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Comparative Studies on Eco-Friendly Biogas Production from Natural Waste Materials

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ABSTRACT

The present study focused on the comparative studies on eco-friendly biogas production from natural waste materials. The biogas production was carried out from animal, kitchen and trees waste by anaerobic digestion process. Batch experimental studies were performed by varying the nature, amount of waste material, temperature, time and pH. It was noticed that the highest amount of biogas was produced from animal waste compared to kitchen and trees waste. The flame test was also conducted to test the biogas production from various type of waste material. As a result, animal waste showed the highest volume of gas and strong flame compares to kitchen and trees waste. Thus, the production of gas has more quality than normal gas and has the potential to use especially agricultural and animal's origin countries.

Keywords: Biomaterials; Tissue engineering; Applications; Relevance; Biogas; Anaerobic digestion; Methane; Organic waste materials; Temperature

INTRODUCTION

Oman produces over 1.5 million tons of municipal solid waste per year but much of it is organic waste that could be converted to energy. An environmental pollution in Oman is air pollution, which results from several sources, such as organic wastes that produce toxic gases. Sultanate of Oman relies mostly rely on oil resources, non-renewable sources and which may be executed at any time. The sustainability of conventional energy together with their pollutions to the earth made renewable energy as the prime need for the time being. Renewable energy is available in all regions of the world and the most famous types come from the sun and are available in huge quantities, but only a small amount of it used - because of the lack of technology and sufficient capital. The purpose of this study was to conduct the production of biogas through anaerobic digestion and reduce the waste and, to create new sources of renewable energy to increase the economic value [1-9].

Anaerobic Digestion

Anaerobic digestion technology aims to reuse agricultural and animal organic waste in an economic, health, and environmental manner, to protect the environment from pollution with the production of biogas as a new and renewable energy source. Scientists start understood the idea that rotting organic matter gives off a flammable gas since the ancient Persians. Shikh Bahai develop the first biogas plant in Bombay in 1859. Desai has designed and built a first cattle dung digester and studied the nature of the cattle dung (Desai) [10]. Especially in this century there has been another rapid increase in the number of plant where in 2007 there were 26.5 million of biogas plant (Sandeep) [11]. Laskri et al. studied about the Factors affecting the production of biogas [5]. Navneeth and Kiran, did comparative study on methane production using poultry waste and kitchen waste [8].

Biogas is gases produced by the breakdown of organic matter in the absence of oxygen and it composed primarily of methane and carbon dioxide. Biogas differs from oil and natural gas at a very important point where the biogas is renewable and clean energy and it produces by the simple process [4]. Biogas is a type of biofuel which is produced by the decomposition of organic matter in an anaerobic digester or fermentation of biodegradable materials such as biomass (food residues or similar), plants and energy crops. Organic waste has become increasingly valuable in alternative energy fields and used as a source of energy generation. The basic principles for the production of biogas are the availability of organic matter such as animal, kitchen, and trees waste [7].

Benefits of Biogas Technology

Produce relatively inexpensive (electricity-thermal) energy used in cooking Lighting, agricultural machinery and others [12-16].

- Reduce the environmental pollutions.
- Improved soil/agricultural productivity through long-term effects on soil structure and fertility.
- Sludge can be used as fertilizer and soil conditioner.
- Conservation of scarce resources like wood.
- Treatment of solid organic waste and other difficult decomposition.
- Achieve high profitability with great returns for investment.
- Improvement of the general condition of farmers due to the local availability of soil-improving fertilizer [4].

METHODOLOGY, DESIGN AND EXPERIMENTATION

Martials and Apparatus

The main materials that have been used to construct the bio-digester are listed below. The plastic container at a length of 38 cm with the volume capacity of approximately 15.12L, CPVC (Chlorinated polyvinyl chloride) pipe (168cm), tee, gas collection unit (inner tube), a bucket of 5-liters capacity, Reducer, ruler, gum, and M-Seal, (blade, and knife) were utilized throughout the fabrication the digester. Also, different types of waste materials, tap water, pairs of rubber gloves were used. The detailed flow chart of experimental methodology was shown in Figure 1 [17-21]

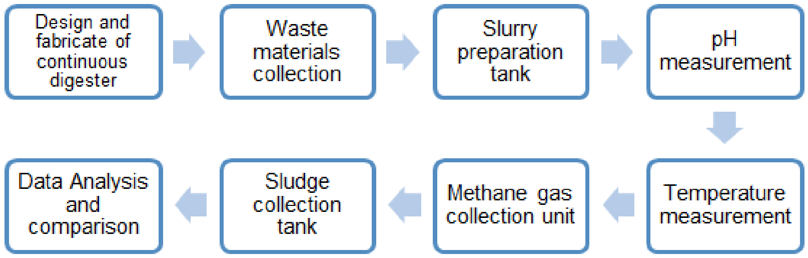

Figure 1. Flow chart of experimental methodology

Design and Fabrication of Continuous Digester

The key element for the success of the experiment was based on the selecting of the reactor system with more efficiency and safety operation. The experimental studies based on the principle of continuous feeding of waste materials into the digester (Figure 2).

