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Biogas Production from Food Waste: A Theoretical Study of NIT Hamirpur Campus

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Abstract—*Food waste, one of the most unrecovered materials in municipal solid waste stream, when disposed off in landfills generates methane which is a potential greenhouse gas. Researchers at the United Nations have estimated that as much as 50% of the food produced is wasted or discarded. Biogas systems that utilize kitchen wastes are 800 times efficient than conventional biogas systems, produce residual organic waste with superior nutrient qualities after anaerobic digestion. A typical Indian food waste possesses 70% moisture content, volatile solid to total solid ratio (VS/TS) of 80, carbon to nitrogen ratio (C/N) of 18-19 and density of about 290 kg/m*^{3}*. Because of high moisture content it is more suitable for anaerobic digestion as compared to thermochemical technologies like combustion or gasification. In the present study, a novel and energy efficient system is proposed for the conversion of post-consumer food scraps at NIT Hamirpur campus into usable biogas, aiming to find out alternatives of LPG cylinders that are being used for cooking of food. In this system, solar power supported anaerobic digesters in multiple numbers is utilized for the generation of biogas. Food scraps from different hostels and canteens are used as feedstock to be digested anaerobically in these digesters under thermophillic and mesophillic conditions. Total food waste generation from all the eleven hostels and one canteen of NIT Hamirpur campus is about 300-400 kg/day. Under the ideal conditions, approximately 600-650 litre/digester biogas will be produced. Approximately 35 LPG cylinders are required in all hostels for cooking the required amount of food daily. If biogas is used as an alternative fuel, the number of LPG cylinders required reduced to half. From the present investigation, we concluded that biogas from food waste can save at least 50% of the LPG gas consumption of the campus and also provide substantial amount of manure for gardening purposes in the campus.*

1. INTRODUCTION

Food waste refers to the food which is fit for consumption but is discarded whether or not after it is kept beyond its expiry date or left to spoil. This is often because the food has spoiled but there can be other reasons like individual eating and purchasing habits. Food wastage can also occur in between food supply chain like spillage, degradation during transportation and distribution phase. The global volume of food waste is approximately 1.6 Giga tonnes while the total agricultural production for food and non-food uses is 6 Giga tonnes [1-2]. The carbon footprint of food produced and not eaten is estimated to 3.3 Giga tonnes of CO_2 equivalent, whereas the blue water footprint i.e. consumption of surface and ground water resources, of food waste is about 250 km^3. Also the food waste produced but not eaten occupies 1.4 billion hectares of land area which is roughly equal to 30% of world's agricultural area. There is no way to get rid of the food waste other than these four ways- dumping it, burning it, converting it into something that can be used again, and minimizing the volume of material goods – future garbage [1]. Food waste is one of the most unrecovered material in municipal solid waste stream and the most important ones to be diverted from landfills [2]. If recovered properly, it is possible to divert a huge quantity of waste to go into the landfill. Also, in landfills, in due course of time it degrades and emits methane gas which is a potential greenhouse gas. India's increasing energy demands and its inability to setup with the demand has led the researchers to find out alternative dependable and sustainable source of energy. Anaerobic digestion of food waste can approximately produce three times more methane by volume than municipal wastewater solids [3]. This methane can be captured and used as an alternate source of energy. Biogas obtained from anaerobic decomposition has the enormous potential of 17,000 MW. It is a cheap and clean fuel which contains 55-70% Methane, 20-45% carbon dioxide and other gases in trace quantities. Due to relatively high moisture content of food waste, bioconversion technologies, such as anaerobic digestion, are more suitable compared to thermochemical conversion technologies, such as combustion and gasifcation [4]. Anaerobic digestion (AD) is a microbial decomposition of organic matter into methane, carbon dioxide, inorganic nutrients and compost in oxygen depleted environment and presence of the hydrogen gas. In the generalized scheme of the anaerobic digestion, the feedstock is collected, coarsely shredded and placed into a reactor with active inoculums of methanogenic microorganisms [3]. Kitchen waste is much more digestible than normal municipal solid waste and thus it needs shorter retention time in the digesters. This directly affects the inflow rate. Also the food waste can be processed in smaller digesters thus the cost involved in construction and operation of digester is reduced. The leftover after the anaerobic digestion has nigh nutritive value and thus can be used as a fertilizer or compost. Systems producing bio gas from food waste by anaerobic digestion are approximately 800 times more efficient than the conventional bio gas systems [5]. Some of the factors that affect the design and performance of anaerobic digestion processes are feedstock characteristics, reactor design and operational conditions [6]. The biomethanization potential of the waste depends on the concentration of four main components: proteins, lipids, carbohydrates, and cellulose. This is due to different bio-chemical characteristics of these components. The digesters can be Mesophilic digesters or Thermophilic digesters. The most successful AD processes at this time are high-solid, thermophilic processes that can produce up to 125 standard cubic meters of bio gas per ton of feed stock, at 50-60% methane concentration. Almost constant methane content is obtained under each initial loading. However, the biogas produced from the digesters of lower loading had higher methane content compared with the digesters that had higher initial loading [4]. By using feedstock having high calorific and nutritive value to microbes, the efficiency of methane generation can be increased by several orders of magnitude [7]. For a typical Indian food waste, the moisture content is around 70%, volatile solid to total solid ratio (CS/TS) is 80, carbon to nitrogen ratio (C/N) is 18-19 and typical density is about 290 kg/m^3[7].

