit from installing compact digesters for on-site production of electricity, heat, fertilizers and CO_2 using organic wastes/ biomass.

Keywords: geothermal energy; anaerobic digestion; organic waste treatment.

1. Introduction

The combined use of geothermal energy sources and anaerobic digestion processes may provide significant advantages for organic waste treatment and valorization. In the region of Eastern Macedonia and Thrace, extensive geothermal fields are available, in areas with intensive agricultural production (Andritsos *et al*., 2011). However, the management of livestock and agro-industrial residues is poor, usually involving final disposal to the natural environment without prior treatment, which entails high carbon footprint (mainly from diffuse methane emissions) and leads to significant pollution of soil and water resources (surface and groundwater). On the other hand, intensive food production in greenhouses, require high quantities of chemical fertilizers and the consumption of natural gas for CO_2 enrichment (Matson *et al*., 1997).

The proposed technology (Figure 1) consists of a compact anaerobic digester which is maintained at the desired digestion temperature using geothermal energy. The digester is inoculated with high activity anaerobic biomass therefore biogas, rich in methane, is generated directly after feeding with organic wastes (livestock wastes, agro-industrial residues). The generated biogas is treated to remove hydrogen sulfide, and accordingly burned inside the greenhouse for heating and/ or CO_2 enrichment purposes. It is well known that increasing CO_2 levels results in enhanced agricultural production (Rogers and Dahlman, 1993). Indeed, CO_2 enrichment is commonly applied at Northern European countries, during the winter season and especially during days of partial or limited sunlight (Dion *et al*., 2011).

The digested solid organic fertilizer is removed from the bottom of the compact digester and spread onto the greenhouse soil to increase soil organic matter and microbial activity, thus further increase the release of CO_2 inside the greenhouse (Schlesinger and Andrews, 2000). The stabilized liquid organic fertilizer is used as an alternative to chemical fertilizers for maximizing plant growth.

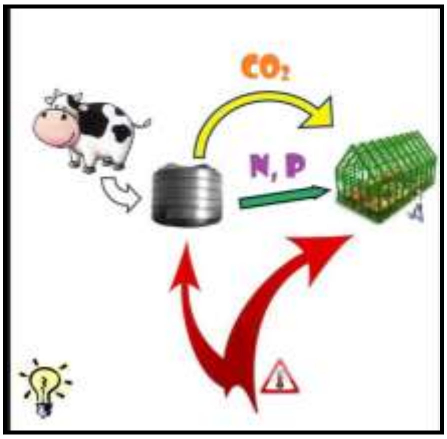

Figure 1: Schematic representation of the proposed technology for organic waste management using geothermal energy resources.

The advantages of using geothermal energy for organic waste processing are the following:

- Optimum digestion temperature (35-40 ^oC) can be achieved throughout the year.
- It is possible to maintain the desired temperature inside the digester during periods without feeding, i.e. when biogas is not produced. Accordingly, it is possible to ensure rapid start-up after feeding the digester.
- The geothermal fluid can be used for thermal pretreatment and/or pasteurization of the organic wastes or the stable liquid fertilizer.

2. Prototype design

A 8 m^3 compact anaerobic digester was designed and constructed (Figure 2). It is made from polyethylene and equipped with a heat exchanger for circulating the geothermal fluid.

Figure 2: Photographic representation of (a) the compact anaerobic digester showing the sampling ports and the motor, (b) the digester paddle mixing system and the heat exchanger and (c) the biogas scrubber.

Mixing is performed using a paddle-mixer to ensure optimum contact between the anaerobic biomass and the incoming organic wastes. The generated biogas is purified by means of a biological scrubber and is accordingly burned inside the greenhouse or used for electricity production.

3. Prototype operation

During the remaining project period, the anaerobic digester will be operated using different agro-industrial wastes (Table 1). The selection of these wastes will be based upon local availability. Wastes and wastewaters from livestock facilities, wineries, olive mills and cheese manufacturing will be used for the study. These are characterized by a high organic content, high concentration of soluble and readily degradable COD and low toxicity. Therefore, it is possible to generate biogas at high rate using the proposed compact digester (Table 2). Simultaneously, a stabilized solid and liquid fertilizer will be recovered for use in agriculture.

Table 1: Physicochemical properties of agro-industrial organic wastes selected for biogas production using the compact geothermal anaerobic digester.

Parameter	Cheese whey	Wine lees	Olive mill	Cow manure	Pig manure
pH	3.5-4.0	4-4.5	4-4.5	7-7.5	7-7.5
EC (mS/cm)	5-6	1-2	6-9	8-15	10-15
CODtot (g/L)	50-60	250-300	40-50	20-30	20-30
CODsol (g/L)	40-50	200-220	20-30	8-12	6-12
NH_4-N (mg/L)	100-200	20-50	20-50	800-1400	1000-2000
PO_4-P (mg/L)	1000-1200	100-200	20-30	40-100	50-120

Table 2: Volumetric organic loading rate and expected biogas production during anaerobic digestion of organic wastes using the compact geothermal anaerobic digester.

Organic waste	COD (g/L)	Biogas ($m^3/m^3{}_w$)	OLR (kg/m^3d)	COD removal (%)
Cheese whey	40-60	30-35	10	>90
Wine lees	250-300	100-150	8	>90
Olive mill	40-60	20-30	2	>75
Cow manure	15-25	7-10	<1	>75
Pig manure	15-25	8-12	<1	>75

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