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RESEARCH ARTICLE

BIOMETHANATION POTENTIAL OF BAGASSE WITH OTHER SUGAR INDUSTRY WASTES

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ABSTRACT

Traditional fossil fuels having limited availability causing energy crisis all over the world. This leads to increasing trend toward the use of cheap and readily available biomass for renewable energy production. Biomass is best source for renewable energy mainly used for biogas production. Sugar cane is a tropical grass of the having stout, fibrous, jointed stalks, the sap of which is source of sugar. Sugar industry mainly produces bagasse, press mud, spent wash and molasses as their byproducts or wastes. Sugar cane bagasse is by product remained after crushing of the stalks that constitutes short fibers and polysaccharides. It is produced comparatively higher in amount than any other agricultural waste. Study was made to see the biomethanation potential of Sugar industry waste mainly sugar cane bagasse, along with cow dung, press mud, spent wash and molasses. 1L capacity digesters were used in batch process for biomethanation studies. Measurement of biogas was done by water displacement method and qualitative analysis was done by gas chromatography. The biogas was recorded up to 30 days. Admixture of bagasse and cow dung yielded 111.75 mL of biogas per day while bagasse and press mud, spent wash, molasses yielded 278.37 mL, 220.37 mL, 250 mL of biogas per day respectively, Out of the four different combinations used for biogas production bagasse and press mud was the best, which produces 278.37 mL of biogas per day with 77.66 percentage of methane.

INTRODUCTION

Increased global demand for energy due to industrial development and population growth in recent years causes energy crisis. Energy is used in the form of electricity for various purposes so disruption to electricity causes serious problems like riots in some countries like South Africa and Tajikistan indicates a powerful need of sustainable energy source. Developed countries are also worried about security of energy supply. Reliable access to modern energy services become inevitable thing for every aspect of development such as reducing poverty to improving healthcare. Development efforts may be affected leading to regional and global stability because of energy crisis. Some 2.4 billion people in the developing world still rely on traditional biomass fuels, while 1.6 billion people i.e. around a quarter of humanity have no access to electricity. According to International Energy Agency (IEA) the world's energy need could be 50 per cent higher in 2030 than it is today. Fossil fuels are especially used in the transportation and power generation sectors. Burning of fossil fuels is not environment friendly as it produces greenhouse gases and other pollutants into the atmosphere that causes serious impact on earth as well as mankind. Improving efficiency along with better harvesting of existing resources and use of sustainable resources will be the best answer for energy crisis. Greater sustainable development and resource recovery has influenced production of renewable energy from biomass. (Tripsa, 2006; Buzdugan and Tripsa, 2006; Gavrilescu and Chisti, 2005). Renewable energy uses energy sources that are continually replenished by nature mainly includes the solar energy, the wind, water, geothermal energy and biomass. Solar energy available is trapped with high quality photovoltaic system can generate electricity Wind energy is used traditionally since thousands of years for purposes like milling grain, pumping water and driving some mechanical devices. Today wind farm having group of wind turbines located either on land or near sea shore to harness the wind energy for mass production of electricity. Hydroelectric power plants uses a dam built across a river to store water in a reservoir. Water released through reservoir flows through turbine and activates generator to produce electricity. Geothermal energy is the natural heat extracted from earth's crust and used for steam production to drive electric generators. One of the clean energy sources is energy from biomass. (Cameial 2008) Municipal solid waste and biomass through bacterial action under controlled environmental condition produce biogas. Above discussed renewable energy sources helps to reduce dependence on exhaustible sources of fossil fuels.

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The importance of biomass as a renewable energy resource has increased in the recent years because of its prevalent form of stored chemical energy as opposite to solar and wind energy which fluctuate widely. Rising awareness of biomass for energy generation is observed in developing countries like

India and developed countries like Netherland, Germany, Finland and Sweden. The global obligation to reduce the carbon dioxide emissions has increased interest in biofuels. The biofuels are expected to be one of the most important in the near future, because they will contribute to the decreasing of the global warming in the world. Biomass is chief source of energy in developing countries like India. Biogas production from biomass is one of the best way of renewable energy and used as car fuel in different countries. (Mohammad J taherjade 2008) India is a major producer of sugar cane in the world hence different types of sugar industry wastes e.g. bagasse, press mud, spent wash and molasses etc are generated in considerable amount subsequently after sugar production. Bagasse is fibrous by product remained after sugar extraction from sugarcane. Press mud is a solid residue obtained from sugarcane juice before crystallization of sugar and considered as a byproduct of sugar industry. Spent wash is the liquid waste produced during molasses fermentation in distillery and causes pollution of soil while molasses is a residual viscous fluid remained after condensing the sap of sugarcane. Bagasse along with other sugar industry waste can be considered as substrate for biomethanation purpose. (Masud Hoosain, 2009) Chemical composition of sugar industry wastes is rich in organic as well as inorganic components having considerable values for biogas production.

