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Study of Biogas and electricity production from food waste in SATI Campus, vidisha, M.P.

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Abstract : Everything, in essence, is about energy. There is no doubt now that energy is fundamental for our development. Energy is vital for the internal and external security of a country and energy issues are at the core of social, environmental and economic security challenges. World is experiencing an economic down turn and in these times, individuals and institutions are more likely to consider options for renewable energy or other measures that help the environment. As the demand for the world's fossil fuel increases and with their price increase, interest has rightly begun to be given to the development of renewable energy sources. The search for energy alternatives involving locally available renewable resources is one of the main concerns of governments, scientists and business people worldwide.

In our institute SATI, Vidisha we have 10 hostels, staff quarters and college canteen and all having their own individual mess, where daily a large amount of kitchen waste is obtained which can be utilized for better purposes. Biogas production requires Anaerobic digestion. Study is to Create an Organic Processing Facility to create biogas and electricity which will be more cost effective, eco-friendly, cut down on landfill waste, generate a high-quality renewable fuel, and reduce carbon dioxide & methane emissions. Overall by creating a biogas reactors on campus in the backyard of our hostels will be beneficial. Kitchen food waste is collected from different hostels Mess, staff quarters and college canteen as feedstock for our reactor which works as anaerobic digester system to produce biogas energy. The anaerobic digestion of kitchen waste produces biogas, a valuable energy resource Anaerobic digestion is a microbial process for production of biogas, which consist of Primarily methane (CH4) & carbon dioxide (CO2). Biogas can be used as energy source and also for numerous purposes. But, any possible applications requires knowledge & information about the composition and quantity of constituents in the biogas produced.

Keywords: Anerobic digestion, Biogas, Land fill, Methane production, Electricity Production.

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1. Introduction : Due to scarcity of petroleum and coal it threatens supply of fuel throughout the world also problem of their combustion leads to research in different corners to get access the new sources of energy, like renewable energy resources. Solar energy, wind energy, different thermal and hydro sources of energy, biogas are all renewable energy resources. But, biogas is distinct from other renewable energies because of its characteristics of using, controlling and collecting organic wastes and at the same time producing fertilizer and water for use in agricultural irrigation. Biogas does not have any geographical limitations nor does it require advanced technology for producing energy, also it is very simple to use and apply.

Deforestation is a very big problem in developing countries like India, most of the part depends on charcoal and fuel-wood for fuel supply which requires cutting of forest. Also, due to deforestation It leads to decrease the fertility of land by soil erosion. Use of dung , firewood as energy is also harmful for the health of the masses due to the smoke arising from them causing air pollution. We need an eco-friendly substitute for energy .

Kitchen waste is organic material having the high calorific value and nutritive value to microbes, that's why efficiency of methane production can be increased by several order of magnitude as said earlier. It means higher efficiency and size of reactor and cost of biogas production is reduced. Also in most of cities and places, kitchen waste is disposed in landfill or discarded which causes the public health hazards and diseses like malaria, cholera, typhoid. Inadequate management of wastes like uncontrolled dumping bears several adverse consequences: It not only leads to polluting surface and groundwater through leachate and further promotes the breeding of flies , mosquitoes, rats and other disease bearing vectors. Also, it emits unpleasant odour & methane which is a major greenhouse gas contributing to global warming.

This fact can be seen in current practices of using low calororific inputs like cattle dung, distillery effluent, municipal solid waste (MSW) or seweage, in biogas plants, making methane generation highly inefficient. We can make this system extremely efficient by using kitchen waste/food wastes.

In 2003, **Dr. Anand Karve** (President ARTI) developed a compact biogas system that uses starchy or sugary feedstock material and the analysis shows that this new system is 800 times more efficient than conventional biogas plants..

Vidisha is a city in the state of Madhya Pradesh, located near the state capital Bhopal. Vidisha is the administrative headquarters of Vidisha District. The city was also known as Bhelsa during the medieval period. The town is situated east of the Betwa River, in the fork of the Betwa and Bes rivers, 9 km from Sanchi. Samrat Ashok Technological Institute (SATI) is a Grant-in-Aid Autonomous college in Vidisha in the central Indian state of Madhya Pradesh. In our institute we have 10 hostels having their individual mess, 86 Staff quarters and college canteen where daily a large amount of kitchen waste is obtained which can be utilized for better purposes.

