Proposal of Biogas Plant for SATI Vidisha College Hostel

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Abstract— This dissertation work object to design a biogas plant for the college campus of SATI, Vidisha. The raw material for the Biogas Plant is the sanitary waste and the food waste obtained form college hostels (5 Boys Hostels and 4 Girls Hostels). The dissertation consists the designed capacity of various units of biogas plant, their structural design along with the dimensional specifications, the quantity of material and the overall cost of instalation of the plant. A biogas plant is a set of various units installed together to utilise organic waste for anerobic production of biogas, which is mixer of various gases mainly about 65% of methane that is flamable in nature. The alarming situation of non renewable energy, tremendeously increasing municiple solid waste that is mostly organic in nature and also to promote sustainble forms of energy, it's important to utilise biomass for energy generation. The process of biogas generation not only prevents open decomposition of organic waste but also renders the processed sludge inactive enough to produce flies and odore nuisance.

Key words: Biogas, Methane, Biomass, Sludge

I. INTRODUCTION

To resolve problem of fossil fuel shortage, which is among world's biggest environmental problems that require long-term potentially active attention for sustainable development. Thus, renewable energy resources appear to be one of the most promising, efficient and effective solutions [1]. There are many renewable energy sources known, like solar energy, Geo-thermal energy, Wind energy, Tidal energy, etc. Biogas is newly established renewable energy that occurs naturally as a by-product during the anaerobic breakdown of organic waste materials present in the environment. Methane (typically 55% – 70% by volume) and carbon dioxide (typically 30% – 45%) are the primary components of Biogas. Also, small traces of hydrogen sulphide (typically 50 – 2000 parts per million [PPM]), water vapour (saturated), oxygen, and various hydrocarbons are also found as a composition in biogas. Due to the lower methane content, heating value is also low as compared to other flammable gases. Therefore, use of biogas is generally limited to engine-generator sets and boilers [2]. But, the major advantage of biogas is to find a safe way for disposal and treatment of manure or sewage, municipal, garden, agricultural and food waste that has organic content in it. The anaerobic digestion not only gives flammable natural gas, but also provides with the organic manure as its residual product for agricultural use [3].

Combustible gas, Methane is the major product of anaerobic fermentation of the organic matter, and has a calorific value of about 40 MJ/m. Production and utilization of renewable energy – both in a global and a national context– is necessary to control unpredictable climate change and to have a check on continuously elevating price of fossil fuels.[4]. The organic waste, especially in rural area is left unattended that find its way directly to the river and other open area potentially harmful and annoying to humans, because of emission of odorous gases and releasing of leach ate that enhances mosquito and flies arrival near the area of disposal **[5].**

II. HISTORICAL REVIEW

The concept that rotting vegetables matter gives off a flammable gas has been already understood since the ancient Persian period. In modern times, an idea stroked to the UK in 1895 that the gas produced by sewage decay can be used to lighten street lamps. This system was first functionally developed in the UK and Germany in the early 1900s for the treatment of sewage. Fully operated drainage systems were installed in many town of Europe and anaerobic digester was observed as a simple mean to considerably reduce the volume of solid matter in the sewage. The gas produced was occasionally commercially used as a source of energy, such as for running vehicles, for heating water, electricity generation, lighting street lamps, etc.

S.V. Desai of India was the first to conduct experiments on biogas production in 1951. This was the first biogas plant of India, developed and installed in 1951, known as Gramalaxi plant of the Khadi and Village Industries Commission (KVIC). The aim of KVIC was to introduce biogas production technology to the famers of rural India. The design of KCIV was standardised in 1962, which continues till date.

III. OBJECTIVE OF STUDY

The dissertation aims to provide a solution to the current waste problem in the college campus where waste is left unattended in the open areas, increasing the chances of diseases, food and water contamination. Currently human feces from the hostel deposits in the hostel's sanitary tank & the food wastes from the hostel mess are left un-buried and untreated. These unhygienic conditions can lead to the bacteria build-up leaving community susceptible to disease. The subdivisions of project are as follows:

- To calculate quantity of waste obtained from the hostels.
- To calculate volume and dimensions of digester feed, biogas digester, gas holding container and effluent holding lagoon.
- To design the specifications and fittings for the same.
- To calculate the total cost of installation of the project.
- To calculate amount of biogas that can be generated.
- To calculate the revenue that can be generated and to suggest possible uses of produced biogas and nutrient enriched organic manure.

IV. METHODOLOGY

A. Location of Raw Material

The organic sanitary waste obtained from the hostels and the food waste obtained from the hostel mess is to be used as the raw material to feed bio-digester for biogas production by anaerobic digestion. The total amount of waste that would be obtained totally depends on the number of students who dwells in the campus hostel (including workers of hostel). The full details of the number of persons that can be encountered for waste calculation, is given in Table.1.

