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DESIGN OF ANAEROBIC DIGESTION TANK: A SUSTAINABLE APPROACH TO SOLID WASTE MANAGEMENT

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ABSTRACT

This study is mainly started with the object to provide sustainable solid waste management to Maddipadu, a town in Prakasam district of Indian state of Andhra Pradesh. Anaerobic digester or anaerobic digestion tank is used to produce bio gas from anaerobic digestion of organic wastes. This technique advantageous in two ways: one is biogas can be used as alternate to fossil fuels and another one is it will be strategy of municipal solid waste management. However, anaerobic digestion is the best practice among available waste-to-energy technologies. This paper mainly decided to design an anaerobic digester for Maddipadu, as a practice of solid waste management. Maddipadu is growing locality in recent years, and it does not contain proper waste management system of municipal solid waste for safe disposal .After conducting a case study on present solid waste management scenario, we found the need of establishment of recycling of solid waste here. But, therefore, we decided to recover energy from the waste, which would be best practice of MSWM.

KEYWORDS: Anaerobic digestion, Bio gas, Maddipadu, Organic waste, sustainable solid waste management, waste to energy technology.

I. INTRODUCTION

Introduction The need to develop and improve sustainable energy resources is eminent due to the finite nature of our fossil fuels. The use of fossil fuels as the main source of energy has caused several economic and environmental challenges. Many of the rural communities in developing countries are forced to rely on the traditional energy sources such as firewood, crop residues and paraffin. These traditional methods are often expensive, not eco-friendly and time consuming. Cooking accounts for 90% of energy consumption in the household of developing countries .further more access to electricity in rural areas is relatively scarce. Biogas is a substitute for firewood and cattle dung that can meet the energy needs of the rural population. Biogas is a combustible gas consisting mainly of methane, carbon dioxide and small amount of other gases and trace elements. It is an environment friendly, economic and alternate means to fossils such as firewood and coal. In many countries biogas is used nowadays for combined heat and power generation (CHP) or it is upgraded and fed into natural gas grids, used as vehicle fuel or in fuel cells. The ultimate methane yield is affected by several factors, such as the feed, species, breed and growth stage of the animals as well as the amount and type of the bedding materials together with the pre storage conditions prior to biogas production . The composition, i.e., the protein, fat, fiber, cellulose, hemicelluloses, starch and sugar content, are also important factors that influence the methane yield. Anaerobic digestion is a suitable technology to treat solid waste and waste water and it has been considered as a waste to energy technology.

Major progress was made in all areas of waste management but the introduction of anaerobic digestion into the treatment of municipal solid waste is one of the most successful and innovative technology developments observed during the last two decades in the waste management field . Anaerobic digestion has become fully accepted as a proven and an even preferred method for the intensive biodegradation phase of organic fractions derived from municipal solid waste. The production of biogas through anaerobic digestion offers significant advantages over other forms of bioenergy production. Limitation of carbon dioxide and other emission through emission regulations, carbon taxes and subsides on biomass energy is making anaerobic digestion a more