Figure 2. Set up of the digester and operational digester

The plastic container at a length of 38 cm with the volume capacity of approximately 15.12 litres was used as a digester Table 1 shows the design specifications for an experimental digester. The procedure that was taken in designing of the digester is following below. Firstly about 1.6 inches (4.2 cm) was drill in diameter with two holes on the top and another one on the side of the container with a knife. The top holes were at the height of 30cm and it was connected with inlet pipe of 30cm in length, while the side hole was at height of 5 cm and it was connected with outlet pipe of 26 cm in length. The container slot was connected to the outlet gas line. Finally, all the joining was completely made airtight by an M-seal.

The digester bottle is transparent so it was painted with black color. Because in the presence of light algae is growth and algae causes the production of oxygen.

Table 1. The design specifications for Continues digester

Total capacity of reactor (V)	15.12 liter
Total height of reactor (L)	38 cm
Diameter of the reactor (D)	80 cm
Liquid Level Height in Reactor from Bottom (A)	15 cm
Empty height of the reactor (B)	23 cm

In the present experimental studies, inner tube of a bicycle of wall thickness of 0.2cm was selected as the storage device because it is made of butyl rubber material which does not react with water vapor in the biogas that might cause corrosion and does not permit gas movement across its boundary of 0.2cm unlike other synthetic rubbers and rubberized vinyl sheets. Storage device is a circular, rubber with outer and inner diameter of 15 cm and 8.6 cm respectively. It has rubber gas hose of outer and inner material of nitrile rubber and SBR synthetic rubber respectively. It was red color gas tube with inner diameter size of 2 inch. The pipe is used to let in gas to the device from the compressor discharge line and to draw gas from the device for burning on biogas burner. The quality gas produced was tested using stove burner and the result was analysed and compared.

Collection of Waste Materials

The biodegradable waste materials used for the demonstrative study are fresh cow dung as animal waste, food waste as kitchen waste, and green waste as trees waste. The waste materials were collected from various nearby sources.

Slurry Preparation Tank

Fresh feed material was collected every week and was stored at kitchen temperature. For the preparation of the slurry, the kitchen wastes were mixed with tap water in a blender. Dilution with water as 1:1 and sampling for further analysis and feeding inside the digester. The similar procedure was adopted for trees wastes but for animal wastes, need to be mixed in blender it can be mixed manually by using stirrer in the tank. At the end of the process about 2.5 litres of each waste slurry was taken and feed into the digester. The mixing was done manually every 5 day for enhanced gas production. The inside and outside temperatures was measured daily by the thermometer. The pH value of the inlet and outlet slurry was measured by pH paper.

RESULTS AND DISCUSSION

The result was shown that flammable biogas was produced from the waste materials through anaerobic digestion for biogas production. These wastes were available at our places and could be used as a source of fuel if managed properly. The experimental study revealed further that cow dung as animal waste has great potentials for generation of biogas and its use could be encouraged due to its early retention time and high volume of biogas yields. It was also found that temperature variation, pH and other factors affect the volume as well as yield of biogas production.

Experimental Studies on Kitchen Waste for Production of Biogas

The experimental studies were carried out for 40 days' time period and the following results were observed for the biogas production, pH, and temperature (Table 2).

Table 2. Experimental parameters of various sources of waste materials

Parameter	Continues Digestion		
	Kitchen waste	Animal waste	Trees waste
Lag days	6	5	15
Total gas yield (m^3)	0.024	0.03	0.0103
Mean outside temperature (^oC)	32.52	32.52	32.52
Mean inside temperature (^oC)	34.75	34.8	34.45
Inlet slurry pH	6.0	7.5	6.2
Mean outlet slurry pH	7.21	6.71	7.34

Comparative Study

Figure 3 shows the amount of biogas production with respective to animal, kitchen and trees waste. The amount of biogas produced was found be high in the digestion of animal waste at the temperature range 35 to 39°C. As well as, the lowest amount of biogas production was found in the digestion of trees waste at the temperature range of 36 to 38°C. Animal manure produced the high amount of biogas because it has a carbon-nitrogen ratio of 25:1 and is considered ideal for maximum gas production. Animal waste was known to contain the native microbial flora that benefits in faster biogas production. It was also stated that cow dung is a very good starter for poor producing feedstocks suggested by research articles. The average temperature of the digester was 34.8°C. It shows that the hydraulic retention time for cow dung is 5 days and gas production starts on the 5th day. Maximum gas is produced at the 30th day which is 0.0075 m^3.

In the case of trees waste, the amount of biogas produced from this waste was very low comparing to animal and kitchen waste. The average temperature of the digester was about 34.45°C. It shows that the hydraulic retention time for trees waste is 15 days and gas production starts on 20th day. Maximum gas is produced at the 40th day is 0.0103 m^3.