The objectives of this study is two-fold; firstly to produce methane gas (biogas) that can generate heat and secondly the electricity.

2. Methodology : Biogas is produced by bacteria through the bio-degradation of organic material under anaerobic conditions. Natural generation of biogas is an important part of bio-geochemical carbon cycle. It can be used both in rural and urban areas.

The feedstock is collected from the hostel mess, staff quarters, canteen mess and transported to plant. The required quantity of feedstock and water is mixed in the inlet tank and the slurry is discharged to the digester vessel for digestion. The gas produced through methanogenesis bacteria in the digester is collected in the dome. The digested slurry flows to the outlet tank through the manhole. The slurry then flows through the overflow opening in the outlet tank to the compost pit. The gas is supplied from the dome to the point of application through a turret and pipeline. When a biogas plant is underfed the gas production will be low; in this case, the pressure of the gas might not be sufficient to fully displace the slurry in the outlet chamber. It is important to design the plant keeping hydrostatic pressure higher at the inlet tank than the outlet tank. The hydrostatic pressure from slurry in the inlet and outlet tanks will pressurize the biogas accumulated in the dome. If too much material is fed into the digester and the volume of gas is consumed, the slurry may enter the gas pipe and to the appliance.

A Typical Biogas System Consists Of The Following Components:

1) Manure collection: As we are constructing the biogas plant for kitchen waste, the waste food collecting in the hostel mess, canteen and staff quarter is stored and transported to the site for feeding

2) Anaerobic digester: The digester in form of dome is the anaerobic digester or reactor.

3) Effluent storage: After the digestion the slurry coming out of the digester is the rich fertilizer, this is stored in the compost pit provided at the outlet of the digester. Later that can be transported to the fields.

4) Gas handling: The generated biogas is stored in the dome and at the top, the biogas trap hole is provided. From the trap hole the flexible pipe line is connected, where it is connected to the biogas stove for cooking food and to biogas generator for electricity generation.

5) Gas use in cooking: The biogas obtained is used for domestic cooking.

6) Gas use in Electricity generation: The biogas obtained is used in biogas generator for electricity production.

3. Design of Biogas Plant

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The total population in our college campus is 1404 persons residing in student hostel, staff Quarters. The waste generated daily is about 152 kg of kitchen waste and it will be utilized for biogas production and further for electricity generation.

3.1. Gas production rate, (G) One kilogram of kitchen waste, if well digested, yields 0.24m3 of biogas according to Dr. Anand Karve, ARTI, 2003. The gas production rate (G) for the available kitchen waste, working with 152kg/day was found to be given by:

Waste Generated (W) = 152kg/day

Gas Production Rate (G) = $152 \times 0.24\ M^3/day$
$= 36.48\ M^3/day$

3.2. Active slurry volume, (Vs) The active slurry volume in the digester is directly related to the hydraulic retention time (HRT). This is the theoretical time that a particle or volume of liquid waste added to a digester would remain in the digester. It is calculated as the volume of the digester divided by the volume of slurry added per day and is expressed as days (Niangua, 2006).

Active Slurry Volume (Vs)

$$Vs = HRT \times 2W/1000$$
$$Vs = 12.16\ M^3$$

Here RT taken is 40 days.

3.3. Calculation of height (H) and diameter (D) of the digester The relative values of height and diameter were calculated from the volume of digester.

Height & Dia of Digester

$$Vs = (\pi/4)\ D^2\ H$$

In practice the ratio of D/H is taken as 2

After calculation , H = 1.57 M
D = 3.14 M

3.4. Slurry displacement inside the digester, (d) The selection of a suitable value of d depends upon gas usage pattern. Since cooking at SATI is usually done three times a day, 50% of the gas to be produced in a day will be made available for one cooking span. But since there is

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a continuous production of gas from the digester, the gas generated during cooking time should also be considered .The total cooking time is about 4 hours, the variable gas storage volume (SD) is obtained from the equation: 4/24G + SD = 50/1 00G.

