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Case Study on Production of Bio Gas from Press Mud

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Abstract:

India has a key position in the worldwide sugar economy, emerging as the foremost sugar producer since 2021-22, surpassing Brazil in production. Additionally, the status of the second-largest sugar exporter globally is held by India. Over the past five years, the sugar industry has been strengthened by the expansion of the ethanol biofuel sector, contributing to the improved financial standing of sugar mills. Press mud, often known as filter cake or press cake, is acknowledged as a valuable resource for green energy production. Press mud is a residual byproduct of the sugar industry. Additional revenue can be generated for Indian sugar mills by utilizing this byproduct as a feedstock for biogas production through anaerobic digestion and subsequent purification to create compressed biogas (CBG). During the 2022-23 timeframe, among the 531 operational sugar mills in India, 330 were privately owned, 190 were cooperative, and 11 were public. The fiscal year 2022-23 recorded India's sugar production at 32.74 million tonnes, along with approximately 11.4 million tonnes of press mud. Regarding regional production, Uttar Pradesh and Maharashtra contribute to approximately 65 percent of the total sugarcane cultivation area, being the primary sugarcane-growing states. The total sugarcane production in India reached about 495 million tonnes in 2022-23, with key contributions from Uttar Pradesh (225.2 million tonnes), Maharashtra (123.9 million tonnes), Karnataka (62.5 million tonnes), Tamil Nadu (16.9 million tonnes), and Bihar (12.1 million tonnes).

Keywords — **Press Mud, Bio Gas, Compressed Bio Gas (CBG), Green fuel, Sugarcane**

I. INTRODUCTION

Press Mud -- the sugar-cane residue in the purification of the juice of the sugar cane, is obtained through a precise process. This process involves dividing the juice and clear juice, which rises to the surface, while mud builds up at the bottom. It is then filtered in order to separate the suspended substances, including insoluble salts and fine bagasse. For every 100 tons of crushed sugarcane, about 3 tons of press mud are produced. It is estimated that 2.7 million tons of mud are produced in our country every year, and this economic soil significantly aids in reclaiming red loamy soil. India annually produces about 10-12 million tons of press mud.

Traditionally, press mud is used as manure through a bio-compost process by spraying spent wash on press mud.

Press mud, also known as filter press mud, is a semi-solid waste material generated during sugar production. Its composition can vary depending on factors like sugarcane or sugar beet variety, processing conditions, and filtration efficiency.

The Organic Matter is 50 to 60% which comprises of Fibers (cellulose, hemicellulose, and lignin), some part Sugars (sucrose, glucose, and fructose) also Proteins with some ratio of Fats and oils with a small amount of waxes.

Inorganic Matter is 30 to 40 % which comprises of Silica (SiO2), also Alumina (Al2O3), Iron oxide (Fe2O3), Calcium carbonate (CaCO3), some amount of Magnesium carbonate (MgCO3) Phosphates and Sulfates

Water Content is 10 to 20 % and typically contains a significant amount of water, which can affect its handling and storage.

Also, the other component's presence is 1 to 5% with impurities like sand, silt, and clay also having Residual pesticides or fertilizers with Microorganisms (bacteria, fungi, and yeast).

The physical Properties of the press mud are as follows:
- pH: 4.5-6.5
- Moisture content: 10-20%
- Bulk density: 0.5-0.8 g/cm3
- Particle size: 0.1-5 mm

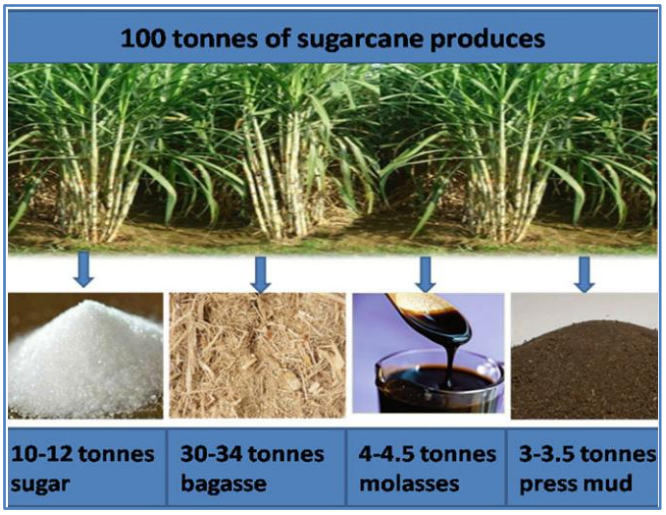

Figure 1- Sugarcane products

The Chemical Properties of the press mud are as follows:
- High organic matter content
- Moderate to high nutrient content (NPK)
- Presence of sugars and other carbon sources

However the exact composition of press mud can vary depending on the specific sugar production process and feedstock used.

