Biogas Production from Water Hyacinth in Co-Digestion with Sugarcane Bagasse

Sagar Chavhan[1], Mrs. Pali Sahu[2]

Department of Civil Engineering, V.I.I.T., Pune,sagarchavhan1434@gmail.com
Department of Civil Engineering, V.I.I.T., Pune,pali.sahu@viit.ac.in

Abstract –

Fossil fuels currently provide the bulk of world's primary energy. Since fossil fuels are nonrenewable natural resources and rate of its utilization exceeds the natural rate of production, an end point exists. There is thus a need for the development of new energy sources that will be more economically competitive. Water hyacinth (WH) and Sugarcane Bagasse can be used to generate energy which could save on the fossil fuels conventionally used as source of energy. In this study, the possibility was explored to mix water hyacinth with Sugarcane Bagasse in different combinations for anaerobic co-digestion, so that energy can be generated as biogas. In this work, different proportion (0%, 25%, 50%, 75% and 100%) of sugarcane bagasse and water hyacinth are going to be used for anaerobic digestion. The investigation will help to find the most proper ratio of different co- substrate that provide an optimize biodegradation potential or enhance biogas potential.

***Keywords*: Water hyacinth, Sugarcane Bagasse, Co-digestion, Biogas**

I. Introduction

The world has gone through the wood age, the coal era, and will likely be done with the petroleum and natural age. Yet we still have wood and coal around but they are not economically competitive with oil and natural gas. The same will happen to oil and natural gas eventually when the rate of exploitation exceeds the rate at which it is generated underground. New and more economic sources of energy are constantly being developed and eventually the best will probably take over from the current oil and natural gas era. Biomass has been defined as the natural biological storage of energy and other materials in complex organic substances primarily by gross photosynthesis. Biogas technology amongst other processes (including thermal, pyrolysis, combustion and gasification) has in recent times also been viewed as a very good source of sustainable waste treatment and management, as disposal of wastes has become a major problem especially in the large cities of many developing countries. The effluent of this process is a residue rich in essential inorganic elements needed for healthy plant growth known as bio-fertilizer which when applied to the soil enriches it with no detrimental effects on the environment. Various wastes have been utilized for biogas production and they include animal wastes, industrial wastes, food processing wastes, plant residues. (Fadairo et al., 2014)

Biogas is an ecological fuel that may replace firewood. Water hyacinth's abundant biomass can be used to produce renewable energy locally, simply fermenting it in anaerobic digester. Anaerobic digestion of lignocellulosic substrates is a much more complex process, requiring the syntrophic and cooperative interaction between several types of microorganisms. It is a complex, natural, multi-stage process of degradation of organic compounds through a variety of intermediates into methane and carbon dioxide, by the action of a consortium of microorganisms. (Sugumaran et al., 2014)

II. LiteratureReview

Various studies were carried out by renowned experts from around the state on water hyacinth and sugarcane bagasse for its biogas generation potential. In 2013, Patil J. H. et al., have studied Kinetics of Anaerobic Digestion of Water Hyacinth Using Poultry Litter as Inoculum. In this study, poultry litter was used as inoculum at mesophilic conditions. A series of laboratory experiments using 0.25l bio-digesters were performed in batch operation mode and modified Gompertz equation was fitted. The kinetic parameters, biogas yield potential (*P*), the maximum biogas production rate (Rm) and the duration of lag phase (λ) were estimated in each case. The results show that Poultry Litter Inoculum (PLI) improved biogas yield significantly and increased biogas yield nearly two times when compared to water hyacinth substrate without Poultry LitterInoculum.

Leandro J. et al., (2015) have studied Biogas Production from Sugarcane Waste: Assessment on Kinetic Challenges for Process Designing. In this study, the kinetic challenges for biogas production from different types of sugarcane waste were assessed. Samples of vinasse, filter cake, bagasse, and straw were analyzed in terms of total and volatile solids, chemical oxygen demand, macronutrients, trace elements, and nutritional value. In this study, methane yields varied considerably, mainly due to the different substrate characteristics and sugar and/or ethanol production processes. In conclusion they have conclude that, for the optimization of AD on a large-scale, continuous stirred-tank reactor with long hydraulic retention times (>35 days) should be used for biogas production from bagasse and straw, coupled with pre-treatment process to enhance the degradation of the fibrous carbohydrates. Keerthana T. and Mrs. Krishnaveni A. (2016) have studied Biogas Production from

Sugarcane Bagasse in Co-Digestion with Vegetable Waste. In this work, the experiment was carried out in 250 ml batch digester for 24 days retention period. The co- digestion was carried on mesophilic temperature with cow dung as an inoculum. The different proportion (0%, 25%, 50%, 75% and 100%) of sugarcane bagasse were used in co-digestion with vegetable waste. They have concluded that, the anaerobic co- digestion of sugarcane bagasse waste and vegetable waste appears to be a suitable technology to treat such wastes, obtaining a renewable source of energy from biogas.

