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Bio-Energy Generation: A Sustainable Environmental Technology for Waste Management

Keerti K. Chowdhary, Archana K.Chowdhary

Abstract: - The paper reports prototype system has been developed, which is suitable for waste management. In Indian context Hostel & hotel industries increased vigorously during last two decades in most of the urban centers in India. The survey of some hostels, hotels showed that various kinds of solid wastes get generated and disposed off in nearby area without caring for any kind of treatment. These wastes can be grouped as Dry waste & Wet Waste. Amongst the various methodologies used for treating solid waste the reuse and / recycling methodology for dry waste whereas Biogas method for treatment of wet biodegradable solid waste found to be most suitable, feasible and economically viable method; It is eco friendly and purely natural process. The entire quantity of solid waste will get converted into biogas and NPK- rich organic manure. The process is very simple and. does not require highly technical personnel to operate it even to run in mega scale plants. The process is anaerobic decomposition of organic matter by a group of micro flora to produce biogas. It is alternative fuel for cooking, which will reduce the demand for fossil fuel. In this paper an Environmental Sound Technology (EST), pertaining to its experimental model with integration of various bio-systems discussed & a typical 25 cum Biogas digester is being design. Enhancing ecological literacy for waste material segregation at source.

Key words: **Biogas Anaerobic Process Hotel Waste, Organic Manure, Biodegradable Waste, Biomass, Microorganisms**.

I. INTRODUCTION

Conventionally, the organic and inorganic materials which have lost their values in the eyes of the first owner are termed as waste, whereas, there is nothing like waste in nature, it is only a 'resource at wrong place'. The alternative scenario is with promise that "garbage is a valuable commodity'', if handled and transformed into render to a socially useful products. Biogas system is one the important technologies to emerge in the last decade for solution of problem which require great deal of experience and judgment, it is suitable in the of field Environmental science. In recent years, there have been many attempts at developing expert system in the field of environmental science, these systems are related to waste water management (BATA, WATERX expert system for anaerobic digester) air pollution control and monitoring process (expert system for gas purification process for power plant), however, only few attempts have been made for developing methology for waste management. Hence an attempt has made in this field by developing a prototype biogas system. Garbage is an unavoidable consequence of prosperous high technology. Hospitality industry as it is called has increased multifold during last two decades in most of the urban centers in India. In big and medium cities, due to various socio-economic factors, there is sudden increase in number of big, small and roadside eateries around every nook and corner of the city. This has contributed to a large quantum of solid waste generated in big cities. It is a problem not only in India but also throughout the world. The word garbage reminds us of an overflowing garbage bin, with rag pickers rummaging through it and animals looking for something to eat. The daily garbage production is increased manifold and it is becoming a big problem to the municipalities.

Wastes can be grouped as follows;

- **a.** Dry waste**:** Paper, Plastic Bags, Paper napkins, Bread wrappers, plastic and glass bottles, oil cans, glass jars, juice and cold drink bottles, wrappings of fruit, straw, paper dishes, metal bottles, rubber, leather, plastics, bed sheet cloths, napkins etc.
- **b.** Wet Waste: Kitchen wastes, peels of vegetables, rotten fruits, fruit seeds, fruit skin pealing and remnants, waste vegetable, roots and stalks, wasted flowers, rotten food, milk, used tea wet powder, vegetarian/non-vegetarian food wasted in the dishes, bones, egg shells, garden waste etc.

The present practice is to throw the entire waste as it is in nearby dustbins. The ill maintained and not so regularly cleaned dust bins pose a pathetic scene to watch. Stray dogs, donkeys, stray cattle and most unfortunately rag pickers always invariably surround it. The organic waste so disposed off gets fast degraded and starts stinking badly. The bad stink further prohibits the house wives and attendants to deposit the fresh waste into bins and thus the waste starts getting spread around setting the chain of filth and unhygienic conditions to a further degree. With expanding world population, increasing energy demands and diminishing stock of fossil fuels, most countries have to pay greater attention to the renewable source of energy. Production of bio energy shows a great potential in this direction. Hypothesis of Jerome Goldstein (1975), is in the following form,

The Economics of Energy + The Economics of Environment + The Economics of Food = the new Alternative in waste recovery.

The energy requirements are not fully met by local resources, only solution is availed to create alternative source whose viability is assured as long as life exists is **"Biogas''** Biogas specially refers to methane produced by the fermentation of organic matter including manure wastewater sludge or municipal solid waste under anaerobic conditions.