Biomethanation is anaerobic process that yields biogas. Biogas mainly contains 60-65 % methane, 35-40 % carbon dioxide, 0.5-1 % hydrogen sulphide and traces of water vapors. Biogas is almost 20% lighter than air and has ignition temperature of 650-750 ^{0} C. Calorific value of biogas is 20 MJ (4713 kcal) per cubic meter. The biogas may be applied in direct combustion systems (boilers, turbines, or fuel cells) for producing space heating, water heating, drying, absorption cooling, and steam production. It can be directly used in gas turbines to produce electricity with fuel cells. It is an important alternative source to reduce the dependence of diesel in Brazil. (Samuel N. M. de Souza et al. 2011) It can be a source of alternative fuel for vehicle. (Virendra K. Vijay 2007, Camilo Carnejo 2008) The present study was undertaken to see the biomethanation potential of bagasse with other sugar industry wastes.

MATERIALS AND METHODS

Materials

1) Sugar industry wastes

- Bagasse
- Spent wash
- Molasses
- Press mud

2) Cow dung

3) Slurry of cattle dung based biogas plant - Cattle dung based biogas plant slurry was collected from a biogas plant situated at Degaon, M.I.D.C. region Satara,

4) Biogas digesters - Preliminary screening studies regarding biomethanation potential of sugar industry waste was carried out by using 1-L capacity glass flasks and plastic carboys.

Methods

1) Collection and storage of sugar industry waste- Sugarcane bagasse, press mud, spent wash and molasses etc. were collected from sites at Kisan Veer Satara Sahakari Sakhar Karkhana (KVSSK) Ltd Bhuinj in sterile plastic bags using sterile hand gloves. Then it was carried to laboratory, and stored in room temperature for further use.

2) Chemical analysis of Sugar industry wastes
Chemical reagents, apparatus and methods used for chemical analyses of sugar industry wastes were as per APHA, 21st edition 2005, Trivedy and goel, 1984 and AOAC 1990).

3) Estimation of TS and TVS - Procedure for TS and TVS estimations was followed from APHA, 21st edition (2005).

4) Measurement, storage and analysis of gas
The gas was measured by water displacement method. Gas was collected in bottles and stored at room temperature Analysis of gas was done at Agharkar Research Institute (ARI), Pune by gas chromatography (Perkin Elmer Auto System – XL). Carrier gas used was H_2 with gas flow rate of 60mL/min. Column used was Para pack Q, detector used was TCD (thermal conductivity detector), column temperature at injection port was 60^0C and at detector 70^0C).

Biomethanation study

- **Control set -** Using only cattle dung slurry as substrate.
- **Test sets -** Using sugar cane bagasse admixed with press mud, spent wash and molasses
- **Influent for biomethanation-** Both control and test sets carried in four different stages each stage constitutes eight days. Mixture of 75 % cow dung and 25% sugar industry waste was used as influent for first stage while second stages having influent made of 50% cow dung and 50% sugar industry waste. Third stage contains mixture of 25% cow dung and 75% sugar industry waste while fourth stage having only sugar industry waste as influent. Mixture of sugar industry waste made by using bagasse, press mud, spent wash and molasses. All above mixtures were prepared in the beginning of experiment and then used for next eight days. Volume of daily loading was decides by calculating volume and retention time of digesters.

Digesters-Total six different digesters are used with different influent content as follows

Digesters and their content were as follows

- A - Cow dung (CD),
- B - Bagasse,
- C- CD + Bagasse,
- D - CD + Bagasse + Press mud,
- E - CD + Bagasse + Spent wash,
- F - CD + Bagasse + Molasse

Table 1. Influent in digesters for biomethanation

Sr.No.	Volume of daily loading (ml)	Proportion of dung slurry admixed with sugar industry wastes at various stages of experiment (g)			
		Stage I	Stage II	Stage III	Stage IV
1	20	5 + 15	10 + 10	15 + 5	20 + 0

Table 2. Physicochemical analysis of sugar industry wastes and cow dung

Sr. no.	Parameter	Unit	Bagasse	Spent wash	Press mud	Cow dung	Molasses
	Physicochemical characteristics						
1	Moisture	%	6.43	89.45	9.06	82.04	13.85
2	Total minerals	%	4.87	4.48	16.92	3.76	10.21
3	total solids	%	93.27	10.55	90.94	17.96	86.15
4	organic carbon	%	0.4	3.52	47.21	8.27	51.13
5	organic matter	%	1.03	6.07	81.39	14.2	88.15
6	C/N		01	5.68	17.6	13.73	38.3
7	Crude fibre	%	38.12	Nil	22.1	3.24	Nil
8	water soluble substance	%	12.26	98.66	25.07	83.27	100
9	Bulk density	Kg/m3	60	1.0291	0.2789	1.0296	1.4639
10	cellulose	%	34	Nil	26.4	2.74	Nil
11	Hemicellulose	%	27	Nil	15.1	1.81	Nil
12	Lignin	%	20.02	Nil	18.88	2.16	Nil

