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Assessment of the Potential for Utilization of Sugarcane Derived Press Mud for Biogas Generation in South Nyanza Sugarcane Zones, Kenya

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***Abstract*—**The sugar industry produces a number of by-products during the process of sugar production such as bagasse, press mud or filter cake, ash, mill effluent, and trash. The press mud from the clarifiers is rich in organic matter thus can be utilized for biogas production. Currently in Kenya, press mud is being dumped as garbage or given to farmers as fertilizer. This disposal method pause some environmental challenges such as air pollution due to odour, surface and ground water pollution and pollutes the soil by increasing the soil wax content. The objective of this study is to evaluate the potential for utilization of sugarcane-derived press mud and use it as a feedstock for biogas production, upgrade biogas using locally available materials and to generate electricity from biogas generated from press mud in sugar factories. The research was carried out in South Nyanza Sugar Zone. The samples of sugarcane press mud were collected from South Nyanza Sugar Company (SONY), Sukari industry limited and Transmara Sugar Company. Chemical analysis and characterization of the composition of the sugarcane were done at Kenya Sugar Research Foundation laboratories in Kisumu City. The result of the compositional analysis of the sugarcane press mud from the three sugar factories had slight variations of 2%. Average values were: Moisture content 63.1%, ash content 16.1%, and C/N ratio 19.6%. This confirms the potential of the sugarcane press mud to produce biogas and the residue after anaerobic digestion is very rich in nutrients hence best bio-fertilizer.

Keywords: Anaerobic digestion, bio-fertilizer, biogas, sugarcane-derived press mud

1. Introduction

Energy is one of the main pre-requisite in contributing towards the economic and social development of a country. Since the dawn of civilization, man has been dependent on energy in one form or the other. The story of energy starts with wood, wood came to be replaced by coal which has partially been replaced by oil. Now a stage appears to have been reached when oil may also have to be substituted by biomass [1]

According to [2], renewable energy technologies are "clean" and "green" because they produce few of any pollutants. Burning fossil fuels, however, sends greenhouse gases into the atmosphere, trapping the sun's heat and contributing to global warming". And according to climate scientists, the temperature of the earth surface has risen in the last century by some degree. If this trend continues, sea levels will rise, and scientists predict that floods, heat waves, droughts, and other extreme weather conditions could occur more often. To reduce these greenhouse gases, renewable sources of energy such as biogas should be used as much as possible.

From the 19thcentury, the main reason for growing sugarcane in different countries in the world is for production of sugar. Due to energy crises, scientists and researchers have realized the value of sugarcane, it-s by products and co-products. Sugarcane is processed to sugar and biomass. This biomass contains many components like lignin, fibre, pith and pentosans, which has plenty of applications in biochemical and microbial field. [3]

Report [4] indicate that the sugar industry produces a number of by-products during the process of sugar production including bagasse, mill mud or filter cake, ash, mill effluent, and trash. Most of these wastes contain biodegradable matter. This could be potentially resourceful for biotechnology processes, which can produce extra by-products for the sugar industry. One possibility is using anaerobic technology for biogas production.

During the process of raw sugar juice clarification, dissolved and suspended solid substances are removed to get the clear juice, a precipitate settles at the bottom of the clarifier which is called press mud, also known as sugar cane mud, sugar cane filter mud, filter press cake or filter mud. In sugar factories, during sugarcane juice clarification, press mud is produced as a by-product, and weighs about 4-5% of the cane weight. [1]

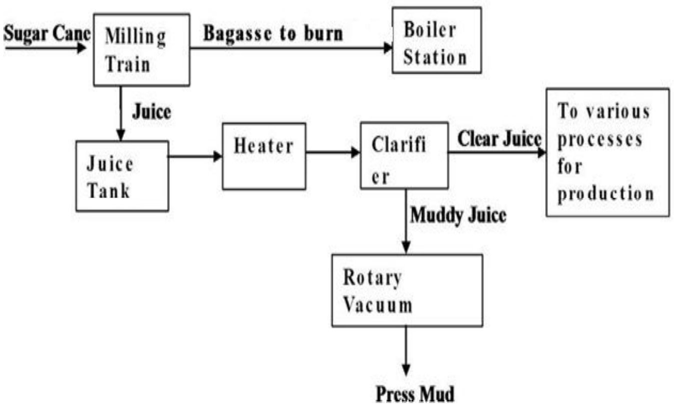


Fig. 1. A schematic diagram of formation of press mud waste in sugar mill. [5]

Sugar derived-press mud also known as filter-cake which is rich in organic matter which is the major source of biogas. The organic matter in the press mud can be tapped through the anaerobic digestion technology and be used as a source of biogas energy. Currently, this press-mud is usually dumped as garbage. Some sugar industries make use of it by converting it into compost. But this compost, along with its advantages, has some disadvantages too: it increases the wax content in the soil. The increase in wax reduces the porosity of the soil causing reduced penetration and permeability which is not desirable-[6].