2. OBJECTIVE

The major objective of the study is to assess the biogas production potential from the food waste generated from NIT Hamirpur campus. The investigations are also made to use the biogas potential as an alternate fuel in place of LPG cylinders during cooking at different hostels of the campus.

3. PARAMETERS AFFECTING THE ANAEROBIC DIGESTION OF FOOD WASTE

pH value: the importance of the ph is due to the fact that methanogenic bacteria are very sensitive to acidic conditions and their growth and methane production are inhibited in acidic environment.

Composition of the Food Waste: It is important in order to predict both the bio-methanization potential and the most efficient AD facility design

Loading Rate: It determines the amount of volatile solids feasible as an input in the AD system. Overloading of the system can results in low biogas yield.

Retention Time: It refers to the time that feedstock stays in the digester. It is determined by the average time needed for decomposition of the organic material, as measured by the chemical oxygen demand (COD) and the biological oxygen demand (BOD) of the influent and the effluent material.

Operating Temperature: It is the most important factor determining the performances of the AD reactors because it is an essential condition for the survival and optimum thriving of the microbial consortia. Bacteria have two optimum ranges of temperature, defined as mesophilic and thermophilic. Mesophilic digesters have an operating temperature in the range of 25-40 °C and thermophilic digesters have operating temperature in the range of 55-65 ^{0}C.

4. THEORETICAL ASSESSMENT

The theoretical assessment of food waste generated from different premises of the institute is presented in Table 1. It can be seen from the Table 1, approximately 300-400 kg of food waste will be generated considering waste generated per capita per day is 10% of the total meal size.

Table 1: Food waste generation at NIT Hamirpur campus

No. of hostels	9(boys)+2(girls)=11
No. of mess	7(boys)+2(girls)+1(Canteen) =10
No. of hostler students	2500(boys)+400(girls) = 2900
LPG cylinders used per day	28 (boys mess)+4 (girl mess)+3 (canteen) = 35
Food waste produced per day*	300-400 kg

*Assuming that waste generated per capita per day is 10% of the total meal size.

5. PROPOSED PROCESS FOR FOOD WASTE DIGESTION, MEASUREMENT AND CALCULATIONS OF IMPORTANT PARAMETERS

Estimated amount of food waste from different premises of the campus may be digested through a series of processes as depicted in Figure 1. First of all, the raw food waste will be grinded using mechanical grinder. The grinded slurry will be screened using suitable mesh. The screening slurry of uniform particle size will be sent to the pre-digestion chamber, where hot water will be mixed in the ratio of 1:1 (w/v). Solar water heater will be used to increase the temperature of water up to 55±5°C. The pre-digestion will be carried out at thermophillic condition. The pre-digested slurry will then be sent to the main digestion tank where mesophillic group of bacteria play their role by digesting the food waste through series of the steps such as acidogenesis, acetogenesis and methanogenesis, leading to the production of methane gas. Mesophilic inoculum will be collected from a working mesophilic sludge digester at wastewater treatment plant of NIT Hamirpur campus. All the food wastes and inoculum will be analyzed for total solids (TS), volatile solids (VS), and fixed solids (FS) in duplicate prior to any digestion tests.

Daily biogas production from the digester will be measured using a wet tip gas meter. Other major parameters such as pH, VFA, B-alkalinity, temperature and specific methanogenic activity (SMA) will be measured on daily basis following the standard methods [8]. After reaching a steady biogas yield, the biogas will be sampled using gas sampling tubes and will be analyzed for H_2, CH_4 and CO_2 contents using a Gas Chromatography (GC).