Dr. Kurchania A. et al., (2016) have carried out study on Water Hyacinth: An Option for Biogas Production. In this work, a semi- continuous biogas digester having the volume of 200 L was developed with inclusion of agitation system where agitation process is carried out with biogas in a closed loop. The chopped and crushed water hyacinth is fed at 4 per cent total solid content in the daily fed reactor through the inlet and stirring with the recirculation of biogas through pipe is carried out with a foot pump three times a day with 10 minutes duration each time. Hydraulic retention time was 25 days. Biogas production was found to be 20–22 L d-1, i.e., 262.5 L/ kg TS water hyacinth. The results revealed that the project is economically feasible and includes a desirable energy gain.

In 2014, Sridhar M. K. C et al., carried out study of Experiments on Co-Digestion of Cow Dung and Water Hyacinth (EichhorniaCrassipes) for Biogas Yield. The study was carried out to determine the effect of adding cow dung to water hyacinth on the biogas yield. Two drums, 100 litre capacity each were used as digesters in the laboratory experiment. Digester A was loaded with 8kg of water hyacinth and 40kg of water, this gave a ratio of 1:5 and the gas yield was measured daily for 9 weeks. Digester B was loaded with water hyacinth, cow dung and water in the ratio 1:1:10 which gave a ratio of the feedstock to water at 1:5. Results from this study showed that addition of cow dung to water hyacinth increased biogas yield as compared to single substrate feedstock.

III. Materials AndMethods

3.1 WaterHyacinth

Water hyacinth is an aquatic plant which can live and reproduce, floating freely on the surface of fresh waters. Its rate of proliferation under certain circumstances is extremely rapid and it can spread to cause infestations over large areas of water causing practical problems for marine transportation, fishing, and at intakes for hydro power and irrigation schemes. Although water hyacinth is seen in many countries as a weed, it is possible to find useful applications as the plant has a high energy and protein content. Fibre from water hyacinth can be used for a variety of applications and products, including paper, fibre board, yarn and robe, basket work, and as an energy feedstock. (Momoh et al., 2008)

Water hyacinth has attracted the attention of scientists to use it as a potential biomass as it is rich in nitrogen, essential nutrients and has a high content of fermentable matter. Apart from biogas, the sludge from the biogas process contains almost all of the nutrients and can be used as a good fertilizer with no detrimental effects on the environment. (Kurchania et al. 2016). The leaves are 10-20 cm across, and float above the water surface. They have long, spongy and buibous stalks. The feathery, freely hanging roots are purple black. An erect stalk supports a single spike of 8-15 conspicuously attractive flowers, mostly lavender to pink in colour with six petals. (Shahabaldin et al., 2015)

Fig. 1: Water Hyacinth (Dr. Kurchania et al. 2016)

Following are some of the characteristics of water hyacinth which makes it suitable for biogas production: (Vidyasagar et al., 2013)

- IdealAttributes
- Wide availability
- Ease ofcultivation
- Frequent harvest cycles
- No / low competition with foodcrops
- Easy toprocess
- Inexpensive

3.2 SugarcaneBagasse

Sugarcane is a grass that is harvested for its sucrose content. After extraction of sugar from the sugarcane, the plant material that remains is termed as bagasse. Sugarcane bagasse is a fibrous residue produced by extraction of juice and is classified like a waste which is widely throwing out to sugar-refineries about 234 millions of tons per year in world. Sugarcane bagasse is used as fodder, input in paper mill and cement works. In sugar refineries, 60% of that is used for cogeneration but this process raises gas emissions and conflagrations in cause of his flammable nature. Many biological treatments (bioethanol production, composting) have been applied for a renewable management of this waste but biogas technology proves to be one of the most efficient process either in factories (energy) or in agriculture (fertilizers). (William et al.,2016)

Currently, the bagasse production in the India is about 8.6 million tons per year. Bagasse is used as a biofuel and in the manufacture of pulp and building materials. For every 10 tonnes of sugarcane crushed, a sugar factory produces nearly three tonnes of wet bagasse. (Keerthana et al., 2016)

A typical chemical analysis of washed and dried bagasse might show:

- Cellulose 45–55percent
- Hemicellulose 20–25percent
- Lignin 18–24percent
- Ash 1–4percent

