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SOURCES OF RENEWABLE ENERGY AND OBTAINING THERMAL ENERGY BY DECOMPOSING VEGETABLE MATERIAL

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Abstract

The present study aimed at the experimental realization of an installation for obtaining the thermal energy by decomposing the plant material. The prototype was made within the Faculty of Agricultural Sciences Food Industry and Environmental Protection, from the Lucian Blaga University in Sibiu, in the discipline of Renewable Energy Sources. This method resulted in bacterial decomposition of wood mass from forest waste which resulted in 14 months of hot water for heating the home (4 l/min), domestic hot water and biogas.

Key words: *thermal energy, experimental installation, composting*

INTRODUCTION

At the global level at present, renewable energy sources are defined as energies that come from natural sources with the property of regenerating themselves naturally within a very short period, or they can be sources that are practically inexhaustible. The notion of renewable energy defines forms of energy resulting from the natural renewable processes produced by energy transfer. Such energy sources are classified into those produced by solar energy, wind energy, flowing water energy, but also biological processes and those produced by geothermal heat that can be captured by humans through different processes. Other non-renewable energy sources also include nuclear energy, but also energy from the burning of fossil fuels, such as oil, natural gas and coal [1, 5].

Of the many elements needed for microbial decomposition, carbon and nitrogen are the most important [3, 8]. Carbon provides both an energy source and the basic building block, which makes up about 50% of the microbial cell mass. Nitrogen is a crucial component of proteins, nucleic acids, amino acids, enzymes and coenzymes required for cell growth and function [1, 4].

Another essential ingredient for successful composting is oxygen. Because microorganisms oxidize carbon to energy, oxygen is consumed, and carbon dioxide is produced. Without enough oxygen, the process will become anaerobic and will produce unwanted odors, including the smell of rotten egg from hydrogen sulfide [6].

The successful experiment carried out by the French inventor Jean Pain in the 70's has shown without hesitation the possibility of achieving energy independence for a house in the rural area [2, 7, 10]. By this method, which meant the bacterial decomposition of wood mass from forest waste, it obtained for 14 months hot water for heating the house (4 l/min), domestic hot water and biogas.

Given the need for relatively large outdoor spaces to store around 50 tons of milled wood, the above method is perfectly suitable for the rural area and not the urban area.

MATERIALS AND METHODS

The main objective of my study is the design and implementation of an experimental module that, to highlight the operation of a hot water installation through bacterial degradation usable in the urban environment. In order to achieve this goal, the concept must meet the following conditions:

- not to affect the environment by smell and humidity;
- not to contaminate the dwelling and/or the space intended for installation with bacteria or other pathogenic microorganisms;
-to be modular allowing the interconnection according to the energy requirement of the building;
- the modules can be adapted dimensional to the spaces intended for them;
- the cost prices should be reduced, by using recyclable resources from plastic and ferrous materials.

The material used as active mass for obtaining heat energy is dry grass. We chose this material because it is a resource is abundant, easily accessible and can be dried and prepared quickly for the experiment.

RESULTS AND DISCUSSIONS

The experimental installation is composed of two zones: the active environment zone in the lower half and the thermal transfer zone to the heating agent used in the upper zone. The active environment is fixed in boxes in an upright position using a polyethylene monofilament yarn. The crates are perforated all over the surface to allow optimal air circulation.

Given that the maximum density of thermophilic microorganisms is located on the outer surface of the layer, the crates after interconnection form slots that facilitate the movement by natural convection of the air. The following photo figure shows the convection mode of the air.

At the top there is an air-liquid heat exchanger which has the role of taking over and transferring the heat from the active environment. The support plates of the exchanger pipes have the role both to increase the surface of the thermal transfer and to facilitate the displacement of the vitiated air due to the perforations around the pipes towards the exhaust.

The exhaust pipe is provided with an activated carbon filter for stopping odors.

As an aerobic process the density of the active material must be carefully considered. From the practice it was found that in the case of too large interior spaces, drying by air circulation is favored. In the case of spaces too small, the air circulation will be made difficult, even leading to the clogging of the active environment.

The whole assembly is kept closed by the polystyrene walls. They maintain constant thermal and humidity conditions inside the plant.

In order to maintain humidity, the equipment is provided with a spray system at the top of the crates.

