A Review on Biogas Production from Municipal Waste using Anaerobic Co-Digestion Technique

Manpreet Singh[1] Muneesh Kashyap[2] Pardeep Singh[3] Gautam Kochher[4]
[1,3,4]Department of Mechanical Engineering [2]Department of Chemistry
[1,3,4]Ramgariha Institute of Engineering and Technology, Phagwara, Punjab, India [2]MRPD Govt. Arts and Science College, Talwara, Punjab, India

Abstract— As the energy of the universe is conserved and it alters from one form to another, a complete and efficient utilization of such energy becomes equally important without affecting the climate properties. The reason behind this reduction is to limit the use of fossil fuels which further leads to a clean and green environment. Indian Government has take initiative in order to make the country clean and through this programme the only attention is paid on how the Municipal Waste gets minimized. Therefore, various strategies have been proposed in order to make pollution free environment. Thus, energy communities have found one solution from many of those and well known as Biogas utilization which is a byproduct of biomass. As municipal solid-waste (MSW) or sewage water (SW) has a high potential to generate biogas (chemical energy) while subjected to microbiological anaerobic digestion process thus it is being widely employed in generating electrical energy in European Continent. The sewage water has potential to generate biogas in combination with the animal manure like Pig, Donkey, Cow etc. Thus in this present work review of literature has been done on the various strategies those are being utilized in order to diminish municipal sewage waste.

Key words: Anaerobic Co-Digestion, Biogas, Cow Dung and Sewage Water

I. INTRODUCTION

As the energy of the universe is conserved and it alters from one form to another, a complete and efficient utilization of such energy becomes equally important without affecting the climate properties. The challenges associated with the conversion of energy (heat i.e low grade energy) to work (high grade energy) are enormous due to individual process irreversibility which leads to decrease in available energy overall. Recently in 2014, International Energy Agency (IEA) published Key World Energy Statistics which includes information on the worldwide energy generation, supply and consumption statistics [1] and which shows total Primary Energy Supply (TPES) has been increased by twice from 1971 to 2012 which is a consequence of population explosion and augmentation in the people's living standards. Due to consequence of this, universal challenges like global warming, acid rain etc. have come into picture which limits the usage of fossil fuels in futuristic energy systems. From the energy statistics, it has been noticed that the percentage natural gas and coal production found to decrease significantly from year 1971 to 2013 for the OECD's [1]. The reason behind this reduction is to limit the use of fossil fuels which further leads to a clean and green environment. The limits on emissions of green house gases are define by various International Treaty such as Kyoto Protocol (United Nations Framework Convention on Climate Change, UNFCCC) and Montreal Protocol. Whereas for Asia (excluding China).

Above discussed energy generation methods are non-renewable in nature but due to some issues related with climate change create a contradictory state which leads to only one solution known to be the "Sustainable Renewable Energy Generation and Utilization". Thus, energy communities have found one solution from many of those and well known as Biogas utilization which is a byproduct of biomass. Thus Biogas consists of renewable energy resources which have very less greenhouse potential that makes it very much viable. A significant increase in the installation of Biogas Plants has been seen from past some decades in Europe region [2]. From the report [2], it is clear that Biogas production is the current area of research and is a futuristic sustainable renewable energy resource that will going to overcome a large part of electrical energy demand. Also, this concept would manage to justify with the waste management strategies which further leads to give benefit in the welfare of civilization.

II. LITERATURE REVIEW

Biogas can be produced through anaerobic digestion (AD), which is a biological decomposition process, of animal manure and slurries in addition to ample range of digestible macrobiotic wastes. The AD process renovates these substrates into renewable energy and recommends natural compost for agriculture. AD is a microbiological process of disintegration of organic stuff, in the deficiency of oxygen. Biogas is a combustible gas consisting of methane, carbon dioxide and small quantities of other gases. Digestate is the decayed substrate which found to be prosperous in macro- and micro-nutrients and thus appropriate to be used as plant compost. The direct benefits of using biogas are: improvement in global warming and reduction in greenhouse gas emissions, waste diminution, flexible and conclusive use of biogas (combined heat and power generation, CHP). European countries are facing massive troubles related with overproduction of macrobiotic wastes from industry, households and agriculture [3].