Slurry displacement inside the digester (d)

Gas storage Volume (SD) = 0.333G
= 0.333 x 36.48
= 12.15 M^3

Then d is obtained from the equation, SD = π/4.D.d,
Now d = 2.7 M

3.5. Slurry displacement height (dh) in Inlet & Outlet tank

h + d = 0.85
h = 0.85 – 2.7
h = -1.85 M
(negative sign means the height is below the tank level)

3.6. Length (l) and breadth (b) of the inlet and outlet tanks

l = 1.5b
SD = 2 x l x b x h

After calculation,
l = 2.20 m
b = 1.47 m
h = 1.85 m

Table : 1 Sizing Factors

Sizing factor	***Values***
Gas Production rate G	36.48 M^3 / day
Active slurry volume Vs	12.16 M^3
Gas Storage Volume SD	12.15 M^3
Height of digester H	1.57 M
Diameter of digester D	3.14 M
Slurry displacement height dh	1.85 M
Length of inlet & outlet	2.20 M

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Breadth of inlet & outlet	1.47 M
Height of inlet & outlet	1.85 M

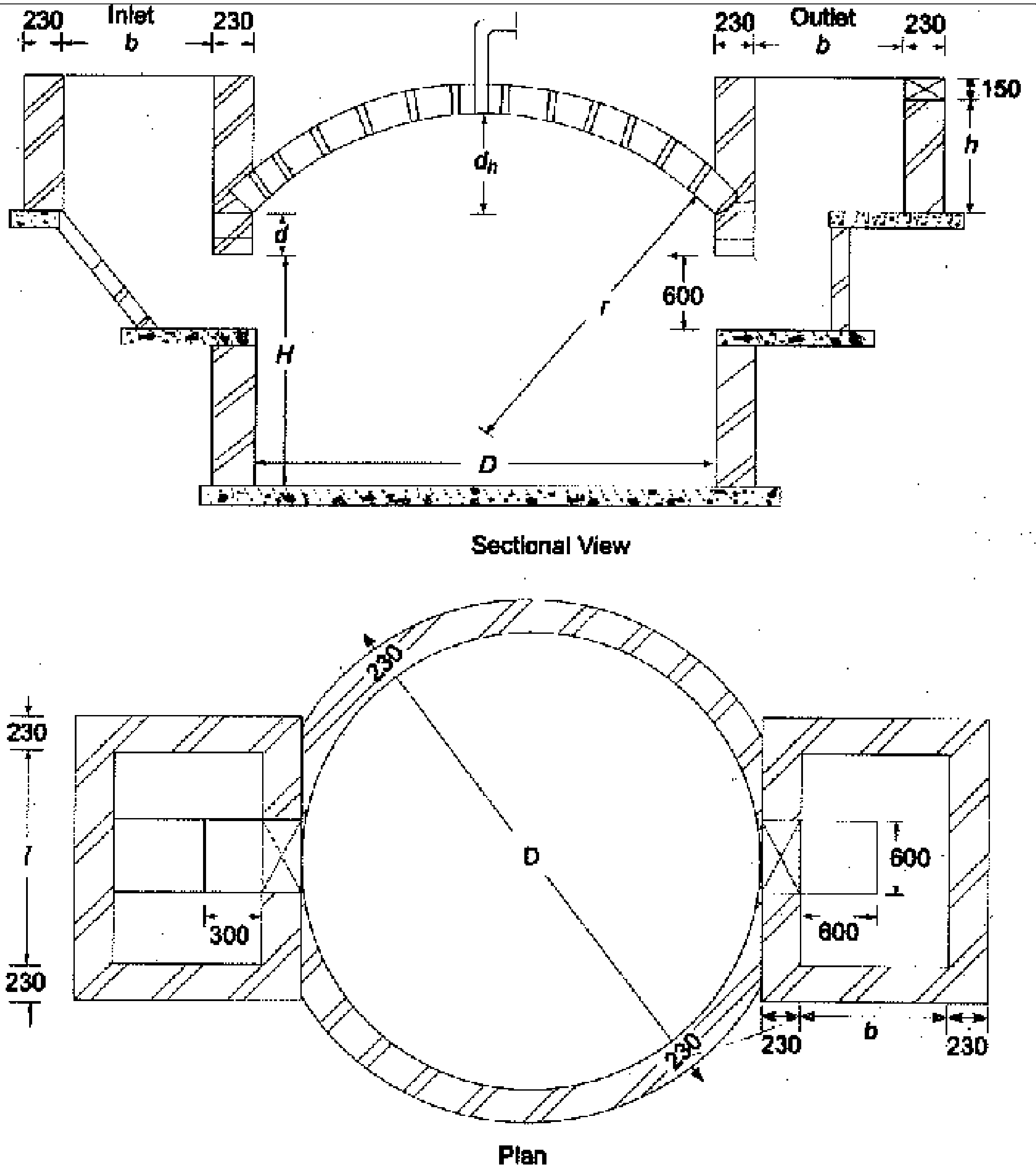

Fig. 1: Diagrammatic sketch of digester with flat bottom

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4. Biogas for kitchen use :

- LPG consumption is 0.24 M^3 /day/ Person.
- Biogas (methane) consumption is 0.80m^3/day/ Person.
- Total Biogas generated per day is 36.48m^3 and per month is 1094.4m^3 which is sufficient for cooking food of 1368nos of person/month.
- Biogas Reduces reliance on fossil fuels.
- LPG has liquid like properties and when leakage occurs the gas flows down in a liquid like manner and stays down for a very long time. This is very dangerous in residential areas. While Biogas disperses into the air quickly as it is lighter than air and is much safer in homes than CNG or LPG.

5. Biogas for electricity Generation : Micro biogas power plant (MBPP) in SATI Campus will be capable of generating 67 kW of electricity daily from food waste in the campus per day. This pioneering study is aimed of building a prototype to be used by internal communities with problems pertaining obtaining regular electricity supply. Food waste supplied by all Hostel mess and canteens in the campus will be converted into methane which will generating electricity . The electricity generated could be channelled to the SATI power supply grid.

