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VARIOUS BIOGAS PRODUCTION ENHANCEMENT TECHNIQUES: A REVIEW

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Abstract: This paper focuses on the techniques by which the biogas production can be enhanced. A detailed analysis of the each technique by which the biogas production can be enhanced are discussed in detail. As fossil fuels are being exhausted and ecological anxiety is growing, non-conventional energy is attaining importance in engineering sector. Biomass which is one of the renewable energy alternative, is secondary form of solar energy. Anaerobic digestion of biomass spawns biogas. Biogas comprises of methane (40–70%) which can be improved to natural gas class. The improved biogas can be inserted into a natural gas grid or can be utilized as a transportation fuel.
Keywords: Biogas, Biomass, Anaerobic digestion, Mesophilic, Thermophilic

I. INTRODUCTION

Energy is an indispensable contribution for societal growth, human well-being, economic progress and enlightening the value of life. All sectors – commerce, agronomy and transportation needs involvements of energy. Consequently, demand of energy has been progressively escalating in the country. This mounting consumption of energy gave rise to increased dependency on fossil fuels. Amplified use of fossil fuels leads to ecological problems both nearby and worldwide. It is well-known fact that the world's key energy assets will be exhausted within following few years. The world is inevitably faced with catastrophes of fossil fuel scarcity and ecological degradation as a result of urbanization, increase in population and industrialization. Exhaustion of fossil fuels can have an adverse effect on the local atmosphere. So, replacements, mainly non-conventional energy resources, have been identified to potentially meet the energy requirements, decreasing the dependency on fossil fuels and to improve the ecological sustainability. Renewable energy sources are wind biomass, tidal, solar, and geothermal [2]. India targets to add closely 16GW of non- conventional energy resources and the contribution of bio power has improved from 7.84% to 8.91% from 2015 to 2016. In India, whole installed capacity of biomass power is 8,701MW at present. A target of 10000MW by the year 2022 is set as a part of its renewable energy mission. Waste to power contribution is 138MW. Compared to other forms of non-conventional energy sources biogas can be stored and transported. The energy can also be converted into other forms such as solid, liquid or gaseous fuel. Anaerobic digestion process of organic waste spawns biogas. The production of biogas can be enhanced by varying the operational parameters, recycling of slurry, agitation, pretreatment and use of additives. This paper presents the various biogas production enhancement techniques.

II. BIOGAS

A. Waste to energy

Biogas is a non-conventional energy source which is spawned by anaerobic breakdown of decomposable living feedstocks i.e. municipal and industrial wastes, animal and agricultural remains. Biogas comprises of methane (40–70%) which can be improved to natural gas class (75–99% methane content). The improved biogas can be inserted into a natural gas grid or can be utilized as a transportation fuel. Anaerobic digestion of decomposable organic wastes, in addition, to provide energy and manure, offers numerous societal and ecological benefits. Biogas backs in the reduction adverse externalities linked with biological wastes such as groundwater and mud adulteration, emission of local air contaminants like dioxins and furans along with methane, a strong greenhouse gas [3,4]. The practice of clean fuel like biogas for cooking, lighting and electricity generation as an alternative of fossil fuels and unprocessed traditional solid biomass will help in restricting GHG releases as well as interior air pollution [12]. The nitrogen present in the slurry after anaerobic digestion boosts compared to untreated animal manure, thus can be used as bio-fertilizer. Bio-fertilizer use in the agricultural land would partially or fully offset the requirement for chemical fertilizers which have high energy demand for production.

B. Anaerobic Digestion

Anaerobic digestion is a chain of biological procedures during which microorganisms disrupt decomposable material in the nonexistence of oxygen. The method is utilized for industrial or household purposes waste management or to yield fuels. A variety of anaerobic digestion technologies transform livestock droppings several other biological waste yield biogas. The breakdown process initiates with bacteriological hydrolysis of the feedstocks. Unsolvable organic polymers, like carbohydrates, are digested to soluble byproducts that become accessible for other bacteria. Acidogenic bacteria then and there transform the sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids and subsequent organic acids into acetic acid, together with additional ammonia, hydrogen, and carbon dioxide. To conclude, methanogens transform these generated products to methane and carbon dioxide. The segregated digested slurry can be composted, used for dairy bedding, straight away smeared to cropland or transformed into any other products. Nutrients in the liquid slurry are used in agriculture as fertilizer.

III. BIOGAS PRODUCTION ENHANCMENT

TECHNIQUES

Different methods by which biogas production can be enhanced are:

- Variation in operational parameters
- Recycling of slurry and slurry filtrate
- Agitation
- Pretreatment
- Use of additives

A. Variation in operational parameters

By monitoring and adjusting several constraints like pH, temperature, OLR, and agitation, the performance of biogas plant and production of biogas can be boosted. Any significant alteration in these can be uncomplimentary for the production of biogas. So these constraints should be varied within the desired range to operate the plant efficiently. The optimum pH value lies between 6.8 and 7.2[5] and operating the plant in the thermophilic temperature range (45^0C- 65^0C) is healthier than operating the plant in the mesophilic temperature range (15^0C– 45^0C).

B. Recycling of slurry and slurry filtrate

The utilization of digested slurry into the reactor has revealed enhancement in the gas production microscopically, as the microbes sweep away are restored back, thus providing supplementary microbial inhabitants. The utilization of the processed slurry with filtrate has been tried out to preserve water and to increase biogas production. Reutilizing of digested slurry with new dung will help in decreasing the problem of starving biogas plants as well as in dealing with low gas production in winter season [6].