The process is popular for treating many types of organic waste because it provides a convenient way of turning waste into electricity, decreasing the amount of waste to be disposed of and of destroying disease causing pathogens which can exist in the waste stream. The use of biogas is encouraged because methane burns with a clean flame and produces little pollution. Biogas has assured importance due to realization of the fact that it could help in substituting consumption of such fuels as fire wood, cow dung, and vegetable and agriculture waste, industrial waste all of which could be put to more productive uses.

II. BIOGAS: HISTORICAL REVIEW

The production of biogas is not new phenomenon. According to Oxford Dictionary it was discovered in the year 1668, air like substance derived from water .The Italian Scientists A. Volta 1776 observed that production of gas from lake, pond ditches during summer season, due to decaying vegetation in the sediment of lake. Humphrey Davy in 1808 collected methane gas from cattle dung in his experiment, and this might be beginning of biogas research. French Chemist and Microbiologist Luich Pasture, he belongs to Cobbler family, reported in 1857 that anaerobic microbe yeast was responsible for production of methane from animal waste. The biogas plant built in 1859 in a Laper’s colony at Bombay. It was reported that at the same time, in England biogas generated was used for street lighting. During World War II energy crises, to over come problem biogas process adopted in France, Algera, Germany After World War II sewage gas was extensively used for generating electricity. Till up today tremendous work has been done in biogas technology report published by Ministry of Non Conventional Energy Source (MNES) and Tat Energy Research Institute (TERI), New Delhi. 2000. Various workers reported that environmental factors affecting the gas production from Cattle dung and agriculture waste. In India, Village Industries Commission (KVIC) in 1961 designed, simple and easy to operate gas plant. Dung is fermented to yield a combustible gas can be used as fuel and sludge residue can be utilized as manure. Gobar Gas Research Station was started in Ajitmal Etawah (UP).

Biogas means social benefits for women and children. Women and children are the big winners in India where every year 20000 families turn away from the traditional fireplace and have a biogas plant installed to provide energy for cooking and generating electricity. A smoke –free and ash-free kitchen means women are no longer prone to lung and throat infections and can look forward to a longer life expectancy. In rural areas, where there is generally no electricity supply, the introduction of biogas has given women a senses of self worth and time to engage in more activities outside the home. Biogas digesters take a form of energy, animal manure, and convert it into two useful products gas and liquid manure. The traditional use of dung provides only one of these two products either the dung is burned directly as a fuel, or it is applied as a fertilizer to gardens. The processing of the cattle or human dung in a biogas digester provide both a better quality gas and liquid manure when compared with the raw product. More than 2 million biogas plants have been built in India so far. Almost 200,000 permanent jobs have been created for the male bread-winners of Indian families.

Biogas technology applied for following industrial sectors.

Alcohol production
Beverage
Distilleries
Dairy and cheese processing
Fish and seafood processing
Fruit and vegetable processing
Pharmaceuticals
Pulp and paper mill
Slaughter House and Meatpacking
Sugar processing

III. MATERIAL AND METHODS: A CASE STUDY

The daily waste from the individual hotel is initially segregated at source. Separate two bins were provided. In first bin all dry non-degradable garbage like plastic, paper, bottles, tins and metallic wastes were stored and kept aside which rag pickers will collect. In another bin wet biodegradable garbage like vegetable waste, food waste, fruit peels, devoid of eggshells, bones etc. were collected. Feed materials (waste) were mixed with water by mixing device and fed into the digester. Reports from Egyptian barracks however state that 85 litre of biogas per person per day are produced form kitchen waste, which means that the demands for cooking are completely covered. The waste produced daily must be between 20-250 gm.per person per day. Under anaerobic conditions the organic materials are converted in to fuel gas and organic fertilizer by microbiological reactions .The fuel gas is called biogas. In the initial stage the biogas yield ranged from. 0.48 to 0.56 m3/kg. V/S added in the digesters. But as the digestion progressed, the yield increased in those digesters, which were enriched with non-veg. food waste and it’s washings. Biogas is the mixture of gases containing 56 to 60 % methane CH_4, 30% CO_2 4% N_2 & 1% H_2S.The gas produced has a heat value 47,00 KJ/m3. It is combustible gas and can be used for cooking, lighting, and in internal combustion engines to power water pumps and electric generators. The sludge of biogas plant used as organic manure. The most economical benefits are minimizing environmental pollution and meeting the demands of energy for various purposes.