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attractive and competitive technology for waste management. There is an abundant availability of cellulose based waste, which could be appropriate for biogas production e.g. lignocellulose and waste textiles. These materials are carbohydrate rich and could be used as a substrate for biogas production. However, the recalcitrance nature of these substrates makes them very difficult to digest, as their structure opposes microbial hydrolysis in biogas production. Today, the application of lignocellulose materials in biogas production is limited and for waste textiles, it is nonexistent. Production of biogas from AD requires work power for production, collection and transport of AD feedstock, manufacture of technical equipment, construction, operation and maintenance of biogas plants. This means that the development of a national biogas sector contributes to the establishment of new enterprises, some with significant economic potential, increases the income in rural areas and creates new jobs. 2. Anaerobic Digestion Anaerobic digestion is gaining more attention nowadays, both as a solution to environmental concerns and also as an energy resource for today's energy-demanding life style. With a total of 244 plants and a capacity of almost 8 million ton of organics treatment capacity, anaerobic digestion is already taking care of about 25% of the biological treatment in Europe. In anaerobic digestion, organic materials are degraded by bacteria, in the absence of oxygen, converting it into a methane and carbon dioxide mixture. The digestate or slurry from the digester is rich in ammonium and other nutrients used as an organic fertilizer. Microorganism from two biological kingdoms, the bacteria and the archaea carry out this process in strict anaerobic conditions. Anaerobic digestion of organic waste is of increasing interest as it offers an opportunity to deal with some of the problems regarding the reduction of the amount of organic waste, while diminishing environmental impact and facilitating a sustainable development of the energy supply. Even though continued progress has been made with other alternative treatment technologies (gasification, pyrolysis, plasma, biological drying, etc.), these technologies have by far not seen the same widespread implementation that anaerobic digestion has been able to achieve. In Europe alone, 244 installations dealing with the organic fraction of municipal solid waste as a significant portion of the feedstock have been constructed or are permitted and contracted to be constructed]. There are many cases of anaerobic digestion systems applied in the agricultural sector at animal feeding operations and diaries to alleviate some of the impacts of manure and for energy production.
The most prominent method to determine the preposition of food waste is to carry out house hold composition analysis. There is no international standard method yet established for household waste composition analysis. Currently, food waste either goes to animal farms as feedstock or to land filling in most cities. Serious health threat associated with food waste as animal food stock has attracted great public attention. Food waste landfills have created serious environmental problems. Anaerobic digestion is extensively acceptable as an efficient process to treat and utilize food waste because it has proven to be promising method for waste reduction and energy recycling.

II. STUDY AREA

Maddipadu is a growing town, in Prakasam district of Andhra Pradesh state. The annual growing of population due to rapid industrialization, leads to increase in solid waste and waste water. It is situated 14km away from district headquarter Ongole. Maddipadu is the sub-district headquarters of Maddipadu village. The total geographical area of village is 1193 hectares. Ongole is nearest town to Maddipadu which is approximately 14km away. Maddipadu belongs to Andhra region. It is located 17 KM towards North from District headquarters Ongole.

Because of the improper management with solid waste at aMaddipadu and by considering the energy demand of Maddipadu, we selected Maddipadu as our study area. However, this study provide a sustainable solid waste management approach to Maddipadu.

III. SURVEY AND COLLECTION OF REQUIRED DATA

This research work started as case study on status of solid waste management practices at Maddipadu and to recommend sustainable solid waste management approaches. The survey for required data for entire research work achieved with the following steps:

1. By interviewing the local people, residents, offices and some important public and private

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organizations. With this we collected the data that, solid waste management is not perfect yet and not able to attend half of the waste even.

2. The challenges to present solid waste management practices are:
    - Segregated solid waste is dumped at aside its recycling is not possible. However, rag-pickers are usually sorted out and took and sell recyclable materials like plastics, glass, etc.
    - Somewhere open dumping is done on low lying area causes violating the practices of sanitary land filling. Open dumping is prone to flooding and major source of surface water contamination.
    - Recycling industries have to be established

3. Finally decided to propose a method of waste to energy technology, as to meet the energy demand of Maddipadu, with this sustainable solid waste management will be achieved.

IV. DESIGN OF ANAEROBIC DIGESTION TANK

1. Waste Generation per Day

S. No	Description	Data
1	Per capita solid waste generation	0.3 kg per capita per day
2	Base year population	5,503
3	Total waste generation	1800kgper day
4	Considering the fraction of bio-degradable Waste excepted (for composting)	810kg per day