Bagasse is often used as a primary fuel source for sugar mills. It produces sufficient heat energy to supply all the needs of a typical sugar mill with energy to spare. The resulting CO_2 emissions are less than the amount of CO_2 that the sugarcane plant absorbed from the atmosphere during its growing phase which makes the process of cogeneration of greenhouse gas neutral. Co- digestion is the simultaneous digestion of more than one type of waste in the same unit. Advantages include better digestibility, enhanced biogas production/methane yield arising from availability of additional nutrients, as well as a more efficient utilization of equipment and cost sharing. Studies have shown that co-digestion of several substrates, for example, banana and plantain peels, spent grains and rice husk, pig waste and cassava peels, sewage and brewery sludge, among many others, have resulted in improved methane yield by as much as 60% compared to that obtained from single substrates. Co-digestion of water hyacinth with sugarcane bagasse can improve the methane production of anaerobic digestion processes. (Eshore et al.,2017)

IV. Methodology

4.1 Raw MaterialCollection

Sample of raw material is collected from selected station points in adequate quantity. Water hyacinth plants are collected from Pashan Lake which is located at 12 km away from Pune city in Pashan village and sugarcane bagasse is collected from Sakharwadi Sugar Industry at Sakharwadi village in PhaltanTaluka, Punedistrict.

Fig. 2: Collection of water hyacinth from Pashan Lake

4.2 SamplePreparation

In sample preparation collected water hyacinth is cleaned and washed with clear water and chopped into small pieces of 2-4 cm size. Smaller sized water hyacinth is then crushed into the mixer (grinder) to prepare its slurry with addition of water. After preparation of water hyacinth slurry it is added into the digester along with the sugarcane bagasse in decided proportions.

Fig. 3: Preparation of sample

4.3 InitialTesting

Selected tests such as pH, Total Solids and volatile solids etc are carried out for collected raw material and prepared inoculam. For performing those tests standard procedure given by APHA is followed.

Fig. 4: Discontinuous Type Anaerobic digester with different ratio of water hyacinth and sugarcane bagasse

4.4 Measurement ofGas

Amount of gas generated from the digester after digestion of inoculam is measured in terms of volatile solids. Measurement of gas generated is done after particular interval and recorded. Initial gas generation rate is measured on 25^{th}day of inoculation. Afterwards at interval of 5 days i.e. on 30^{th} and 35^{th} day of inoculation gas generation rate is measured and recorded. The biogas yield is found out by expression given by Central Public Health and Environmental Engineering Organisation(CPHEEO):

Total waste quantity: W (tonnes)
Total Organic / Volatile Solids: VS = 50 %, say
Organic bio-degradable fraction: approx. 66% of VS = 0.33
x W Typical digestion efficiency = 60 %

Typical bio-gas yield: B (m^3) = 0.80 m3 / kg. ofVSdestroyed (3)

V. BiogasYield

The biogas yield is found out by expression given by Central Public Health and Environmental Engineering Organisation (CPHEEO):

Biogas Yield in m^3 = 0.80 xVSdestroyed (4)

Table 1: Biogas yield of different ratios of water hyacinth and sugarcane bagasse

Day	Biogas Yield, lit / kg	
	Ratio A (1:1)	Ratio B (1: 0.5)
25^{th} day	268.8	192
30^{th} day	297.6	196.8
35^{th} day	302.4	225.6

5.1 Variation of Gas Generation Rate

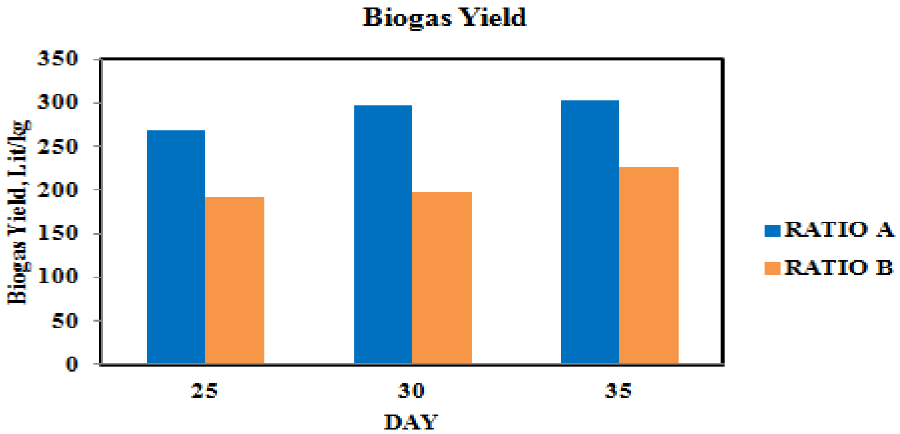

Fig. 5: Variation of Biogas Generation Rate

It is observed that as the time increases the gas generation rate also increases. The maximum amount of gas generated is 302.4 lit / kg of VS for ratio A (Ratio of water hyacinth and sugarcane bagasse as1:1 i.e. 3kg of water hyacinth and 3kg of sugarcane bagasse) on 35th day and minimum is 192 lit / kg of VS for ratio B on 25th day.