Theoretically, biogas can be converted directly into electricity using a fuel cell. However, very clean gas and expensive fuel cells are necessary for this process. This is therefore currently not a practical option. In most cases, biogas is used as fuel for internal combustion engines, which convert it to mechanical energy for powering an electric generator to produce electricity-[7].

2. Materials and Methods

2.1 Area of the Study

The research was carried out in three sugar factories in Kenya from the same sugarcane ecological zone/ belt, that is, the South Nyanza Sugar Zone. The composition analysis was done at Kenya Sugar Research Foundation situated at Kibos, Kisumu.

The press mud samples were collected from South Nyanza Sugar, Transmara Sugar and Sukari International Sugar Companies.

2.2 Analytical Procedure

2.2.1 Compositional Analysis

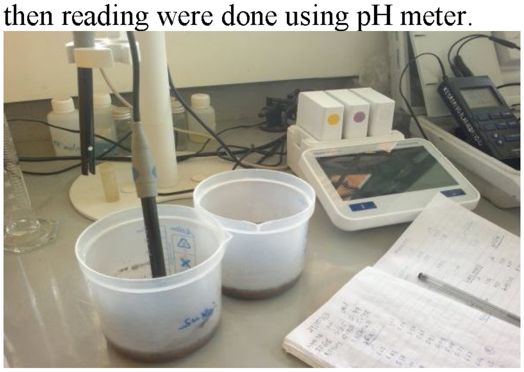
During the characterization of the sugar-derived press mud, the following aspects were investigated: Moisture (%), Solids (%), Volatile Matter (%), Ash (%), Sugars (%),Organic Carbon, fibre content, Nitrogen, C/N Ratio, and pH of 10% solids of dry sugar-derived press mud.

- Organic Carbon was determined by the loss-on-ignition (LOI) method for the determination of organic matter which involved the heating destruction of all organic matter in the soil or sediment. 5g weight of sample was placed in a ceramic crucible which was then heated to 400°C overnight [8]-[9]-[10]. The sample was then cooled in a desiccator and weighed.
- Moisture and ash contents were estimated by gravimetric methods by drying at 105°C and by complete combustion at 800°C in the laboratory furnace, respectively.
- For estimation of fibre content, press mud was weighed accurately and washed over a tarred 100 mesh sieve until the water run clear. Excess water was drained off and the sieve along with its contents was dried in an oven at 105°C to constant weight. Fibre content was calculated from the increase in weight of the tarred sieve [11].
- Sugar content (pol/sucrose) in the press mud sample was determined by measuring the optical rotation method in a Polarimeter machine.10g of

the samples were taken in plastic beakers, toped up with water to 50g, $Pb(NO_3)_4$ was added and stirred. The solution was filtered and the filtrate was read in the in the Saccharimeter/polarimeter machine.

- Nitrogen was analysed through Kjeldahl method. Where 5g of the sample was weighed and 1g $CuSO_4$, 10g K_2SO_4 and 30 mL Con. H_2SO_4 and then digested in Kjeldahl until a green colour appeared. The solution was decanted and 40% NaOH solution was added and afterwards titrated against HCl. And from titrate multi equivalence of acid for NH_3 absorbed calculated and used to get nitrogen % present in the sugar press mud [13].

- pH value was determined by weighing 10g of sample and was toped up with water up to 50g, shaken for 10 minutes in laboratory shaker and then reading were done using pH meter.



- C/N ratio was calculated by dividing Organic Carbon by Nitrogen.