Table 3. Macronutrient analyses of sugar industry wastes and cow dung

Sr. no.	Parameter	Unit	Bagasse	Spent wash	Press mud	Cow dung	Molasses
	Macronutrient						
1	Nitrogen	%	0.4	0.62	2.44	0.6	1.15
2	Phosphorus	ppm	0.13	279.14	2.21	0.05	584.52
3	Potassium	%	0.24	2.04	0.74	0.21	3.38
4	Calcium	%	0.541	0.55	3.35	0.28	0.96
5	Magnesium	%	0.824	0.35	0.68	0.21	0.89

Table 4. Micro nutrient analyses of sugar industry wastes and cow dung

Sr. no.	Parameter	Unit	Bagasse	Spent wash	Press mud	Cow dung	Molasses
	Micronutrient						
1	Iron	ppm	197	53.81	1760.13	695.64	91.28
2	Manganese	ppm	1.1	4.86	234.7	49.11	8.78
3	Zinc	ppm	6.8	24.6	33.77	3.95	2.06
4	copper	ppm	0.1	1.61	24.31	3.53	1.68

Table 5. Biomethanation potential of sugarcane bagasse admixed with other sugar industry

Sr.No	Digester	1	2	3	4	5	6	7	8	Total biogas generated in 8 days	Average biogas yield (ml)	Gas produced (L/gm of TVS)	% of methane
1	A	190	175	112	95	125	48	95	55	895	111.87	0.127	76.64
2	B	38	60	45	65	150	140	58	73	629	78.6	0.228	49.74
3	C	180	110	82	115	162	70	95	80	894	111.75	0.16	74.32
4	D	225	260	292	355	375	315	210	195	2227	278	0.455	77.66
5	E	235	230	230	185	165	148	270	300	1763	220	0.091	54.7
6	F	220	225	230	235	265	270	275	280	2000	250	0.237	69.02

RESULTS

Physicochemical analysis of sugar industry wastes and cow dung is given in table no 2. It shows bagasse has 6.43% moisture content while spent wash and cow dung has higher moisture content 89.45 and 82.o4% respectively. Press mud and molasses has 16.92 and 10.21 % minerals, while bagasse has 4.87 %. Organic carbon is highest in molasses and press mud while bagasse has only 0.4%. Organic matter is at higher level in molasses and in press mud 88.15 and 81.39 and bagasse has only1.03% organic matter. C/N ratio which is 20 for biogas production is found only in press mud and cow dung other wastes requires modifications. Cellulose and hemi cellulose content in bagasse is 34, 27% while in press mud it is 26.4, 15.1% other waste spent wash and molasses no cellulose and hemi celluloses. Lignin % is 20.2 and18.88% in bagasse and press mud while spent wash and molasses is free from lignin. Macronutrient level in different wastes was given in Table No 3. The higher Nitrogen level was found in press mud and molasses as 2.44 and 1.15%, while bagasse has 0.4%. Phosphorus was highest in molasses and spent wash bagasse has 0.13 ppm, potassium was found highest in molasses and spent wash i.e. 3.38 and 2.04% calcium and magnesium % in bagasse was 0.541 and 0.824%. Micronutrient level in different wastes was given in Table No 4. Iron was found highest in press mud 1760.13 ppm, while in cow dung ,molasses and bagasse it was 695.64, 91.28 and197 ppm . Manganese, Zinc and Copper was at higher level in press mud 234.7, 33.77, 24.31ppm respectively while in bagasse it was only1.1, 6.8, 0.1ppm respectively.

Biomethanation potential

Biomethanation potential of sugarcane bagasse admixed with other sugar industry wastes were shown in Table 5. Cow dung alone produces average 111.87mL/day (0.127 L/gm of TVS) with76.64% methane and bagasse produces 78.6087mL/day (0.228 L/gm of TVS) with 49.74 % methane. There was no appreciable increase in cow dung and bagasse combination which produces biogas similar to cow dung only, combination of cow dung bagasse and spent wash and molasses also produces higher amount of biogas with higher percentage of methane as compare to dung and bagasse alone. While the combination of cow dung, bagasse and press mud produces 278 mL/day of biogas with 77.66 % methane. Out of the four different combinations bagasse and press mud was found to be the best combination for biomethanation.

Conclusion

- The biomethanation process was studied up to 30 days at ambient temperature (37^0–38^0C)
- Sugarcane bagasse was comparatively a poor substrate for biomethanation.
- Cow dung alone was not found to be good substrate for biomethanation but when admixed with different sugar industry wastes gives good yield of biogas.
- Influent containing sugarcane bagasse admixed with press mud yielded highest amount of biogas i.e. 278 mL per day (0.455 L/gm of TVS) with 77.66 methane percentage. This shows that bagasse and press mud combination is best combination among the other combinations for biogas production.
- The project could help to minimize pollution caused by Sugar industry wastes from the area and could be eco-friendly that can achieve the goal of the zero pollution.

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