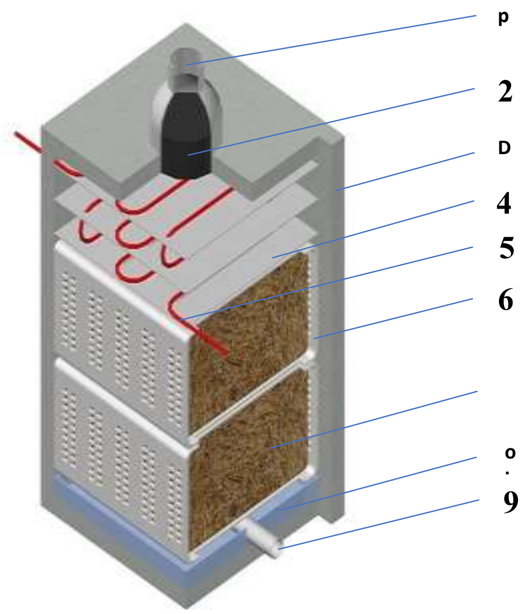

Photo 1. The experimental way of obtaining thermal energy through bacterial degradation
Legend:
1. Exhaust air exhaust connection;
2. Activated carbon filter;
3. thermal insulation;
4. Support plates for the heat exchanger;
5. Circulation pipe of the thermal agent;
6. Crate support for active material;
7. Active material;
8. Tray for collecting the excess moisture; 9. Air supply connection (orig.)
Source: Own design.

Technical specifications and dimensional calculations:

Experimental module dimensions: 50 X 60 X 100 cm

Heat exchanger element dimensions: 40 X 50 cm

Number of heat exchanger elements: 3

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Length of heating circuit plate: 160 cm
Total length of thermal agent circuit: 160x3 = 480 cm
Heat volume:
- an inside diameter of the pipe of 8 mm was considered

$$V = V=\pi(d/2)^2\ l\_conduct=\pi(0.8/2)^2\ 480=241.26\ cl=2.41\ l$$

Average active volume/crate:

$$V_{average} = 27.5 X 37.5x7= 7,218.75\ cm^3$$

Total average active volume:

$$V_{total} = 7,218.75 X 10 = 72,187.5\ cm^3 \text{ aprox. } 0.07\ m^3$$

Photo 2. Convective air circulation inside the module
Source: original.

Preparation of the experiment

A solution with the culture medium was prepared by mixing 10 l water and 1 kg humus from the forest.

For all 10 crates, a conatation of 5 kg was used, returning to each crate 0.5 kg dry grass. This quantity was evenly distributed and manually pressed (Photo 3).

After pressing, to keep the grass inside the plant upright, it was fixed with polyethylene wire in the form of a grid. It was then followed by soaking the material in the solution previously prepared and draining the water by keeping the crate horizontal.

Photo 3**.** Distribution and pressing of the vegetal material
Source: original.

Each 5 boxes, after their interconnection, were inserted inside the equipment on two rows (Photo 4).

As a thermal agent I used mineral oil. It has the property of remaining permanently in liquid state during the experiment.

Given that the experiment is carried out over a long period of time, the measurements were performed daily for a period of 2 months.

The parameters followed were the temperature of the thermal agent, the temperature of the active mass, the humidity and the concentration in carbon dioxide determined at the top of the installation.

Run the experiment

At 7-day intervals we monitored the degree of decomposition of the plant material used

In order to keep the humidity constant at 90% relative humidity after each determination, the spray and aeration system was started.

Photo **4.** Construction of the installation
Source: original.

Photo 5. Settling the plant biomass in the box set
Source: original.

Experimental results

In this experiment, we followed the way in which such a system behaves, thus establishing its viability.

If during the first 7 days the temperature was maintained around 30 °C in which the activity of the mesophilic bacteria was recorded in the next 7 days the temperature rose to 55-60 ºC and remained constant at this level due to the activation and replication of thermophilic bacteria.

The measurements are presented in the table below.

Photo 6. Temperature measurement during the experiment
Source: original.