As mentioned in the previous section, the aim of this study is to distinguish whether this micro biogas power plant could generate methane gas and produce electricity by means of food wastes as the feedstock.
This micro biogas power plant will indicate the amount of methane gas produced with the certain amount of feedstock used every day. This machine works 24 hours per day with total amount of feedstock ranging from 140kg to 160kg. By using food waste and organic waste from hostel mess and canteens around the campus, this micro biogas power plant will digest all the waste and turn it into methane in order to produce electricity. With the total amount of 152kg of mixed food waste per day, there is about 38 cubic metre of methane can be produced and about 70kW electricity can be generated per day. The digesters that is used for the purpose of production of biogas can be used in mesophilic conditions, which mean a temperature range of 20 to 25 degrees Celsius to 40 to 45 degrees Celsius. Through the lab test that has been conducted in the environmental lab, the temperature of the water in the tank and in the digester are 35.7°C and 37.5°C respectively. This is pretty much possible that cow dung is employed in the form of a substrate.

5.1. Calculations:

Food waste generated in SATI Campus is 152kg/day.
Formula to calculate total gas production For 152kg waste

$$= 152 \times 0.24$$
$$= 36.48\ M^3/\text{day}$$

Energy calculation of biogas plant > 1m3 =19 Mega joules

So 36.48 x 19 = 693.12 MJ

To convert it to KWh >> 693.12/3.6 = 192.53KWh

Note: when we convert it to electrical energy 65% of energy lost as Heat and other mechanical losses as utilized by electrical generator. Only 35% is available for electricity generation.

So 192.53 x 35/100 = 67.38 kW is available as electrical energy from 152 kg of food waste.

