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Design of an Anaerobic Digester for Biogas Production from Night Soil

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Abstract - *Bio-gas technology is attracting worldwide attention as a decentralized energy system. Bio-gas provides conventional source of energy at low cost. Use of human wastes or any other wastes could help us to effectively dispose it and gain energy from it. In this project, designing to use the human wastes generated in our college hostels as the source for production of biogas through methane could be obtained. Biogas produced from human wastes consists of components methane, carbon dioxide, hydrogen sulfide and nitrogen. Nitrogen is present in a very minimum level. The remaining hydrogen sulfide and carbon dioxide can be removed by using respective scrubbers. In hostels LPG gas is used for the cooking purpose. A 19kg gas cylinder is used for 10 days in a hostel. So, then collect the hostel population details and the calorific value of LPG and methane to find the effectiveness of the plant. Then calculate the amount of night soil produced, using the population details. Here consider that a person produces 0.4kg of night soil per day.*

Key Words: Biogas, Anaerobic digestion, Night soil, Methane, Fossil fuels.

1. INTRODUCTION

Management of waste has become one of the biggest problems we are facing today. The rapid increase in the volume of waste is one aspect of the environment crisis, accompanying recent global development. It has been estimated that India, as a whole, generates as much as 25 million tons of urban waste of diverse composition per year. It is estimated that the per capita waste generated in India is about 0.4 kg/day with the compostable matter approximately 50-60% [1]. Most common practices of waste processing are uncontrolled dumping which causes mainly water and soil pollution. Besides dumping or sanitary land filling, the final disposal of waste can be carried out by other methods like incineration and composting. The increase in pollution causes an increase in the quantity and type of urban and rural wastes. Such wastes are undesirable pollutants to the environment and time could even be a health menace. As far as rural wastes are concerned, there are enormous quantities of organic materials that are not utilized. India and many other countries are suffering from the entire problem due to urbanization, which are a very rapid process and a worldwide phenomenon. Biogas plants have been accepted by now in the country as a device for improving the quality of the life of the people. They help in recycling of cattle wastes and produce both fuel and manure from the same quantity of dung. At present it is understood that over 3 million families own biogas plant in the country [2]. At the same time there are efforts to also use alternatives feed stocks like human excreta, and also other agricultural wastes, water hyacinth etc. The safe disposal of night soil/human excreta is of major consideration for any sanitary programs and one of them can be through feeding it into the biogas digesters [3]. It is agreed that the use of the gas from night soil will be considered taboo by the majority of our people. Human excreta, is a principal vehicle for the transmission and spread of a number of communicable diseases. Therefore, proper treatment of human waste is very important [4].

1.1 Biogas

Biogas, the methane rich gas, is the by-product of anaerobic digestion that breaking down the organic materials in the absence of air. Biogas can be produced from raw materials, such as manure, agricultural waste, municipal waste, food waste, etc. Biogas is a renewable energy sources. Biogas is primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S), moistures and siloxanes. This energy release allows biogas to be used as a fuel for cooking, lighting and generating electricity. Cooking is the most convenient use of biogas. Biogas is an alternative promising substitute to fossil fuel. Utilization of raw material such as human waste considered beneficial in terms of the process because it does not require additional starter (microorganisms seed), and a supply of microorganisms occurs continuously during the feeding of raw materials. This directly supports the sustainability of the production of biogas.

1.2 Anaerobic Digestion

Anaerobic digestion is the process by which organic matter like night soil is broken down to produce biogas and bio fertilizer. This process happens in the absence of oxygen in a sealed, oxygen free tank called an anaerobic digester. In anaerobic digestion, organic matters are degraded by bacteria, in the absence of oxygen, converting it into a methane and carbon dioxide mixture. The anaerobic digestion process consists of the four different steps,

- Hydrolysis
- Acidogenesis
- Acetogenesis
- Methanogenesis

1.3 Night Soil

Night soil is mostly used to represent, in general, a mixture of human faeces and urine. The two are waste products of the bodily metabolism. The appearance, physical and chemical characteristics of faeces or urine depends largely on the health of the person excreting the material, as well as on the amount and type of food and liquid consumed.

2. METHODOLOGY

First estimate the night soil waste for design of anaerobic digester for biogas production in our college hostel. Based on the hostel population to estimate the night soil produced per day. Night soil produced per day by a person is 0.4 kg. Then to estimate the biogas production. 1 kg of biogas produces 0.04 m^3 to 0.07 m^3 of volume is obtained. Based on the details to estimate the gas production rate. Based on the estimation of night soil and estimation of biogas to design the anaerobic digester.