Table 1. Variation of the temperature of the thermal agent over the entire measurement period
Source: original

Day	Temp. [ºC]	Day	Temp. [ºC]	Day	Temp. [ºC]
1	21.4	21	42.1	41	63.6
2	21.6	22	45.6	42	62.2
3	21.3	23	49.8	43	63.9
4	21.9	24	54.3	44	61.6
5	23.1	25	54.8	45	58.0
6	27.8	26	55.9	46	61.7
7	30.3	27	56.0	47	63.8
8	32.3	28	56.9	48	61.9
9	33.5	29	57.5	49	59.5
10	33.7	30	56.3	50	62.9
11	33.9	31	58.3	51	61.0
12	34.2	32	59.7	52	63.7
13	34.5	33	57.8	53	59.3
14	34.7	34	62.2	54	60.7
15	34.9	35	59.7	55	60.7
16	35.3	36	61.4	56	62.9
17	35.5	37	62.4	57	59.8
18	35.9	38	59.8	58	61.3
19	36.6	39	57.5	59	62.2
20	38.8	40	59.8	60	61.7

Source: original.

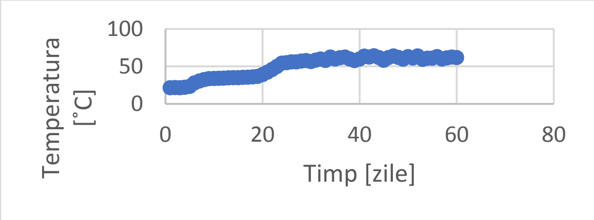

Fig. 1. Temperature variation during the measurement period
Source: original.

CONCLUSIONS

The experimental data demonstrated the viability of the proposed system. As such, the possibility of creating an installation that works in the urban environment can be said to be realistic.
In the conditions in which we considered it appropriate to develop an experimental installation without automation system regarding the aeration of the active environment in the conditions of its deprivation of sufficient oxygen, choosing the manual, daily alternative, to determine the carbon dioxide we can say that the operation has given good thermal results.
Based on the obtained results, the following recommendation has been done:
- the current spray system, due to the complexity of the tube arrangement so that it evenly moistens the mass of active material, it can be replaced with an ultrasonic fog generator. In this way, the entire active surface of the decomposing material will be moistened.
The location of the fog generator on the air supply circuit which leads to the penetration of water vapor into the material depth. From practical experience it has been shown that the replacement with perforated vertical plates of crates will lead to an adequate adjustment of the density of the active material.
It is compulsory to automate the air inlet, the humidity control and the intermittent discharge of the thermal agent once the operating temperature is reached. In this way, we can determine the amount of heat provided by a modular unit and we can size an installation that energetically supports a building.

REFERENCES

[1]Bain, R.L., 2007, World Biofuels Assessment, Worldwide Biomass Potential: Technology Characterizations. NREL/MP-510-42467, National Renewable Energy Laboratory, Golden, CO, USA, 140 pp.
[2]Chicago Board of Trade, 2006, CBOT Soybean Crush Reference Guide. Board of Trade of the City of Chicago, Chicago, IL, USA.
[3]Compost heater, https://en.wikipedia.org/wiki/Compost_heater, Accessed on 18 April 2019.
[4]Cornell composting, http://compost.css.cornell.edu/, Accessed on 20 May 2019
[5]Diaz, L.F., Bertoldi, M., Bidlingmaier, W., 2007, Compost Science and Technology, Volume 8, Elsevier.
[6]Haas, M.J., McAloon A.J., Yee W.C., Foglia T.A., 2006, A process model to estimate biodiesel production costs. Bioresource Technology, 97(4): 671-678.
[7]McSweeney, J., 2019, Community-Scale Composting Systems: A Comprehensive Practical Guide for Closing the Food System Loop and Solving Our Waste Crisis, https://www.amazon.com/Community-Scale Composting-Systems-Comprehensive-Practical/dp/1603586547, Accessed on 29 July 2019
[8]Pain, J., 2014, The Compost-Powered Water Heater: How to heat your greenhouse, pool, or buildings with only compost! Publishing house Countryman Press.
[9]Reif T., 2008, Profitability analysis and risk management of geothermal projects. Geo-Heat Center Quarterly Bulletin, 28(4):1-4.
[10]Sheehan J., Camobreco V., Duffield J., Graboski M., Shapouri H., 1998, Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus. NREL/SR-580-24089. National Renewable Energy Laboratory, Golden, CO, USA.