2. Quantity of Influent

Total Organic Waste per day = 810 kg

For proper digestion, required amount of water = 20% of total organic waste

= 0.2*810

=162 kg

Therefore,

Total quantity of waste to be treated = 810+162 = 972 = take as 1000 kg

3. Dimension of Anaerobic Digester

Volume of Anaerobic Digester $V = V_1+V_2+V_3$

Volume of Anaerobic Digester $V = V_{col}+V_{gst}+V_d+V_{sl}$

Volume of Anaerobic Digester $V = (V_{gst}+V_d)/0.8$

4. Determination of $V_{gst}+V_d$

Vgst+Vd = Total volume of Influent per day * HRT

= 1000 kg per day * 40 days

= 40,000 kg

= 40 m^3

5. Total Volume and Diameter of Digester

Volume of Digester V = 40/0.8

= 50 m^3

Diameter of Digester $D = 1.3078*V^{1/3}$

D = 4.81 m

6. Components of Anaerobic Digester

$V_{col}= 0.05*V = 2.5m^3$

$V_{gst} = 0.5*(V-V_{col})*K = 0.5*(50-2.5)*0.4 = 9.5\ m^3$

$V_d= 40-9.5 = 30.5\ m^3$

$V_{sl} = 0.15*V = 7.5\ m^3$

Total volume of Anaerobic Digester V = 2.5+9.5+30.5+7.5

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= 50 m3, Hence O.K.

7. Cross-section of Anaerobic Digester

D= 4.81 m

$V_1 = 0.0827*D^3 = 9.2032\ m^3$

$V_2 = 0.05011*D^3 = 5.5764\ m^3$

$V_3 = 0.3142*D^3 = 34.965\ m^3$

$R_1=0.725*D = 3.487m$

$R_2=1.0625*D = 5.110m$

$R_3= D/2 = 2.405m$

$H_1= D/5 = 0.962m$

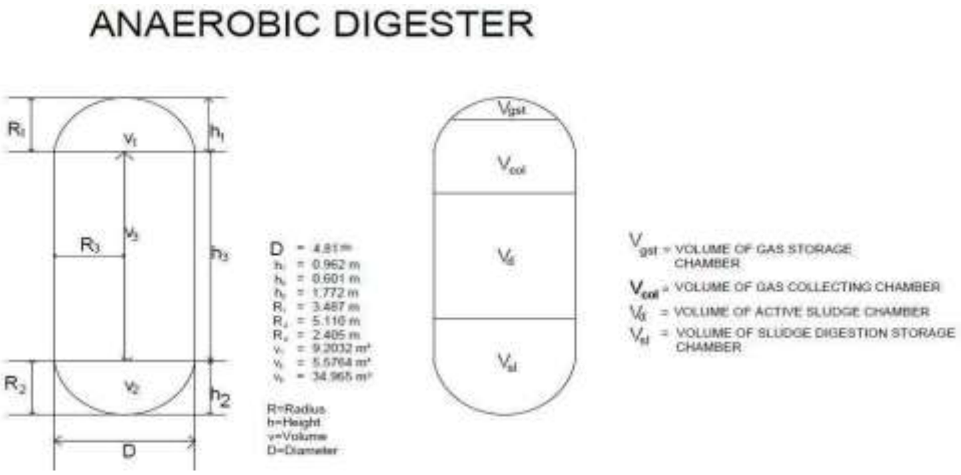
$H_2= D/8 = 0.601m$

$H_3= (4/3.41)(V_3/D^2) = 1.772\ m$

Total Volume of Anaerobic Digester = $V_1+V_2+V_3$ = 9.2032+5.5764+34.965 = 49.7446m^3, Hence O.K.

The details of the anaerobic digester were presented in the figure.1

Figure-1
Details of Designed anaerobic digester



V. CONCLUSION

Anaerobic decomposition of waste is also known as biomethanation process. It is one of the important of sustainable techniques for treatment of bio degradable part of solid waste in subtropical climates in this process stabilization occurs and bio gases liberated by the conversion of organic matter which in turn can be used as energy. Such system will divert 93.5% of solid waste from land filling and it will also decrease disease, improve the quality of life of people in MADDIPADU, avoid environmental pollution. This project will solve the energy demand at Maddipadu.

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