C. Agitation

Some technique of stirring inside a digester is not vital but beneficial. The key intentions of agitation are:

- Elimination of the metabolites made by the methanogens
- Mixing of bacterial population and new substrate
- Prevention of scum development and sedimentation
- Prevention of prominent temperature gradients within the digester
- Establishment of a uniform bacterial population density
- Inhibition of the establishment of dead spaces which would reduce the active digester volume.

D. Pretreatment

The key compositional and physical features of lignocellulosic biomass, that shake their degradability, are the grade of cellulose polymerization and its crystallinity, reachable surface area, the existence of lignin and hemicellulose and degree of hemicellulose acetylation. In order to overcome these complications, it is healthier to apply treatment preceding to anaerobic digestion. The aim of any pretreatment method is to disorder the composite structure of lignocellulosic constituents thereby boost the accessibility of substrates to microbes. A pretreatment procedure should attain an enhancement in the digestibility of the treated material, lessen ecological trash and surge over-all biogas generation. Pretreatment methods, subject to their elementary mode of action, can principally be characterized as physical, thermal, chemical and biological, with each group comprising numerous distinct technologies [7].

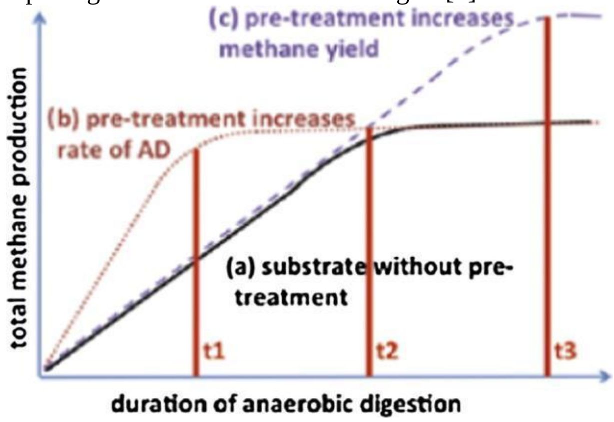

Figure 1 Effect of pre-treatments on rate of anaerobic digestion and increase the methane yield [15]

Physical Pretreatment : Mechanical pretreatments are generally used to improve breakdown of cellular wastes. The rate restraining step of AD is hydrolysis which can be accelerated by pretreatment. Pretreatment will break cell walls of the cells in the feedstocks and thus reducde the time from days to minutes.

Thermal Pretreatment : Thermal pretreatment will expose substarte to excessive temperatures so as to stimulate chemical reactions and solubilise largeer biomolecules. Temperature range of thermal pretreatment range from 1500C to 2220C under 700 – 2300kPa.

Chemical Pretreatment : Addition of acids and bases to AD feedstocks have been heavily inspected through a variety of substrates including sludges, wastewater treatment plant remains, biological waste, plant filtrates and manures [16]. While acid hydrolysis has been investigated using sulphuric and hydrochloric acids, the addition of alkalis is further efficient at improving the AD process [9]. Of the alkaline pre-treatments which have been investigated, sodium hydroxide (NaOH) is the most effective for improving organics hydrolysis and the AD process [8].

4) Biological Pretreatment: Biological pre-treatment comprises means that consume pre-digestion enzymes and bio-surfactants to boost digestion. Pre-digestion includes two-stage digestion – a digestion stage preceding the main digestion process. By exposing the waste to different digestion constraints prior to the main AD process, scientists target to improve the digestibility of waste. Prior to AD, oily wastewater was subject to a 24 h digestion with Bacillus. During this time, exoenzymes were unconfined by the bacteria to slash triglycerides, diglycerides, and LCFA, and raise the concentration of VFA present. This results in better contact between microbes and the VFA substrates, significantly increasing mass transfer of soluble nutrients into the sludge.

E. Use of Additives

Efforts are made to increase gas production by stimulating microbial action by means of diverse biological and chemical additives under different operational circumstances. The suitability of an additive is likely to invincibly depend on the type of substrate.

Biological additives : Biological additives include diverse plants, weeds, crop residues and microbial cultures which are obtainable naturally. Crushed leaves of a certain leguminous plant (like Gulmohar, Leucaena leucocephala, Acacia auriculiformis, Dalbergia sissoo and Eucalyptus tereticonius) are found to stimulate biogas production between 18% and 40%. Rise in biogas production due to certain additives is for the reason that of the adsorption of the substrate on to the additives surface. This leads to high-localized substrate concentration and an additionally suitable environment for the growth of microbes. The additives also help to conserve favorable surroundings for fast gas production in the reactor.

Chemical additives : Numerous inorganic additives that increase gas production can be used. Higher concentration of bacteria could be reserved in the digester by the addition of metal cations as cations increase the concentration of the bacteria. The accumulation of iron salts at various concentrations [$FeSO_4$, $FeCl_2$] have been found to boost gas production rate. Nickel ions (2.5 and 5 ppm) heightened biogas up to 54% due to the activity of Ni-dependent metalloenzymes involved in biogas production. Addition of rock phosphate (RP) evidenced superior to single super phosphate (SSP). Process stability amplified with accumulative levels of silica gel, representing that volatile acid were used up at a faster rate in the existence of an adsorbent. Using Ca and Mg salts as energy supplements, CH_4 production was improved and frothing was avoided[10,11].

IV. CONCLUSION

Biogas is one of the non-conventional energy substitutes. It can replace fossil fuels, thereby decreasing the emission of greenhouse gases and other harmful emissions. Methane formation in anaerobic digestion involves four different steps. The byproduct of anaerobic digestion can be used as fertilizer. There are several factors which affect the production rate of biogas. Numerous enhancement methods are a variation of operation parameters like pH, temperature, agitation, and loading rate, recirculation of slurry, use of additives and pretreatment.

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