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PRODUCTION OF BIOGAS BY ANAEROBIC DIGESTION OF PRESS MUD USING IRON, COBALT AND NICKEL

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ABSTRACT

Biogas generation from the anaerobic digestion has revealed to be one of the best technology as an alternate energy source to fossil fuels, which can reduce the adverse environmental pollution and yield nutrient sludge as bio fertilizer. Sugarcane Press mud is one of the Sugar industry wastes which has a potential source of biogas. The present study is to enhance the rate of biogas production from press mud by the supplementation of trace elements in a batch mode. Many literature reports Nickel, Cobalt and Iron as desired trace elements which compensate the nutrient deficient in the substrate and improves the biogas yeild. Dry Press mud (8% TS) is fed in one litre digesters and cow dung as inoculum with the addition of trace elements (Ni,Co and Fe) in an incubator at mesophilic temperature range at a period of 30 days Characterization (Total solids (TS), Volatile Solids(VS), Ash content, Moisture, COD, Cellulose, wax, Crude fibre, Crude protein, Carbon/Nitrogen ratio, Calorific value) of press mud has been done.. Addition of Fe gives the maximum production of biogas (520 ml/day) in the anaerobic digestion of Press mud.

KEYWORDS: Biogas, Press mud, Fe,Co,Ni.

Growing energy demand and faster depletion of fossil fuel reserves prove the over exploitation of these fuels. On other side, global environment is degrading with the combustion of fossil fuels resulting global warming, which is a future threat. To resolve these problems, a shift to renewable energy source is required. One of the renewable energy resources is biogas generated from the organic wastes through anaerobic digestion. This technology has more advantages over the other renewable energy resources. Biogas is a non polluting fuel which leaves less amount of carbon di oxide to the atmosphere.. Along with the product biogas, its digestate gives a nutrient rich bio manure, a green fertilizer which reduces the adverse effect of chemical fertilizers and also prevents the environmental pollution caused by the degradation of bio manure.

Anaerobic Digestion process of solid wastes takes place on the degradation of organic wastes by several groups of micro organisms in an anaerobic environment. Methane (60-65%) contributes a major component in the product biogas, followed by carbon di oxide (30-40%), hydrogen (0-1%) and some traces of hydrogen sulphide. Four biochemical mechanisms involved in this technology are hydrolysis, acidogenesis, acetogenesis and methaogenesis. Hydrolysis occurs when bio polymers such as carbohydrates, proteins and fats convert into monomers sugars, amino acids and peptides. In the next phase, acidogenesis soluble monomers are converted into short chain volatile fatty acids such as acetate, formate and long chain fatty acids propionate, butyrate by the acidogenic bacteria. Acetogenic micro organisms produce acetic acid largely along with hydrogen and carbon di oxide in acetogenesis. Final phase is methanogenesis in which methanogens generate methane and carbon di oxide.

Biogas can be generated from the biomass, that includes food waste, agro industry waste, horticulture waste etc., Sugar industry effluents, comprises of bagasse, press mud, molasses and spent wash. Press mud also known as sugarcane filter cake is a residue formed as a result of filteration of sugar cane juice. Press mud is a soft, light weight, spongy amorphous substance and appears from dark brown to black color. Press mud has a potential of biogas production.

Press mud along with bagasse generate biogas which contains 52% methane content and proved to be a good substrate for anaerobic digestion. Combination of press mud with sugarcane bagasse yield maximum amount of biogas than bagasse with other sugar industry wastes. The digestate obtained from anaerobic digestion of the press mud has rich nutrient content. Anaerobic digestion of press mud took a short time of 4-5 hours to produce biogas. Press mud with kitchen waste in different proportion had showed a significant increase in biogas production. Addition of Cobalt and Nickel was studied for 6% slurry of press mud. Only few studies have been in the literature on the anaerobic digestion of press mud. This paper works on the study of the rate of biogas generation by the anaerobic digestion of press mud (8% slurry) process with the addition of Iron, Nickel and Cobalt.

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MATERIALS AND METHODS

Substrate

Sugar cane press mud sample collected from a sugar industry at Kurungulam, in Thanjavur district of Tamil Nadu is taken as substrate.