AD is a microbiological progression of disintegration of natural matter in deficiency of O_2. The chief goods of this practice are biogas and digestate. Biogas is generally found to be a flammable gas, having mostly of CH_4 and CO_2. Digestate is the decayed substrate that is the residual which left after the AD process. Throughout AD process, very modest heat is liberated in distinction to aerobic disintegration which is usually done in presence of oxygen. The compound energy which is generally chemically enclosed within the substrate leftovers chiefly in the formed biogas, in type of CH_4. The procedure of biogas development is a consequence of associated course steps, in

which the preliminary object is constantly wrecked down into minor units. Explicit clusters of micro-organisms are concerned in every entity stride. These organisms consecutively decay the products of the earlier steps. The easy illustration of the AD process is shown in **Error! Reference source not found.**, highlighted the four foremost practice steps: hydrolysis, acidogenesis, acetogenesis, and methanogenesis.

A. Hydrolysis

Hydrolysis is tentatively the initial stage of AD, throughout which the intricate natural substance (like polymers) is decayed into smaller entities. Throughout in the hydrolysis process, polymers like lipids, nucleic acids, carbohydrates, and proteins get transformed into purines, glucose, glycerol and pyridines.

A diversity of microorganisms is concerned in hydrolysis, which is usually conceded out by exoenzymes, formed by individual microorganisms which crumble the un-dissolved PM. The goods coming out from hydrolysis process are found to be get decomposed further by the microorganisms involved and thus employed for their own metabolic processes.

B. Acidogenesis

Throughout acidogenesis, the products of the microbiological reactions of hydrolysis are transformed by acidogenic or fermentative bacteria into methanogenic substrates. It is generally found that the chemical classes like plain sugars, fatty acids and amino acids are transformed into acetate, CO_2 and H_2 (70%). The classes also get converted into volatile fatty acids and alcohols (30%).

C. Acetogenesis

Products obtained from the 2nd stage i.e. acidogenesis that cannot be directly transformed into CH_4 by methanogenic bacteria, are rehabilitated into methanogenic substrates during acetogenesis process. Volatile fatty acids (VFA) and alcohols are oxidized into methanogenic substrates which are acetate, H_2 and CO_2. VFA has long carbon chains (more than 2 carbon) and alcohols having long carbon chains (more than one unit) are usually oxidized into acetate and H_2. The creation of H_2 amplifies the partial pressure of H_2. This is generally taken as a waste product of 3rd stage process and slows down the metabolism of the acetogenic bacteria.

D. Methanogenesis

The fabrication of CH_4 and CO_2 from intermediary products is usually conceded out by methanogenic bacteria. It has been noticed from the various studies that nearly 70% of the produced CH_4 originates from acetate whereas the residual 30% is formed from alteration of H_2 and CO_2, according to the following equations:

Methanogenesis is a significant step in the whole AD process as it is the slowest biochemical reaction. Methanogenesis is rigorously subjective by operation conditions. Composition of feedstock, feeding rate, temperature, and pH are illustrations of features manipulating the methanogenesis process. Methane production can be terminated if either of the following is present there: digester overloading, temperature changes or large entry of oxygen.

A great amount of diverse AD-technologies and AD plants are established today all over the globe. The chief figure of AD plants in the contemporary civilization delights principal and secondary sludge (bio-solid) in civic wastewater treatment plants. These plants essentially alleviate the dissipate stuff and the biogas formed is frequently of slight significance. For several of the great wastewater plants, the biogas created is employed for electricity fabrication and the scheme of civilizing the biogas relents is drawing more consideration. A huge amount of solitary domestic biogas units have supplementary be accomplished in developing countries. These units will frequently tender gas for cooking and elucidation in the domestic life. An additional chief application for AD is the industrialized waste water which can be obtainable from, predominantly, food processing productions where wastewater is seriously contaminated throughout merely degradable macrobiotic carbon. Anaerobic action is essentially a way to diminish BOD whereas the nutrients such as N_2 and phosphorous are left undamaged. A superior mode to execute anaerobic treatment of community sewage water would be to recuperate the whole nutrients and intense metals from the wastewater following the anaerobic treatment using film technology. In this manner, the remuneration of anaerobic process respecting space speed, small slush construction and charge can be completely oppressed and the expensive nutrients can be reprocessed.