Uses of Press mud:
1. Biogas production: Press mud can be anaerobically digested to produce biogas (a mixture of methane and carbon dioxide).
2. Composting: Press mud can be composted and used as a nutrient-rich fertilizer.
3. Animal feed: Press mud can be used as a nutritious feed supplement for cattle and poultry.
4. Soil amendment: Press mud can be used to improve soil structure and fertility.
5. Energy production: Press mud can be burned to produce energy or used as a fuel source.

Studies show that the traditional / Existing methods for disposing of mud are unsuitable for the economy and cause environmental pollution. However, because of its reasonable amount of easily digestible organisms, press mud has excellent potential for biogas production. The excess crushed slurry can be utilized as a superior-quality fertilizer. Despite the presence of some biogas plants, their effectiveness is unsatisfactory due to the existence of wax and issues of brisk acidification.

A small brief on the manufacturing of sugar:

1. First the sugarcane collected from the farmers is washed to remove the dust, cut and shredded to remove the leaves and the roots, etc.
2. The juice is now extracted by the milling process.
3. The raw juice is filled in the clarifier in which phosphoric acid, lime, and sulfur dioxide is mixed with agitators, then the mixture is kept for settling down and the removal suspended and colloidal particles are collected in the flock. Then the clean juice from the upper section is collected and at the bottom of the clarifier sludge and mud are collected and then drained to a rotary filter.
4. The filtration process consists of the removal of Clarified mud from the clarifier further filtered in the rotary filter. Mud & sludge are stick on the periphery of rotating drum by the action of the section. Solid cake is removed from the drum by the doctor's blade.
5. Evaporation is done to concentrate the liquid.
6. The syrup is again treated with sulfur dioxide for the crystallization of sugar on the pan station, Vaccum pans the syrup is evaporated until saturated with sugar. At this point “seed grain” is added to serve as a nucleus for the sugar crystals, and more syrup is added as water evaporates.

7. Centrifuge, the massecuite from crystallizer is drawn into revolving machines called centrifuges. The perforated lining retains the sugar crystals, which may be washed with water, if desired. The mother liquor "molasses" passes through the lining because of the centrifugal force exerted and after the sugar is "purged" it is cut down leaving the centrifuge ready for another charge of massecuite.
8. The final process is the packing of the sugar crystals.

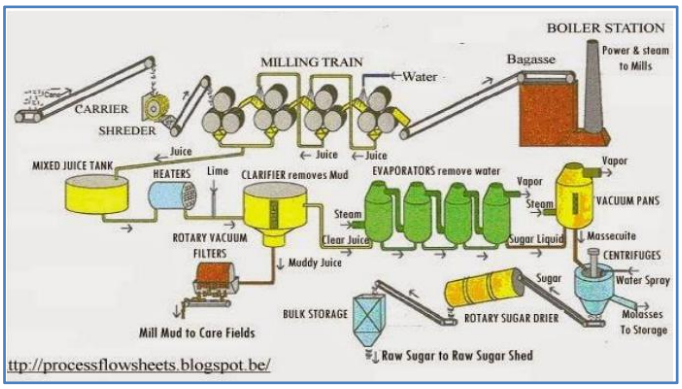

Figure 2 - Sugar cane processing in a sugar factory

The use of press mud as a feedstock for CBG offers several advantages.

