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**—**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/ characterization on the composition of the sugarcane were done at Kenya Sugar Research Foundation laboratories in Kisumu City.

The result on 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**—**Biogas, Sugarcane derived press mud, anaerobic digestion, bio-fertilizer

I. Introduction

ENERGY is one of the main essential pre-requisite towards contribution for the economic and social development of the country. Since the down of civilization, man has been dependent on energy in one form or the other. The story of the energy starts with wood, wood came to be replaced by coal and coal by oil only partially. 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 averagely 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 this 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 as the main product. 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 fields. [3]

[4] Reports 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 resource for biotechnology process, which can produce extra by-products for the sugar industry. One possibility is using anaerobic technology for biogas production.

During the clarification of the mixed cane juice to remove the dissolved and suspended solid substances 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 about 4-5% of the cane weight. [1]

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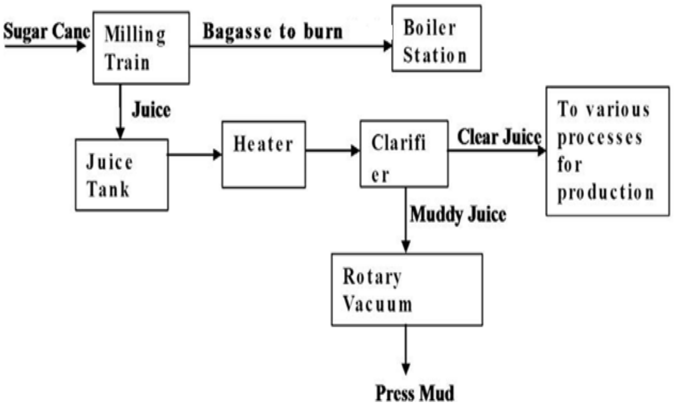

Figure 1: A schematic diagram of formation of press mud waste in sugar mill. [5]

Press-mud also known as filter-cake is rich in organic matters which are the major source of biogas. The organic matters in the press mud can be tapped through the anaerobic digestion technology. 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 still and is currently not a practical option. In most cases, biogas is used as fuel for combustion engines, which convert it to mechanical energy, powering an electric generator to produce electricity. [7]

II. MATERIALS AND METHODS

a. *Area of the Study*

The proposed research was carried out in three of Sugar factories in Kenya from same sugarcane ecological zones/ belts. 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, TransmaraSugar and Sukari International Sugar Companies as selected area of study.

b. *Analytical Procedures*

1) *Compositional Analysis*

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

- 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 105ºC and by complete combustion at 800ºC, 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 sieves along with its contents were dried in an oven at 105ºC to constant weight. Fibre content was calculated from the increase in weight of the tarred sieve [11].
- Sugar content in the press mud sample was determined by measuring the optical rotation of the filtrate in a Polari-meter machine.
- Nitrogen was analysed through the titration against sodium hydroxide. 5g of the dry sample was digested and then the solution was then titrated then nitrogen was calculated from the volumes.
- pH value was determined by weighing 10g of sample , water was added to 50g and then reading were done using pH meter.
- C/N ratio was calculated by dividing Organic Carbon with Nitrogen.

III. 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 parameters as recoded 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 industries*	*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, 7.0, 7.5, 8.0 and 8.5 and maximum in the pH range of 7.0-7.5. The samples collected average is good because it falls within the required range.

The C/N ratio of the substrate is an 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.

Future activities to be done include:

- Design and fabrication of a simple biogas digester for the testing of biogas production
- Cleaning of the biogas by removing the impurities to concentrate the methane content
- Production of electricity from the biogas by using cleaned biogas as biofuel to drive the generator to produce electric power.

IV. Conclusion

The press mud contains ~ 83.4% volatile solids, which are biodegradable in nature, and a good proportion of nitrogen (C/N ratio of 19.8). This makes it a very good material for generation of bioenergy (methane) by anaerobic biomethanation.

The optimum conditions for biogas generation from press mud are: solid concentration 6%, C/N ratio 18, pH 7.0-7.5,and temperature 35-40^{o}C.

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