Trace Elements

In this paper, Cobalt Chloride, Nickel Chloride and Ferric Chloride (Merck Life Science Private Limited) are used as trace elements to improve the quantity of biogas production from sugar cane press mud.

Apparatus Design

The apparatus used for the anaerobic digestion made of borosilicate glass consists of one liter conical flask and two liter conical flask and a plastic bottle for water collection. The flasks are interconnected with bent glass tubes for air and water flow. The mouth of the conical flasks are closed with rubber corks with holes for inlet and outlet of biogas and water. Both the flasks are made air tight by parafilm and is also wrapped with cello tapes.

Experimental Procedure

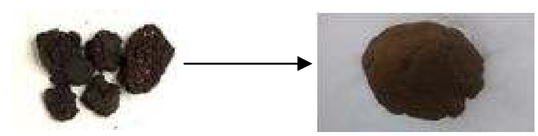
Four sets (A,B,C,D) of lab scale digesters are used for the present study. Anaerobic Digestion was carried out with 80% working volume and 20% headspace. Press mud of 8% Total Solids was taken as substrate in the anaerobic digesters and fresh cow dung (10% volume of the substrate) was added as inoculum in all the four digesters to initiate the anaerobic digestion process. Distilled water is used for the preparation of slurries and is homogenized using a magnetic stirrer (1MLH, AMPS:0.85,CAT No. 220/230v EDMS-2885). Press mud alone was taken in digester A. 0.5 grams of Cobalt, Nickel, Iron were supplemented in the digesters B, C and D respectively. To maintain the feasible pH range (~7) inside the digesters $NaHCO_3$ was added to all digesters. Headspace of the four digesters was filled with nitrogen gas to exclude Oxygen to provide anaerobic environment inside the digesters. The digesters are then kept in the Incubator (Bacteriology incubator) at 38°C (mesophilic temperature range). The produced biogas from the press mud was collected and measured by the water displacement technique. Figure. 1 shows the experimental set up of anaerobic digesters of press mud inside the incubator performed for this work.

Figure 1:

CHARACTERIZATION AND ANALYSIS

Pretreatment of Press Mud

The impurities contained in press mud such as stones, hay, dust (figure.2. (a)) and these impurities were removed physically and sun dried for a week to remove moisture. It was then mixed in a blender for size reduction. After blending, press mud get transformed into powder form (figure.2 (b)). The pretreated press mud powder was used as a substrate in the anaerobic digesters. Pretreatment of press mud had been done to get more surface area of particles.



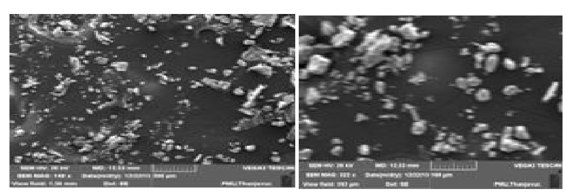
(a) Untreated (b) Pretreated

Figure 2:

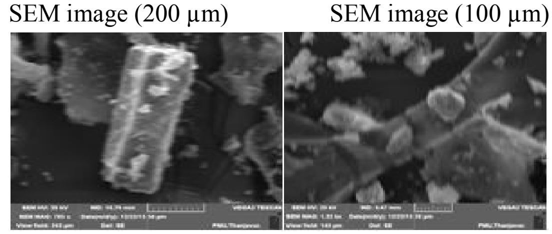
Scanning Electron Microscope

A scanning electron microscope (SEM) images a sample by scanning it with a high-energy beam of electrons, which interact with the atoms of the sample producing signal that shows its surface topography.

SEM analysis was taken for press mud powder and it shows the high resolution image of press mud varies from 20 µm to 200 µm. The reduced dimensions of press mud particles will increase the surface area as more active sites are obtained.



SEM image (200 µm) SEM image (100 µm)



SEM image (50 µm) SEM image (20 µm)

Figure 3: SEM images of press mud (powder)

Physico Chemical Analysis of Press Mud

Press mud was analyzed for Total Solids (TS), Volatile Solids (VS), Moisture content, Ash content, Carbon/Nitrogen ratio, and Calorific value (kcal/kg). pH of the slurry was checked by digital pH meter(0806280).