The total faecal waste and the food waste that can be produced during the working session of the college, hence the total load of raw material that is liable to be imposed on the bio-digest or is given in Table.1.

The accommodation in the hostels may vary during vacations or may be due to some administrable reasons, but since many times the hostels may run full, the capacity of the bio-digester must be large enough to contain all the waste that can be generated. Also, the numbers of hostels in the campus are subjected to increase in future expansions, therefore, for the time being at least the bio-digester capacity must be sufficient to hold maximum of the waste generated.

All the hostels are located near to each other; therefore, the location of the biogas plant must be such that the pipeline connections that would be provided for carrying the sanitary raw material from the hostels to the plants cost less. The food waste can be manually collected for feeding bio-digester. The location of all the hostels and the capacity of waste generation from each hostel is shown in Table.1.

As the objective of the project is to design a biogas plant for the hostel of college campus of SATI, Vidisha. The methodology involves the planning that deals with the location finalization of the proposed project, units of biogas plants that are to be designed, calculations involved in the biogas plant for determining amount of waste to be dealt and the respective dimensions of various units of biogas plant, the material that could be used for the construction, the techniques involved for construction and the estimation of overall project cost.

B. Location of Proposed Biogas Plant

The following criteria's must be fulfilled by the site, which is selected for the construction of biogas plant on it:

- The available area should be adequate to accommodate all the units of the plant altogether
- The site must receive full sunlight without any hindrance by the surrounding structures and vegetationsSite should not be at a lower level as compared to the surrounding area, so that water logging can be avoided
- The existing water table of the site must be much lower and alos there must be no nearby well for water extraction.
- In case where the water table is high and site s important, additional arrangements must be made to avoid waste and water contact

Hostel Name	Capacity	Fecal Waste per Day (kg/day)	Food Waste per Day (kg/day)	Total Waste
Kalpana Chawla Girls Hostel	167	167 x 0.5 = 83.5	167 x 0.1 = 16.7	100 kg/ day
Indira Gandhi Girls Hostel	210	210 x 0.5 = 105	210 x 0.1 = 21.0	126 kg/ day
120 seater Girls Hostel	120	120 x 0.5 = 60	120 x 0.1 = 12.0	72 kg/ day
Polytechnic Girls Hostel	87	87 x 0.5 = 43.5	87 x 0.1 = 8.7	52.2 kg/ day
New Polytechnic Boys Hostel	62	62 x 0.5 = 31	62 x 0.1 = 6.2	37.2 kg/ day
Old Polytechnic Boys Hostel	74	74 x 0.5 = 37	74 x 0.1 = 7.4	44.4 kg/ day
Jawahar Lal Nehru Boys Hostel	107	107 x 0.5 = 53.5	107 x 0.1 = 10.7	64.2 kg/ day
Ravindra Nath Tagore Boys Hostel	121	121 x 0.5 = 60.5	121 x 0.1 = 12.1	72.6 kg/ day
CV Raman Boys Hostel	115	115 x 0.5 = 57.5	115 x 0.1 = 11.5	69 kg/ day
Total	1036	518	103.6	621.3 kg/day

Table 1: Raw Material that can be obtained as per the capacity of the hostels

- It is always suggested to Selecta site at least 20 m away from the water sources such as wells, springs, tube wells, etc to avoid possible contamination of water sources.
- The site selected should be away from trees or tree stumps to mitigate the root hazard in the pre/post construction phase.
- The plant must be as close as possible to the waste source (cattle-shed, poultry waste collection chamber, kitchen waste, night soil pipe), to avoid wastage of raw materials specially the waste substrate,
- The nearest water source should not be at a distance of more than 20 minutes walk. Otherwise more time in fetching water from the source to the plant will bring unnecessary burden to the owner during the operation of the plant.
- Soil should not be too loose and should have a bearing strength of 2 kg/cm2
- It should be nearer to the intended place of gas use (eg. home or farm), Since if longer gas-pipe is used the cost will be increased as the pipe is expensive. Furthermore, longer pipe increases the risk of gas leakage due to more joints in it.
- The edge of the foundation of the plant should be at least two meters away from the house or any other building to avoid risk of damages.
- Keeping in mind all the above stated criteria's for site selection of biogas plant, a location near to all the hostels and free from any obstacle has been finalized.

