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Basic Requirements of Anaerobic Digestion- A Review

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ABSTRACT

The reduction of CO2 emissions, large demand of fossil fuels and environmental issues are the reasons for studies to develop new technologies to obtain energy from biomass. More attention is being directed toward biological production of biogas using Anaerobic Digestion Processes. Biogas generating technology is a favourable dual purpose technology at present. Biogas typically refers to an odourless gas produced by Anaerobic Digestion (AD) of biomass using microorganisms. It has an approximate composition of 50-70% Methane (a combustible gas), 30-50% Carbon dioxide and other trace gases. Among other applications, the gas can be used for heating, cooking and electricity generation. Biogas production from anaerobic digestion is a promising technology for sustainable energy development.

Keywords: Biomass, Anaerobic Digestion, Sustainable

I. INTRODUCTION

With rapid urbanization, the quantities of municipal solid waste, an important by-product of an urban lifestyle, is increasing at a rate faster than urbanization itself [1]. The proper management strategy is necessary to avoid the pollution caused by the Municipal Waste (MW). MSW contains compostable organic matter (fruit and vegetable peels, food waste), recyclables (paper, plastic, glass, metals, etc.), toxic substances (paints, pesticides, used batteries, medicines), and soiled waste (blood stained cotton, sanitary napkins, disposable syringes). Solid Waste Management (SWM) is an organized process of storage, collection, transportation, processing and disposal of solid refuse residuals in an engineered sanitary landfill. It is an integrated process comprising

Several collection methods, varied transportation equipments, storage, recovery mechanisms for recyclable material, reduction of waste volume and quantity by methods such as composting, waste-to-power and disposal in a designated engineered sanitary. The frequently used procedure to control the MW pollution is recycling and converting the MW to organic amendments. Biogas can be used in place of fossil fuel derived energy and it is clean and renewable [2]. Global warming is the main problem of our country caused by emission of CO2 due to combustion of fossil fuel. Different biomass are used for anaerobic digestion that includes; waste water, sewage sludge, food waste, fruits and vegetables waste, municipal solid waste, etc. Biogas production has multiple benefits like energy production, waste minimization, land filling reduction, reduction of pollution levels, bio-fertilizer from digestate, pure chemicals, and creation of green jobs. Anaerobic digestion (AD) is the most common method for sludge stabilization. Moreover, this digestion process using various anaerobic bacteria produces biogas including methane that can be an alternative source of energy. AD has been successfully used for sludge treatments of various kinds for example sewage sludge [3]. Waste activated sludge [4] and cow manure [5]. However, very few studies have applied AD for paper sludge (PS treatment) [6]. However, very few studies have applied AD for PS treatment. Lin et al [7].

Rapid growth of population and uncontrolled and unmonitored urbanization has created serious problems of energy requirement and solid waste disposal. Vegetable market wastes contribute to a great amount of pollution; hence, there has been a strong need for appropriate vegetable waste management systems [7]. Vegetable wastes that comprise of high fraction of putrescibles organic matter cause serious environmental and health risks. It is known that organic waste materials such as vegetables contain adequate quantity of nutrients essential for the growth and metabolism of anaerobic bacteria in biogas production [8]. India produces 150 million tonnes of fruits and vegetables and generates 50 million tonnes of wastes per annum, Therefore it become necessary to develop appropriate waste treatment technology for vegetable wastes to minimize green house gas emission [9] .The process of digestion and production of biogas depends on the composition of feedstock and the fermentation products of the vegetable wastes. The main objective of this study is to employ anaerobic digestion process as a sustainable technology for digesting the vegetable wastes, produced in large amounts during harvesting, handling, transportation, storage, marketing and processing, and to provide the renewable source of energy as well as to reduce the potential green house gas emission [10]. The specific objectives are (i) to optimize the methane gas evolution from the vegetable waste. (ii) To get an understanding of the anaerobic digestion of the vegetable wastes under ambient temperature conditions by conducting a lab scale study and hence to investigate the biogas yield and the kinetics of anaerobic digestion of vegetable waste fed.