Press mud storage refers to the methods and facilities used to store press mud, a by-product of sugar production, in a safe and environmentally friendly manner. Here are some considerations and options for press mud storage:

1. Open pits: Press mud can be stored in open pits or lagoons, but this method poses environmental risks due to potential leachate contamination and odor issues.
2. Covered storages: Storing press mud in covered facilities or sheds helps minimize odor and leachate issues.
3. Slurry storage tanks: Press mud can be stored as a slurry in tanks, which allows for easy handling and transportation.
4. Drying beds: Press mud can be dried in beds or pads to reduce moisture content, making it easier to handle and store.
5. Composting facilities: Press mud can be composted to produce a nutrient-rich fertilizer, reducing storage needs.
6. Land application: Press mud can be applied directly to land as a fertilizer or soil amendment, eliminating storage needs.

Considerations:

1. Moisture content: Press mud with high moisture content requires more storage space and may be more prone to odors and leachate issues.
2. Odor control: Storage facilities should be designed to minimize odors and prevent nuisance.
3. Leachate management: Storage facilities should have leachate collection and treatment systems to prevent environmental contamination.
4. Pest control: Storage facilities should be designed to prevent pest infestations.
5. Fire safety: Storage facilities should be designed to prevent fires and have fire suppression systems.
6. Regulatory compliance: Storage facilities should comply with local regulations and guidelines.

Proper press mud storage is essential to prevent environmental issues, ensure safety, and maintain quality for further use or disposal.

Pressmud: A Valuable Byproduct

- Pressmud, also known as filter cake or press cake, is an agricultural waste product from sugar production.
- It is obtained during the repeated filtration of cane juice before sugar extraction.
- Approximately 3-4 percent of press mud is produced per tonne of crushed cane.
- Traditionally, pressmud is recycled as manure through composting and supplied to local farmers.
- Recognized as a resource for green energy, pressmud can be used to produce biogas through anaerobic digestion, leading to compressed biogas (CBG) creation.
- It is beneficial for crops and horticulture due to its richness in micronutrients.

Figure 3 - Byproduct details

1. The complexities associated with the feedstock supply chain are eliminated, unlike in the case of agricultural residue where biomass harvesting machinery is required for harvesting and aggregation.
2. The feedstock is sourced from one or two producers or sugar mills, as opposed to agricultural residue which involves multiple producers/farmers within a narrow window of 45 days per year.
3. Unlike municipal solid waste, the quality of press mud is not a concern, as the presence of inorganic material can damage anaerobic digesters, leading to lower gas output.

Usually, a yield of 3-4 percent (weight by weight) of press mud is obtained from the input sugarcane processed in a unit.

India's Press Mud Production

"Annual Production: India produces approximately 11.4 million tons of pressmud annually" [1].

"Press mud is a residual byproduct of the sugar industry, generated during the processing of sugarcane" [2].

"Sugar Production: In the fiscal year 2022-23, India's sugar production reached 32.74 million tons, with the primary sugarcane-growing states being Uttar Pradesh and Maharashtra" [3].

"CBG Potential: The produced press mud has the potential to yield approximately 460,000 tons of Compressed Biogas (CBG), valued at Rs 2,484 crore" [2].

As we have already discussed India is one of the largest producers of sugarcane and sugar, generating significant amounts of press mud, the

COMPOUND	PERCENTAGE(%)
Cellulose	11.4
Hemi cellulose	10.0
Lignin	9.3
Protein	15.5
Wax	8.4
Sugar	5.7
Sodium	0.22

Figure 4 - Compound and their Percentage

approximately 25 tonnes of press mud are needed to produce a tonne of CBG.

Press mud availability can vary depending on several factors, including:

1. Sugar production cycles: Press mud is a by-product of sugar production, so its availability is closely tied to sugar production cycles.
2. Sugarcane harvesting seasons: Press mud availability is typically higher during sugarcane harvesting seasons, which can vary depending on the region and climate.
3. Sugar mill operations: Press mud availability can be affected by sugar mill operations, including factors like crushing capacity, processing efficiency, and maintenance schedules.
4. Geographical location: Press mud availability can vary depending on the geographical location of sugar mills and sugarcane production areas.

Press mud can be used to generate biogas through anaerobic digestion, a process that breaks down organic matter in the absence of oxygen. Here's a step-by-step guide:

1. Pre-treatment: Press mud is mixed with water to create a uniform slurry, and its pH is adjusted to optimize microbial growth.
2. Anaerobic Digester: The slurry is fed into an anaerobic digester, a sealed tank where microorganisms break down the organic matter.
3. Microbial Activity: Microbes like methanogens, acidogens, and acetogens convert the organic matter into biogas (CH4 and CO2) and digestate.
4. Biogas Collection: Biogas is collected from the digester and stored in gas holders or upgraded to biomethane.
5. Digestate Handling: The remaining digestate can be used as a nutrient-rich fertilizer or further processed into compost.