$$Acetic\ Acid \xrightarrow{methanogenic\ bacteria} methane + carbon\ dioxide$$

$$Hydrogen + Carbon\ Dioxide \xrightarrow{methanogenic\ bacteria} methane + water$$

A comprehensive biogas competence for indulgence manure from numerous farms in amalgamation with supplementary organic wastes for instance food dissipates and source-sorted domestic dissipates – the so-called co- digestion – was initiated in Denmark at the end of the 1980s. Accumulation of even minute amounts of crude industrial dissipates increases the gas production appreciably. Particularly oily or fatty dissipates contain much elevated gas potential than manure and a lot privileged concentration of organic matter (contain superior dry matter content) but the problem associated with this is the ravages which is found to be rich in carbohydrates and proteins will recover the gas acquiesce per division of reactor capacity. It has been found from the studies that absorption of sewage slush or manure yields about 1 to 2 cubic meter biogas per cubic meter reactor capacity per day as the reactors will generate among 4 to 10 cubic meter biogas per cubic meter reactor capacity through addition of ca. 20 % oily ravage.

Bio-energy research has received incredible interest all around the globe owing to abrupt scramble in gasoline prices and ecological disquiets. At the contemporary electricity generating competence and other existing energy resources, an enormous breach exists among the demand and supply (above 15%) and the conservative energy possessions of the nation are insufficient. Agricultural crop deposits fabrication in India is concerning 550 Mt/year and is expected to augment in the upcoming decades. Bulk of the harvest residues are also processed in unprofitable manner or get smashed in isolation. Distant from the yield deposits, additional bio-waste for instance creature excreta afforest

wastes and agro-industrial dissipates are in addition accessible in profusion and be able to cooperate a key character in complementing the energy possessions of the nation. Waste mass resources comprise a variety of natural and derivative materials, for instance timbered and herbaceous genus, bagasse, farming dissipates, devastate from paper, MSW, industrialized waste, food dispensation dissipates, residual oil, uncooked oil, marine plant life and algae, etc., which might be potentially employed for creation of constructive fuels and chemicals. The typical bulk of bio energy is formed as of timber and timber wastes (64%), pursued by community solid waste (24%), farming waste (5%) and landfill gases (5%) [4]. There is no dispute on the concern that renewable energy is the merely sustainable energy in nature. Bio compost energy in scrupulous is solitary of the purest or cleanest forms of energy provided by nature. Furthermore, they are extremely advantageous from the perspective of ecological contamination control and a benefit for carbon recognition.

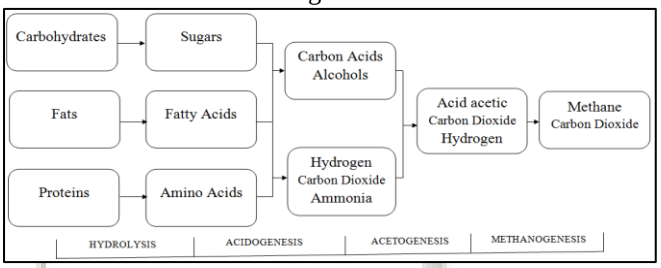

Fig. 1: The main process steps of AD [3]

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Abubakar et al. (2012) [12] studied the anaerobic digestion of cow dung for biogas production and they explained that there is a great deal of environmental pressure in many parts of the world to ascertain how livestock waste can best be handled. Livestock manure, like cow dung in the absence of appropriate disposal methods can cause adverse environmental and health problems such as: pathogen contamination, odour, air borne ammonia, green house gases, etc [13]. Anaerobic digestion has been considered as waste-to-energy technology, and is widely used in the treatment of different organic wastes, for example: organic fraction of municipal solid waste, sewage sludge, food waste, animal manure, etc [13].

III. Conclusions

From the study it has been concluded that as animal manure has adverse effects on the environment after the digestion process so it may beneficial when sewage water has been added to it. This will result in diminishing the municipal waste along with benefits related with the peoples' health. Also, this concept would lead to make India as a clean country.

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