3. HYDRAULIC DESIGN

1) Generation rate of night soil

Night soil produced per day by a person = 0.4 kg

Percentage of methane obtained = 65%

Population = 2350 = 3000 approx.

Night soil produced per day = 1200 kg

Ratio of mixing night soil to water = 1:3

Detention time period in India = 40 to 60 days = 50 days approx.

2) Gas production rate, 'G': One kg of night soil produced about 0.04 m^3 to 0.07 m^3 of gas. The gas production rate G for the available waste thus given as

G = 0.07W

Where W = 1200 kg/day

3) Active Slurry Volume, 'V_S': The active slurry volume is given by

$$V_s = HRT\ X\ \frac{W_{ns} + W_w}{1000}$$

Taking HRT = 50 days

Where

$$W_w = 3W_{ns}$$

3) Determination of H and D: Usually a H/D = 1 to 0.66. Knowing the active slurry volume from above calculation, H can be calculated from equations

$$V_s = \frac{\pi}{4}\ X\ D^2\ X\ H$$

Where H = 0.66D, H = Height of cylindrical portion of the digester, D = Diameter of the digester

4) Estimation of slurry displacement parameter,'d': The selection of a suitable value of d depends upon the gas usage pattern. If the cooking time is about 3 hours, the variable gas storage volume V_{sd} is obtained from equation

$$\frac{3G}{24} + V_{sd} = 0.5G$$

Where V_{sd} = Slurry displacement volume (m^3)

5) Slurry displacement in inlet and outlet tank, 'h':

h + d = 0.425

6) Design of outlet tank: Usually a rectangular shape with l = 1.5b is selected. If the inlet and outlet cross sectional areas are selected to be identical we get

$$V_{sd} = 2\ X\ l\ X\ b\ X\ h$$

7) Design of dome height, 'd_h': The dome height is obtained by the equation

$$d_h = A + B$$

$$A = [\frac{-q}{2} + \sqrt{R}]^{1/3}$$

$$R = [p/3]^2 + [q/2]^2$$

$$p = 0.75D^2$$

$$q = -0.6\ X\ 6\ X\ \frac{G}{H}$$

$$B = -[{}^{q}/_{2} + \sqrt{R}]^{1/3}$$

8) Radius of dome, 'R_d': The radius is obtained by the equation

$$R_d = \frac{[(D/2)^2 + d_h{}^2]}{2d_h}$$

9) Volume of gas holder, 'V_{gh}':

$$V_{gh} = {}^{g}/_{2}$$

Where g = gas production rate

Table -1: Design Parameters

Parameter	Value	Parameter	Value
G	84 m^3/day	V_{sd}	33.6 m^3
V_s	240 m^3	L	7.7 m
D	8 m	B	5.13 m
H	5.3 m	d_h	3.25 m
d	0.425 m	R_d	9 m
h	0.425 m	V_{gh}	42 m^3

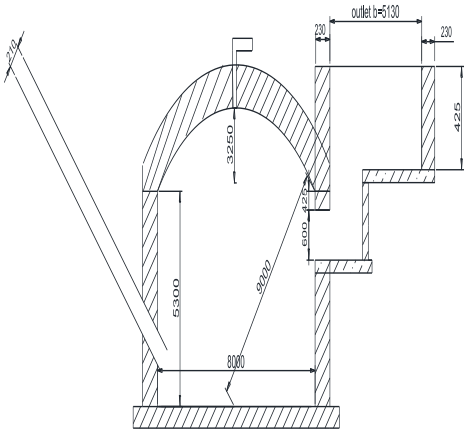

Fig -1: Anaerobic Digester with calculated dimensions

4. CONCLUSION

Effective image of the gas helps manhood to move towards making a better environment sludge obtained are used for agricultural purpose. Studies show that using the sludge we can increase agricultural productivity 33%.The anaerobic digester process is known to be used for protective manners which proves yielding methane in a desire level from 84 cu. m of biogas 65% of methane can be obtained which is approximately 55cu. m / day. Generally 1 m^3 volume of biogas is equal to 0.45 kg of LPG of nearly 3 kg of firewood so, the biogas is cheaper and safer than the LPG. As Tamil Nadu has perfect climatic condition for the biogas plant, installation of such a plant becomes easy. Maintaining the temperature of 30-35^{0}C is also easy including mesophilic condition here wasted water proves to be used. Smart usage of night soil converts waste into valuable product is helps human survey socially and environmentally.

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