C. Units of Biogas Plan

The whole biogas plant is designed into following units, that serves their importance individually for biogas production:

1) Feeding/ Mixing Unit: This chamber is designed to feed the bio-digester with the raw material (Human feces + food waste). Feeder is equipped with a grinder that grinds the raw material into slurry. Also, water can be feeded into the same unit before it is passed on to digestion chamber.
2) Digestion Unit: It is the chamber where human defecation & food waste from the hostel mess will be fermented over a hydraullic retention period of approximately 60 days. It is absolutely air tight and hence allows anaerobic decomposition of organic matter to form methane and other flammable gases. The gases produced will raise to the dome shaped top due to light weight and will be directed to the gas compensation unit, leaving behing manure and decomposed slurry at bottom of the floor, which will later be directed to the exhaustion chamber or lagoons.
3) Gas Compensation Unit: Construction of this unit aims to collect the biogas generated before it has been passed on for further use. The chamber accomodates the gas produced into the digestor and supplied to the user when required.
4) Exhaustion Unit (Lagoon): Lagoons are shallow open pits that are constructed with outer boundaries and base of lean concrete, to accomodate the exhausted organic manure obtained from the digestion unit. The purpose of drying manure into the laggons is to retain its moisture content and making it fertile by seasoning.

V. OBSERVATIONS

All the calculations for volumes and dimension are already done in methodology section of the document. A brief of all the dimensions are given in Table. 2.

Total Person	1036
Feeder	Volume = 1.875 m^3 Cylinder, Height = 1 m; Radius = 0.3 m
Digester	Capacity of sludge = 75 m^3 Capacity of Gas = 41.5 m^3 Total Capacity = 116.5 m^3 ; increased 25% = 145.625 m^3 Cylinder with Hemispherical Top, Radius = 3 m; Height of cylinder = 2 m ; Total Height = 5 m
Compensation Tank	Volume of Gas = 83 m^3 ; decreased 75% to maintain pressure = 31.12 m^3 Cylinder with Hemispherical Top, Radius = 2 m Height of Cylinder = 1.2 m Total Height = 3.2 m
Lagoon	Volume = 50% of total sludge volume = 37.5 m^3 4 Rectangular open tanks, Length = 10 m Width = 8 m Height = 1.2 m

Table 2: Summary of Dimensions and Volumes of various biogas plant units

Particulars of Items And Detail of Work	Quantity	Total
Earthwork Excavation: For Feeding chamber For Digester For Compensation Tank Embankment: For Lagoon	1.873 m^3 75 m^3 150.72 m^3 32 m^3	259.593 m^3
Brickwork For Feeding chamber Mortar For Digester Mortar For Compensation Tank Mortar For Lagoon Mortar	0.753 m^3 10.93 m^3 3.16 m^3 3.84 m^3	18.683m^3
Concrete Work For Base Of Feeding Chamber Of Digester Of Compensation Tank Of Lagoon For Domes Of Digester Of Compensation Tank	0.57 m^3 4.05 m^3 1.88 m^3 48 m^3 8.80 m^3 4.04 m^3	67.34 m^3
Reinforcement In Digester In Compensation Tank	1.056 kg 0.4848 kg	1.5408 kg
Plastering Of Feeding Chamber Of Digester Of Compensation Tank	6.908m^3 18.84m^3 12.56m^3	38.308m^3

Table 3: Abstract of Quantities

VI. COSTING

Particulars	Quantity	Unit Rate	Total
Earthwork	259.593 m^3	Rs. 107 / m^3	Rs. 27,776
Brickwork Bricks (II class bricks) Mortar (1:4) Cement Sand	18.683 m^3 0.56049 m^3 3.7366 m^3 14.9464 m^3	Rs. 3567 / m^3 (Bricks+ Masonry)	Rs. 66,642
Concrete (M25 -1:1:2) Cement Sand Aggregate	67.34 m^3 16.83 m^3 16.83 m^3 33.66 m^3	Rs. 5036 /m^3	Rs. 3,39,124
Reinforcement (Mild steel and Medium Tensile steel bars.)	1.5408 kg	Rs. 41.50 / kg	Rs. 65
15 mm Plastering	38.308	Rs. 106 /	Rs. 4,061

(1:4) Cement Sand	m^3 7.6616 m^3 30.6464 m^3	m^2	
Miscellenious cost (pipe fittings + covering of lagoon + DC motors and others)			Rs.15000 (approx.)
Total			Rs. 4,52,670

Table 4:

VII. CONCLUSION

Designed biogas plant typically contains feeder, digester,gas compensation unit and sludge holding lagoon. The daily estimated feed is 1.875m3 (fecal waste + food waste) and the waste will be kept in the digestion chamber for a hydrualic retention period of 60 days. After 60 days half of the matter from the digestion chamber will be taken out in the lagoon and the process will be repeated every 40 days. The total space occupied by the proposed biogas plant is 20m x 23m (approximately 460m^2) and overall installation cost is Rs. 4,52,670. The biogas produced by proposed biogas plant is only sufficient to be used in 2 or 3 hostels of approx total student and staff strength of 578.

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