IV. BIOGAS DIGESTERS

The digestion has three main stages. The first, hydrolysis involves breaking down the large macromolecules to sugars amino acids and fatty acids by

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bacteria under aerobic conditions. The second stage is accetogenesis, during which acetogenic bacteria convert sugars into short chain acids mainly acetic acid. The third stage is methanogenesis which is carried out by anaerobic bacteria. Here the acids are converted into methane. The materials used in biogas production are mixture of complex organic matter, biopolymers that are digested by micro organisms. Production of optimal biogas the factors influencing are water content of slurry of substrate 40%, seeding of biogas plants, C: N ratio of substrate, anaerobic conditions in reactors, pH, of slurry 6.5 to 7.5, VFA volatile fatty acids contents 582 to 623 mg/lit. Biogas produced contaminated particularly H2S and SO2, since both are extremely corrosive to metal parts; removal of H2S is highly desirable before the gas is used as an engine fuel. Several methods, of SO2 and H2S separation can be used viz. Water scrubbing, caustic scrubbing, solid absorption, and liquid absorption. Following reaction occurs during scrubbing process. Other sources of biogas are landfills anaerobic lagoons and sewage treatment plant. There are two general types of biogas digesters fixed volume and fixed pressure Fixed volume digester produce a gas that has a variable pressure depending on the amount of gas being produced. Fixed pressure digesters (also referred to as floating dome digesters) have a variable volume which also depends on the amount of gas being produced. The fixed pressure digester has the advantage of being able to supply gas to an appliance like a gas fridge, or a gas generation since they require a constant gas pressure.

V. DESIGN OF BIOGAS PLANT

The fixed dome biogas plant buried underground. There are three main connecting parts:

Mixing Chamber: where animal excrement is mixed with water before it is poured into digester chamber.

Digester Chamber: Where excrement and water are fermented. Methane and other gases will be produced in the chamber and these gases will push manure and slurry at bottom of the floor into expansion chamber.

Expansion Chamber: Collects excess manure and slurry. When gas is being used, manure and slurry will flow back into digester chamber to push gas up for usage. When the excess manure exceeds the volume of the chamber, the manure will be drained out.

This system is called dynamic system, when gas is produced inside the pit, the gas pressure will push manure and slurry at the bottom of the pit to flow up into expansion chamber. When this gas is used the slurry in the expansion chamber will flow back into the digester chamber to push the gas up for usage. This happens consistently. The plant will be operated efficiently for a long period of time if the gas pit does not cracked and the system runs regularly. In each case the strength of plant depends on fine construction, specifications of materials according to the criteria suggested by biogas programme, and strict adherence to the instruction manual on maintenance of the biogas.

VI. CALCULATION OF THE SIZE OF BIO-GAS PLANT

Formula used = Fresh manure day x amount of animal x 2 (for cow/buffalo) or x 3 (for pig) x Retention time (60 days)

Fresh Excrement of Animal per Day.

1 meat or buffalo produces 8 kg of fresh excrement per day

1 milk cow produces 15 kg of fresh excrement per day

1 pig (over > 60 kg) produces 2 kg of fresh excrement per day

1 pig (< 60 kg) produces 1.2 kg of fresh excrement per day

200 chickens or 200 birds, Bio-gas plant should be built at the size of 1 M^3

Modified RCC KVIC biogas plants for Goshalas of M.P. has been designed for different capacities viz. 25 cum, 35 cum, 45cum, 60 cum, 85 cum. It is found that RCC KVIC Biogas plants are better than conventional Biogas plants. There is a minor increase in cost i.e.18% to 30% while the space required for RCC KVIC Biogas digesters is less for designed capacity and life of Biogas digester is increased many times as compared to the old conventional old methods of constructing Biogas Digesters.

VI. RESULT AND DISCUSSION

Waste collected from hostel & hotel bins had high content of moist fermentable matter, Organic waste gets fast putrefaction during its initial stage, which creates malodour problems, to overcoming this malodour problem, Biogas technology is the ideal and use option. The biogas option was the most sensible, feasible and economical way for hostel & hotel waste treatment. Biogas production coupled to mushroom production however, provides the best option if capable of being successfully deployed as envisaged. Waste slurry was put in to an anaerobic reactor filled with toilet slurry, the gas production increased up to 160% as compared to the kitchen waste.