VI. Conclusion

Based on the study carried out with water hyacinth and sugarcane bagasse following conclusions are obtained:

1. It is seen that, the water hyacinth alone can produce biogas, but if it is used with some another material having potential of biogas generation such as sugarcane bagasse, its efficiency of biogas generation rateincreases.
2. Both the ratio used in this study have significant amount of biogas generation, but ratio of 1:1 (A) gives the more biogas yield as compared to ratio of 1: 0.5(B).
3. It has been seen that, development of culture during starting phase takes longer time. Hence culture can be added by using cow dung, which will reduce the starting phase time period of gasgeneration.

REFERENCES

[1]. Fadairo A.A. and Fagbenle R.O., 2014. Biogas Production From Water Hyacinth Blends, HEFAT 2014, 10th International Conference On Heat Transfer, Fluid Mechanics And Thermodynamics, Orlando, Florida.
[2]. Sugumaran P., Elamvazhuthi P., Dhamodharan M., Sundaram S., 2014. Biogas production from water hyacinth blended with cow dung, Indian Journal of Energy Vol 3 (1).
[3]. Momoh, O.L. Yusuf N. Waogazie and L. Ify, 2008. Effect of Waste Paper on Biogas Production from Co-digestion of Cow Dung and Water Hyacinth in Batch Reactors, Journal of Appl. Sci. Environ. Manage. Vol. 12 (4).
[4]. Shahabaldin R., Mohanadoss P., Amirreza T., Shaza Eva Md, MohdFadhilMd Din, ShazwinTaib M., Farzaneh S. , Fadzlin Md. S. 2015. Perspectives of phytoremediation using water hyacinth for removal of heavy metals, organic and inorganic pollutants in wastewater, Journal of Environmental Management 163.
[5]. DrKurchania A., Er B Velmurugan, Dr. Narra M., ErVyas B. and Saiyad S. U., 2016. Water Hyacinth: An Option for Biogas Production, AkshayUrja.
[6]. William S. S., Emmanuel N. J. and Cesar K., 2016. Improving Biogas Production of Sugarcane Bagasse by Hydrothermal Pretreatment, Chemical and Biomolecular Engineering.
[7]. Keerthana T. and Mrs. Krishnaveni A., 2016. Biogas Production from Sugarcane Bagasse in Co-Digestion with Vegetable Waste, International Journal of Latest Engineering Research and Applications (IJLERA) Volume – 01.
[8]. Eshore S., Mondal C., Das A., 2017. Production of Biogas from Treated Sugarcane Bagasse, International Journal of Scientific Engineering and Technology, Volume No. 6.
[9]. Eltawil M. A., Belal E.B., 2009. Evaluation and Scrubbing Of Biogas Generation from Agricultural Wastes and Water Hyacinth, Biological Engineering Misr J. Ag. Eng.
[10]. Leandro J., Athaydes L., Marcell N., Thomas S., Jan L., Michael Nelles and Walter Stinner, 2015. Biogas Production from Sugarcane Waste: Assessment on Kinetic Challenges for Process Designing, Int. J. Mol. Sci.
[11]. Patil J. H., Molayan L. A., Bhargav S. and Sowmya S. R., 2011. Anaerobic co-digestion of Water Hyacinth with Primary Sludge, Research Journal of Chemical Sciences, Vol. 1(3).
[12]. Patil J. H., Molayan L. A., Muralidhara P. L., Desai S. M., And MahadevaRaju G. K., 2013. Kinetics Of Anaerobic Digestion Of Water Hyacinth Using Poultry Litter As Inoculum, International Journal Of Environmental Science And Development, Vol. 3, No. 2.
[13]. Saravanan. M. and Manikandan. K., 2012. Experimental Study on Biogas Production in Batch Type Digester with Different Feed Stocks, International Journal of Research in Environmental Science and Technology.
[14]. Sridhar M. K. C., Coker A. O., Hammed B. and Oliyide A., 2014. Experiments on Co-Digestion of Cow Dung and Water Hyacinth (EichhorniaCrassipes) for Biogas Yield, International Journal of Sciences: Basic and Applied Research (IJSBAR).