5.2. Converting Technologies : The Chemical energy of the combustile gases is converted to mechanical energy in a controlled combustion system by heat engine. Then this mechanical energy activates a generator to produce electrical power. The most common heat engine used in for biogas energy conversion are combustion engines and gas turbines. Combustion engine can be internal combustion or external combustion type
In this case we can use combustion engines as they are more efficient and less expensive than gas turbines. Biogas is burned for running the generator.

6. ENVIRONMENTAL IMPACT: The environmental impact of such a system is that it removes waste material that would be a potential source of pollution and converts it into usable energy. Biomass and biogas technology has helped to improve the quality of our environment by eliminating the food wastes that would otherwise accumulate and become a source of pollution and possible contamination. Energy demand must be managed to cope not only with energy but with environmental problems, as well. The energy production from renewable sources is one of the main issues to reduce environmental damage and greenhouse gases emissions, as climate agreements encourage non fossil fuel use in the future.

This study will have many positive environmental effects seeing a sustainable shift in the area, these include;

- Lower odor due to reduction in open disposal.
- Reduction in spread of disease due to less waste left openly across the campus.
- Reduction of greenhouse gas emissions of present fuel/energy sources.
- No external energy source required.
- Generation of sustainable and cleaner biogas.
- Generation of sustainable natural fertilizer.
- Reduced demand of LPG and electricity grid.

7. CONCLUSION: Energy being one of the driving forces in the nation's growth India should produce it adequately. There is a need of sustainable energy sources in India to fulfill the power demands of growing population. Along with the energy solution environment should be balanced well. To achieve social-economical stability India should start developing energy from renewable sources such as bio-energy. Biogas, a traditional energy generating technology seems promising satisfying the energy needs of both urban and rural population. There are many advantages of biogas system such as waste to energy conversion, NPK rich manure, ease in operation for urban as well as for rural people. Biogas is supportive to agriculture hence can improve the status of farmers. The technology may lack somewhere but new adaptations in technology can solve the problems. Future aspirations of biogas technology are in transportation fuel, fuel cells, industrial level electricity generation and heat generation etc. Biogas can bring progress economically, socially as well as environmentally. Conditions Available in India such as climate, biomass availability and hands on operation etc are encouraging for biogas generation and utilization.

Based on the findings of this study, the following conclusion can be drawn:

- The biogas digester is simple but effective option to save cost on power.
- It was established that there was enough waste (152kg per day) for production of sufficient biogas of about 36.48m3 per day to substitute the use of LPG.
- The produced amount of gas can generate about 67 KW of power per day, which can be used in college campus for street lightining at night.
- Organic fertilizers can be made from the slurry generated after the biogas production process. This can be used in college horticulture.
- With prudent management practices biomass production offers the opportunity to address multiple environmental concerns e.g.: land degradation, biodiversity, CO_2 emissions, other GHG and acid rain pollutants, and local and regional health problems.
- Reduction in solid waste management.

REFERENCES :

1. James Kuria, Jomo Kenyatta University of Agriculture and Technology "DEVELOPING SIMPLE PROCEDURES FOR SELECTING, SIZING, SCHEDULING OF MATERIALS AND COSTING OF SMALL BIO – GAS UNITS"
2. Viewg "BIO GAS PLANT IN ANIMAL HUSBANDRY"
3. IS CODE 9478 – 1989 "FAMILY SIZE BIOGAS PLANT"
4. SUYOG VIJ "BIOGAS PRODUCTION FROM KITCHEN WASTE"
5. Karve of Pune A.D (2006). "COMPACT BIOGAS PLANT COMPACT LOW-COST DIGESTER FROM WASTE STARCH". www.bioenergylists.org.
6. Shalini sing, sushil kumar, M.C. Jain, Dinesh kumar (2000), "THE INCREASED BIOGAS PRODUCTION USING MICROBIAL STIMULANTS".
7. Ogur, E. O. and Mbatia, S. IJES , "CONVERSION OF KITCHEN WASTE INTO BIOGAS"
8. M.A.O. Mydin, N.F. Nik Abllah "GENERATING RENEWABLE ELECTRICITY FROM FOOD WASTE"
9. Sustinable Sanitation and water management.