The techniques used for the conversion of organic materials to biogas have been in existence for many years. Methane generation has been applied to meeting the energy needs in rural areas. In England, India, Taiwan, for example, methane generating units as well as plants using cow manure and municipal waste have been in operation for years. In United States there has been considerable interest in the process of anaerobic digestion as an approach to generating a safe clear fuel as well as source of fertilizer [5,6].

II. ANAEROBIC DIGESTION

Anaerobic digestion (AD) is a process in which microorganisms break down biodegradable material in the absence of oxygen. Anaerobic digestion can be used to treat various organic wastes and recover bio-energy in the form of biogas, which contains mainly CH_4 and CO_2. Methane could be a source of renewable energy producing electricity in combined heat and power plants.

III. PHASES OF ANAEROBIC DIGESTION

1) Hydrolysis: Hydrolysis is a reaction with water. Acid and base can be used to accelerate the reaction. It is a process where complex organic molecules (cellulose, proteins and fats) are broken down into simple sugars, amino acids and fatty acids by an enzyme called hydrolase.

2) Acidogenesis: The monomers formed in the hydrolytic phase are taken up by acidogenic bacteria to be further degraded into short chain organic acids, alcohols, hydrogen and CO_2.

3) Acetogenesis: In the stage acitogenic micro-organism further break down the hydrogen and CO_2 gas to produce mainly acetic acid and organic acid and alcohols which are subsequently converted into acetate. The acetate serves as a substrate for methane-forming bacteria, which grows in a synergetic relationship with methane forming bacteria.

4) Methanogenesis: In the final stage, bacteria known as methanogen, convert the acetic acid into methane, CO2 and water under strict anaerobic conditions. A nutrient rich by-product, known as the digestate, is formed during this process. As explained, in the fourth and final stage of the anaerobic digestion, methane is formed by methanogenic bacteria, either by breaking down the acids to methane and CO2 or by reducing CO2 with hydrogen.

IV. FACTORS AFFECTING YIELD AND PRODUCTION OF BIO-GAS

1) Temperature: Temperature is one of the critical parameters in biogas production. Failure to properly control the reaction temperature may lead to decrease in process efficiency and indirectly affect the rate of reaction, the solubility of heavy metals and carbon dioxide as well as buffering. There are three temperature ranges in the anaerobic digestion which are: 1) Psychrophilic : 0-15˚C ,2) Mesophilic 15-45 ˚C, 3) Thermophilic : 45-65 ˚C .The operation in the mesophilic range is more stable and requires a smaller energy expense. The temperature between 350C to 37o C is considered suitable for the production of methane.

2) PH (Acidity or alkanity): Biogas production is greatly influenced by pH of digester contents. It is essentially a measure of acidity and alkalinity of a solution. A pH value of 7 is regarded as neutral, less than 7 as acidic and greater than 7 as alkaline. A too acidic or too alkaline environ¬ment is viewed as detrimental for bacterial activity. A pH between 7 and 8.5 is optimum range for increased gas yield. Sometimes, it becomes necessary to bring the pH value to a desired range which can be done by introducing additives.

3) Loading rate: Loading rate normally expressed as amount of waste materials fed per unit volume of digester capacity is an important parameter that affects gas yield. Pretreatment of feed was identified as one of the contributing factor for increasing the biogas yield. If the loading rate is too high, pH of the digester content tends to fall due to its becoming acidic, results in inability of micro-organisms to biodegrade all feed materials.

4) Salinity: The effect of salinity on biogas yield have negative impact on gas output. The final biogas generation might be strongly inhibited, rather than hydrolysis, VFA formation and acetate production, due to salinity.