The results of characterization of press mud were given in the table 1.

Table 1: Characterization of Press Mud

S. No.	Physicochemical Analysis	
	Parameters	**Result**
1.	Total Solids (TS) (%)	84.54
2.	Volatile Solids (VS) (%)	73.42
3.	Moisture (%)	61.24
4.	Ash content (%) (Dry weight basis)	26.78
5.	Sugar (%)	11.45
6.	COD of 10 % solids (g/L)	67.8
7.	Crude wax (%)	8.32
8.	Crude protein (%)	10.27
9.	Fibre (%)	13.8
10.	Calorific value (kcal/kg)	3146.20
11.	Carbon/Nitrogen ratio	16.5

RESULTS AND DISCUSSION

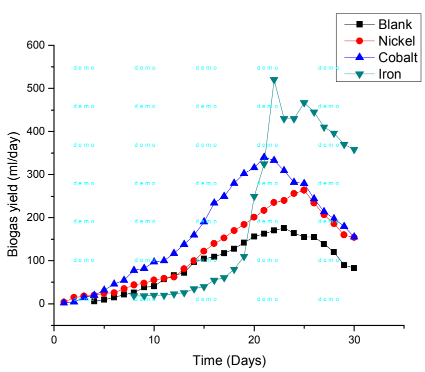


Figure 4: Daily biogas production of press mud

Daily biogas production from press mud was given in Figure 4. Intially the digester A (Blank) and digester D (Iron) starts its biogas generation on 4th day of digestion. Digester B (Cobalt) and digester C (Nickel) starts its biogas generation on the 1st day itself. Production of biogas increases gradually and shows maximum yield approximately after 15 days in all the four digesters. Addition of Iron (digester D) shows a peak value of 520 ml/day on its 18th day, followed by Nickel (digester C) and Cobalt (digester B) and Blank (digester A) respectively. The highest production of biogas of Cobalt is 340 ml on 21st day, Nickel shows its peak yield as 264ml/day on 25th day and 176 ml of biogas production in blank. The anaerobic digestion process extend around 30 days. The decline in biogas production declined after 24th to 27th days in all four digesters. It was observed from the graph that the addition of Iron shows a maximum yield in the anaerobic digestion of press mud. Thus trace elements play a significant role in the rate of anaerobic digestion of the press mud.

Cummulative biogas production can be proportional to the specific growth rate of methanogens in the anaerobic digester.

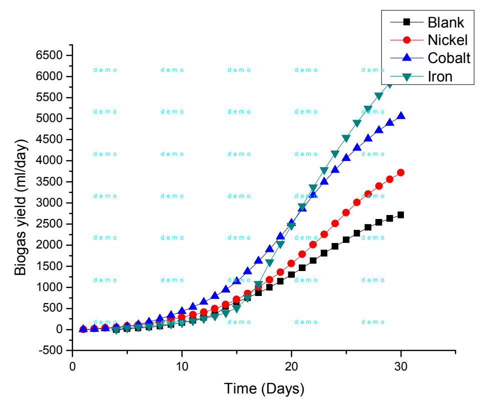


Figure 5: Cummulative biogas production of press mud

The results from the cumulative biogas production of press mud for four anaerobic digesters shows S shape curve which represents sigmoid function. The production of biogas from press mud increases from 15 days of digestion. From the figure 5., the maximum production of biogas obtained from digester A, digester B, digester C and digester D are 2713 ml/day, 3714 ml/day, 5053 ml/day, 6100 ml/day respectively at a Hydraulic Retention Time of 30 days under mesophilic condition. The digester D shows a peak yield of 6100 ml/day while digester A which contains press mud alone show a least production of 2713 ml/day. Hence Iron addition to press mud shows relatively higher yield of biogas from press mud.

CONCLUSION

Anaerobic digestion of press mud gives a bio fuel, bio manure and also reduces the environmental pollution caused by disposal of press mud to the environment. Press mud proves to have high potential source of biogas production in batch digesters under mesophilic conditions of 38°C. Hence the rate of the biogas production of press mud is enhanced with the supplementation of Nickel, Cobal and Iron.

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