VII. CONCLUSION

This paper discusses the applicability of knowledge-based approach to waste management system. A prototype system has been developed for this purpose. The biogas system developed for waste management can serve as a tool for selecting the best alternative for the purpose. The method is found to be excellent for the hostel & hotels that have problem of disposal of daily waste. Not only do biogas digesters meet the thermal energy needs, but they also have significant other benefits such as

a) Biogas and manure are two added products

b) Round the year operation is possible.

c) Reduction of solid waste at source, which will be help in lowering, downs the load of city solid waste disposal system.

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d) Various fungi, bacteria and actinomycetes are responsible for bioconversion of hostel & hotel waste. These organisms can be used effectively as inoculums to accelerate degradation process.
e) The health problem will be reduced due to segregation of perishable solid waste.
f) Stinking sites and the dirty blots on the city will be out.
g) Excellent quality organic manure will be made which will be useful as soil conditioner.
h) A better yield of agricultural products will be a plain bonus.
i) Improved health and reduce respiratory elements.
j) Reduce ground water pollution
K) Reduce deforestation and resulting soil erosion
l) Reduce depletion of solar nutrients
m) Reduce green house gas emissions
n) The slurry provides an excellent fertilizer and thereby increases crop production or can be sold to generatic income.

Biogas can have a higher heating value in the range of 150 to 650 Btu/scf (6 to 24 MJ/ m^3) which is about half that of natural gas. The medium heat gas can be fired in a number of prime movers for power generation (mechanical thermal or electrical). The energy produced is considered renewable energy.

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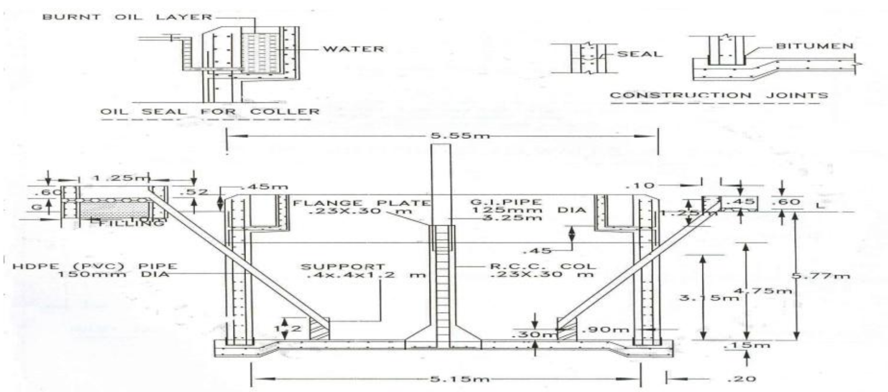

Fig.1 Cross Sectional Elevation

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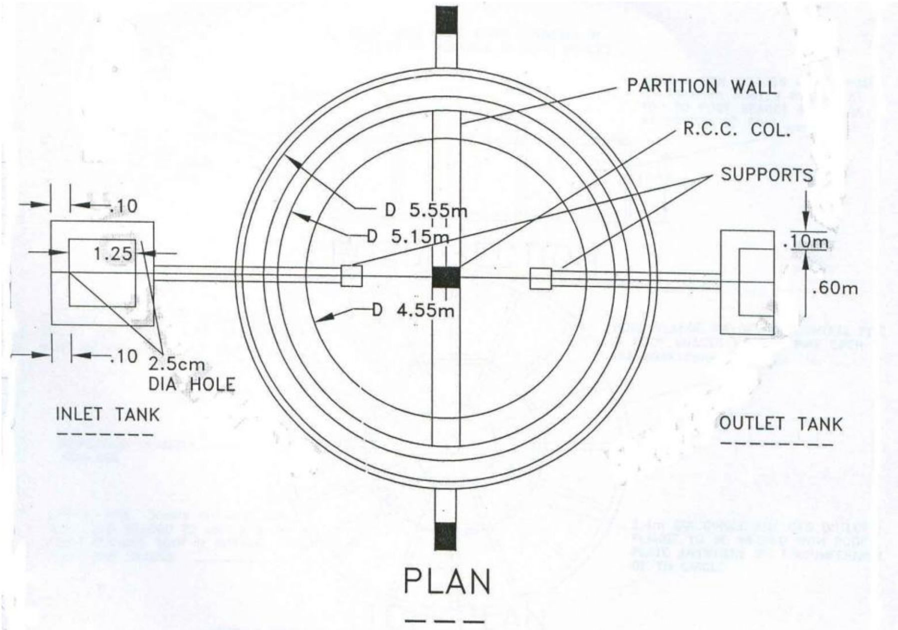

Fig.2 Details of Digester Constructed in R.C.C. Structure