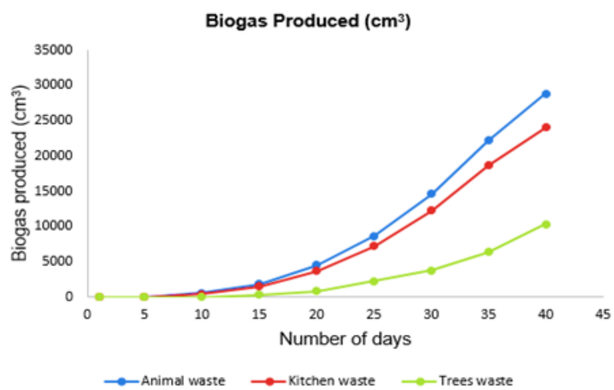

Figure 3. Production of biogas Versus Number of days

pH Measurement During the Studies

The graph below shows the pH of the digestion of animal, kitchen, and trees within the retention period of 40 days. The pH of animal waste, kitchen waste and trees waste began in 7.5, 6.0 and 6.2 respectively on the first day. Then the pH continued to decrease at animal waste at day 10 and reached to 6.8. On the other hand, the pH began increases to 6.7, 6.6 for kitchen waste and trees waste respectively. After 30 days the pH reaches to 6.4, 7.6 and 7.5 for all three wastes respectively, thereafter it was reduce the pH for animal waste to 6.25 and increase to 7.6, 7.8 for kitchen and trees waste respectively at the end of the digestion period. It is important to maintain the pH of an anaerobic digester between 6 and 8; otherwise, methanogen growth would be seriously inhibited (Figure 4) [22-29].

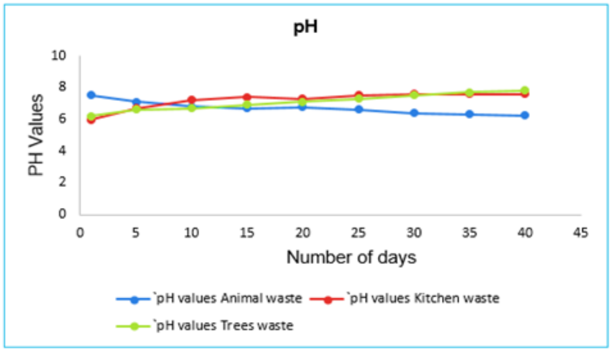

Figure 4. pH readings of various waste materials with respect to number of days

Inside and Outside Temperature Measurement during the Studies

The inside and outside temperature of the animal waste digester was same at the first day, then the inside temperature keeps increasing as well as the outside temperature until it reaches to 31°C in the fifth day. The temperature of the digester was in the range 29°C to 39°C, while the outside temperature was in the range 29°C to 35°C, and these temperature readings are suitable for the production of biogas. Empirical data taken from existing biogas plants clearly shows that gas production continues increasing in the mesophilic phases that mean the temperature from 35°C to 39°C [5] (Figure 5).

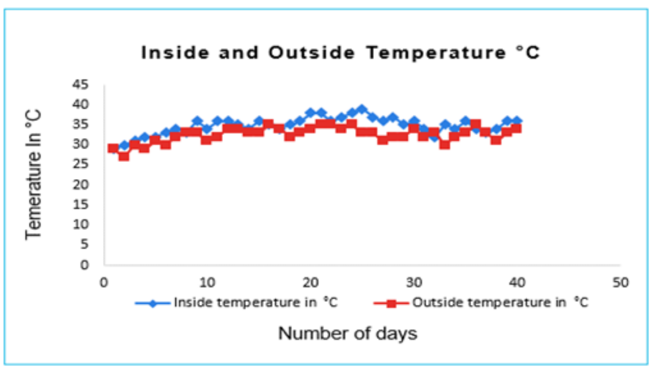

Figure 5. Outside and inside temperature of the animal waste with respect to number of days

CONCLUSIONS

The present research focused on the comparative studies on eco-friendly biogas production from natural waste materials. The biogas production was carried out from animal, kitchen and trees waste by anaerobic digestion process. It was observed that the animal waste was produced the heights amount of biogas compare to the other type of organic wastes. The amount of biogas produced from animal, kitchen and trees wastes were 0.03 m^3 0.024 m^3 and 0.0103 m^3 respectively. This could give a promising evidence of the anaerobic digestion as a viable and feasible treatment technology of organic waste, in particular, the animal manure simultaneously generating biogas as the renewable energy. Therefore, it can be concluded that anaerobic digestion is the excellent method to generate an alternative fuel that can be used for the local purposes such as lighting, cooking, and generate electricity, manage the waste accumulation and to obtain organic fertilizer. As well as, it is a good system to reduce the waste from our community, hence reduce the radiation of the harmful gases that affect the atmosphere and cause environmental issues such as global warming produce methane gas will help to reduce the many of the diseases that occur due to pollution problems.

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