2.2.2 Anaerobic Biomethanation in laboratory

The collected sugar-derived press mud sample was diluted to about 50% in an 18.2 liter capacity wide mouth water bottle. Volume of the substrate in the bottle was 10 liter. It was inoculated with the sludge collected from an anaerobic plant based on cow dung and pre-acclimatized with press mud for 10 days. The bottle was kept in a room, maintained at about 30°C. The total gas production was measured by using water displacement method at an interval of 24 hours. Contents of the bottle were mixed manually, after every gas measurement. Daily gas production was recorded.

2.2.3 Analysis of produced biogas

Gas analysis has been done by Gas Chromatograph, using porapak Q column and thermal conductivity detector for methane and carbon dioxide in biogas samples.

3. Results and Discussion

General characteristics of press mud are given in Table 1. The moisture content in the samples varied from 60.1 to 67.1% (averaging 63.1%). The press mud used for characterization contained about 83.4% volatile solids. The C/N ratio was ~19.8. The organic matter present in the press mud consisted mainly of parameters as recorded in the table. In fact, the chemical composition of press mud depends on the cane variety, soil conditions, nutrients applied in the field, process of clarification adopted and other environmental factors.

Table 1: Characteristics of the sugar press mud

Parameter	*Sony sugar company*	*Transmara sugar company*	*Sukari industry*	*Averages*
Moisture (%)	67.7	63.7	60.1	63.1
Solids (%)	32.3	36.3	39.9	36.9
Volatile Matter (%)	87.0	83.2	79.9	83.4
Ash (%)	13.0	16.8	20.1	16.6
Fibre (%)	15.5	23	18.7	19.0
Sugars (%)	5.4	6.7	6.8	6.3
Nitrogen (%)	4.8	3.7	4.3	4.3
Organic Carbon (%)	85.8	83.0	82.2	83.7
C/N Ratio	17.8	22.4	19.1	19.8
pH of 10% solids	7.4	7.6	7.5	7.5

The pH is an important parameter for biogas production. Biogas generation from press mud is expected to be high at pH values of 6.5-8.5 and maximum in the pH range of 7.0-7.5. The samples average pH of the samples collected is good because it falls within the required range.

The C/N ratio of the substrate is another important parameter for the biogas production. On the one hand, biodegradation of nitrogenous compounds contributes to the neutral pH stability. The nitrogen is also important for bacterial cell growth, which is an important phenomenon in the whole process of bio-methanation. At low C/N ratio, carbon addition stimulates methane production by reducing ammonia inhibition.

At high C/N ratio, carbon addition decreases the methane yield as nitrogen becomes a limiting nutrient and bacteria suffer a nutrient deficiency. The methane content of biogas also depends on the C/N ratio. At higher C/N ratio, the percentage of methane decreases in the biogas.

3.1 Daily Gas Production

Fig. 2 represents the volumes of daily gas accumulation and it shows a belt shape trend. It was observed that gas generation started at the very next day of charging the digesters with the slurry. The rate of gas generation gradually increased with increasing the digestion period. The graph also indicates that during the digestion period, most of the daily gas production range was between 200 and 600 mL. In this reactor, the peak gas production of 1100 mL was observed on the 20th day. It was observed that gas production rate declined after 26th days.

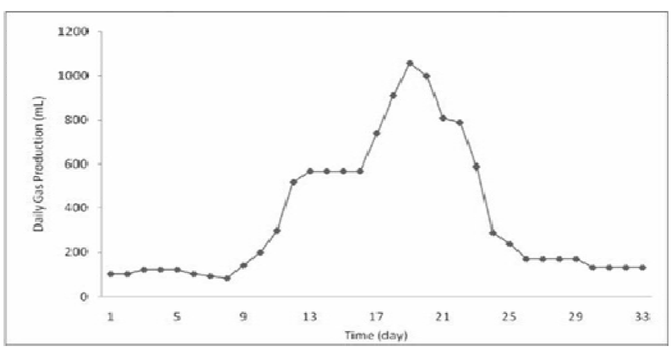


Fig. 2. Daily gas production in the laboratory experiment

4. Conclusions

The present methods for disposal of press mud from sugar industry are not environmentally sound. Its disposal is a problem and creates environmental nuisance. But generation of biogas from the substrate will reduce environmental problem. It has been found from the characterization of press mud that the organic matter content is high, so they are suitable for biogas production. The sugar industry will be financially benefited by installing biogas generators, as the economic analysis reveals that the production of biogas and bio-fertilizer from press mud is economically feasible.

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