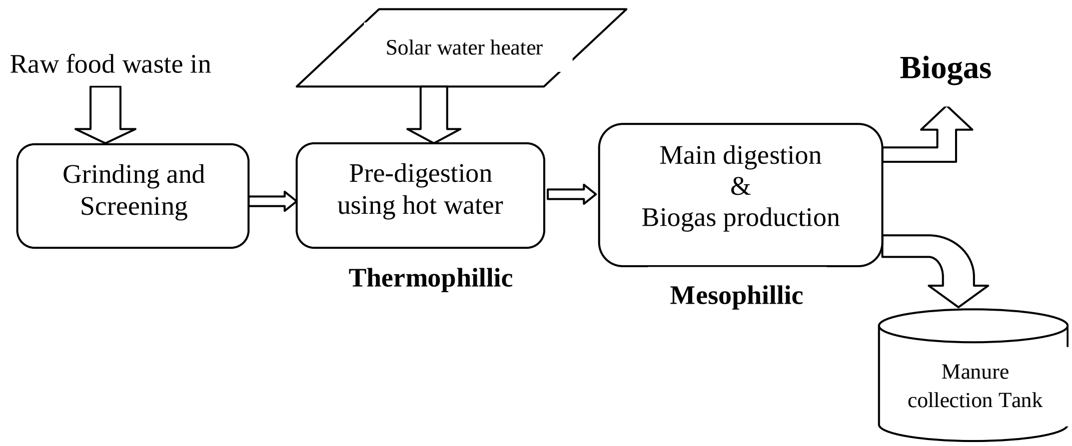

Figure 1: Proposed arrangement for Biogas generation

6. THEORETICAL ESTIMATION OF BIOGAS PRODUCTION

Theoretical estimation of biogas generation from the collected food wastewater was presented in Table 2. It can be seen from the table that proper functioning of digester would be producing adequate amount of biogas, which will save approximately 50% of the LPG used for cooking in the campus.

Table 2: Estimating LPG cylinders saved

Calorific value of Biogas	**21.6 KJ/L**
Calorific value of LPG	94 KJ/L
Specific heat of water	4.186 Joule/gram degree Celsius
Density of LPG	0.557 Kg/L
Energy Required for heating 100ml of water from 30 degree to 100 degree Celsius	29.302 KJ
Amount of biogas required for heating 100ml of water from 30 degree to 100 degree Celsius	1.3566 L
Amount of LPG required for heating 100ml of water from 30 degree to 100 degree Celsius	0.3117 L
Quantity of water that can be heated by 650 L of biogas	48 L
Quantity of LPG required for heating 48L of water	149.616 L or 83.3361Kg
Amount of LPG in standard cylinder in India	14.2 kg
Amount of LPG cylinders saved per Digester	**6**
Total LPG cylinders that can be saved from 3 digesters of 1000L digester	**18**

7. CONCLUSION

Here, the potential of Biogas from food waste was highlighted by the case of NIT Hamirpur Campus. In this theoretical analysis, all the results are drawn under batch system. Food waste to biogas can be effectively used as a sustainable approach towards renewable energy and waste disposal. We concluded that biogas from food waste can save at least 50 % of the LPG gas consumption of the campus and also provide substantial amount of manure for gardening purposes in the campus. Kitchen waste can be useful under community level biogas programme, where we can save LPG for cooking purposes.

REFERENCES

[1] Lin, C.S.K., Pfaltzgraff, L.A., Herrero-Davila, L., Mubofu, E. B., Abderrahim, S., Clark, J.H., Koutinas, A.A., Kopsahelis, N., Stamatelatou, K., Dickson, F., Thankappan, S., Mohamed, Z., Brocklesby, R. and Luque, R., "Food waste as a valuable resource for the production of chemicals, materials and fuels. Current situation and global perspective", *Energy & Environmental Science*, 6, 2013, pp 426-464

[2] United States Environmental Protection Agency (USEPA). Municipal solid waste generation, recycling, and disposal in the United States: Facts and figures. Washington, DC. 2008.

[3] Vaid, V. and Garg, S., "Food as Fuel: Prospects of Biogas Generation from Food Waste", *International Journal of Agriculture and Food Science Technology*, 4, 2, 2013, pp 68-71.

[4] Zhang, R., El-Mashad, H.M., Hartman, K., Wang, F., Liu, G., Choate, C. and Gamble, P., "Characterization of food waste as feedstock for anaerobic digestion. *Bioresource Technology*, 98, 4, 2007, pp 929–935.

[5] Kale, S.P. and Mehele, S.T.. "Kitchen waste based biogas plant.pdf". *Nuclear Agriculture and Biotechnology/ Division, assessed on 04 March 2016.*

[6] Kumar, S.A., Marimuthu, C., Balaji, E.P. and Riswan, S.S., "Biogas Production from Kitchen Waste Water using USAB Reactor", *International Journal of Chem Tech Research*, 6, 9, 2014, pp 4135-4142.

[7] Vij, S., "Biogas Production from Kitchen Waste", B.Tech Thesis, NIT Rourkela, India, 2011.

[8] APHA. Standard methods for the examination of water wastewater. 18 ed. American Public Health Association, Washington DC, USA, 1998.