5) Carbon nitrogen ratio: For the efficient gas generation it is necessary to maintain C/N ratio within desired range. Organic solid wastes mostly comprised of protein, starch and fat. In anaerobic conditions, nitrogen is an essential nutrient for microorganisms to grow and multiply in number. It is very important to maintain nitrogen concentration throughout the process so that it will not cause disturbance to the process the microorganism consumed. The most optimal C/N ratios in a methane generation process were in the range of 20 - 30. It also has been stated that carbon is about 25 to 30 times faster than nitrogen because they uses carbon as the source of energy while Nitrogen used for building cell structure. For the improvement of C/N ratio, Co-digestion of mixtures is employed.

6) Hydraulic Retention Time (HRT): HRT is defined as the average time spent by the input slurry inside the digester before it comes out. HRT is chosen so as to achieve at least 70-80 per cent digestion. HRT varies between 20 to 120 days depending upon the design and operating temperature of the digester. HRT for digesters operating in countries of tropical region like India is usually taken as 40-50 days. In countries of colder climates like China, digesters are designed for HRT of about 100 days.

7) Moisture content: This should be about 90% of the weight of the total contents. With too much water the rate of production per unit volume in the pit will fall, preventing optimum use of the digester. If the water content is too low, acetic acid will accumulate, inhibiting the fermentation process and hence production and also thick scum will be formed on the surface. The water content differs according to the raw material used for fermentation. Nature of organic materials, materials rich in cellulose and semi-cellulose with sufficient protenaceous substance produce more gas.

8) Agitation (Stirring): the purpose of mixing and stirring inside the digester is to blend the fresh material with the dig estate and thus inoculate the fresh material with microbes. Such mixing avoids temperature gradients within the digester and also prevents scum formation. Scum can result in blockage of the gas pipe or potentially lead to a foaming over the digester. Mixing greatly helps to ensure intimate contact between micro-organisms which leads to improved fermentation efficiency and biogas yield.

9) Microbial Activity: There are several factors and class of materials which act as inhibitor to bacterial activity during anaerobic fermentation. When these chemicals and factors reach certain level, bacterial activity almost stops thereby severely affecting gas yield. For example, when volatile acid concentration reaches a value of 200 ppm, or ammoniacal nitrogen concentration exceeds a value of 1500 ppm, microbial activity is greatly retarded. A retarded microbial activity ultimately results in low quality gas with low methane content in relation to other constituents.

10) Inoculum: Cow dung slurry was used as a source of inoculum since rumen of cow contains anaerobic microbial population. The cow dung slurry was prepared by mixing water in 1:5 proportions and sieved to remove coarse particles. The cow dung slurry and the FW slurry were mixed in 1:1 proportion and the mix was poured in the reactor. The nitrogen gas was sparged through the reactor to remove the oxygen toxicity to anaerobes. The total solids (TS) concentration of the mix was 9000ml/L with volatile fraction of 86%. The reactor content was mixed thoroughly by 100% recirculation from the outlet (top) to the inlet (bottom) of the reactor with the help of the slurry pump.

V. APPLICATIONS AND SCOPE OF BIOGAS:

Biogas can be used as a replacement for natural gas in vehicle fuel. If compressed it can replace natural gas for use in vehicles. Biogas can be used for electricity production. Residues left from biogas are a valuable fertilizer especially at the place where soil quality has become degraded through over-intensive farming.

VI. CONCLUSION AND DISCUSSIONS

It is recognised that biodegradable waste can be feedstock to produce useful energy, leading to waste minimisation at the same time. Among various treatment methods, anaerobic digestion to produce biogas from organic waste is a proven environment friendly route for waste treatment and energy recovery .It can drastically reduce the depletion of natural resources. Physical and chemical characteristics of the organic wastes are important for designing and operating digesters as they affect the biogas production and process stability during anaerobic digestion. The design and performance of anaerobic digestion processes are affected by many factors. Some of them are related to feedstock characteristics, reactor design and operation conditions hence with better equipment, adjustment of conditions and if the feedstock is digested properly, more reasonable results can be obtained. Insulation of the digester gives good biogas yield as compared to non-insulated one. According to studies, Continuous fed digesters results in good quality of methane. Hence biogas production by means of anaerobic digestion has become an established and proven technology for management of waste.

VII. REFERENCES

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