PARAMETER	AVERAGE VALUE (%)
Moisture	76.3
Volatile Matter	76.6
Sugars	6.4
Wax	7.2
C/N ratio	14

Figure 5 - Parameters with Average value

Types of Anaerobic Digesters:
1. Continuous Stirred Tank Reactor (CSTR): Suitable for high-solids press mud.
2. Batch Anaerobic Digester: Ideal for small-scale operations.
3. Fixed Dome Biogas Digester: Simple, low-cost design.
4. Floating Drum Biogas Digester: Suitable for large-scale operations.

Optimization Factors:
1. Temperature: 35-40°C for mesophilic digestion.
2. pH: 6.5-7.5 for optimal microbial growth.
3. Retention Time: 15-30 days for complete digestion.
4. Organic Loading Rate: 2-5 kg/m³/day for efficient biogas production.

By leveraging press mud for biogas generation, we can reduce waste, produce renewable energy, and create a valuable fertilizer.

Here are some mechanical means to store press mud:
1. Conveyor Belt Systems: Use conveyor belts to transport press mud to a storage area, such as a silo or warehouse.
2. Pneumatic Conveying Systems: Use compressed air to transport press mud through pipes to a storage vessel.
3. Screw Conveyors: Use screw conveyors to transport press mud to a storage area, such as a bin or silo.
4. Belt Filters: Use belt filters to dewater press mud and store the filtered mud in a compact form.
5. Centrifuges: Use centrifuges to separate liquids from press mud and store the solid mud in a compact form.
6. Press Mud Pumps: Use specialized pumps to transport press mud to a storage area, such as a tank or lagoon.
7. Storage Silos: Use silos to store press mud in a dry and compact form, with features like aeration and mixing systems.
8. Rotary Drums: Use rotary drums to store press mud, with features like heating, cooling, and mixing systems.
9. Auger Systems: Use augers to transport press mud to a storage area, such as a bin or silo.
10. Vibratory Feeders: Use vibratory feeders to transport press mud to a storage area, such as a bin or silo.

These mechanical means can help handle and store press mud efficiently, reducing labor and environmental impacts. However, the choice of technology depends on factors like press mud characteristics, storage capacity, and budget.

The type of feedstock to be used for CBG production and financial viability of a plant depends on many factors like cost of input feedstock, location of plant, etc. As per SATAT scheme, the responsibility of setting up of CBG plant lies with the entrepreneur and therefore applicant is requested to assess CBG production and financial viability of its plant by itself.

The following tentative yield of various feedstocks are normally considered as per discussion with various existing and proposed CBG Plants and various technology providers. However these are only directional in nature and actual yield may vary substantially depending on quality of feed stock.

Feedstock	CBG Production(Ton)	Feedstock requirement (Tentative)
Agriculture Residue	1	10 Ton
Press Mud	1	25 Ton
Spent Wash	1	10 KL
Bagasse	1	10 Ton
Municipal Solid waste	1	20 Ton
Cow Dung	1	50 Ton
Chicken Litter	1	25 Ton
Forest Residue	1	15 Ton
Napier Grass	1	10 Ton
Sewage Waste	1	15 MLD

Figure 6 - CBg generation table by differnt feedstock as per SATAT

Suggestions

1. Comprehensive research is essential to developing technologies for press mud storage that prevent methane emissions into the environment and minimize gas loss from the feedstock.
2. Additionally, periodic training sessions conducted by state renewable energy nodal agencies and biogas development and training centers should educate operators on the functioning of CBG plants, handling scientific equipment, and feedstock characterization.
3. To prevent long-term economic instability in CBG plants from unsustainable feedstock costs, the government should establish a mechanism to control press mud prices below a specified threshold. Encouraging sugar mills to commit to extended agreements (10-15 years) with CBG plants, featuring an annual rate increase of 5-10 percent, will ensure economic viability.
4. Bioenergy policies streamlining the approval process for projects should be implemented by states with the highest CBG potential from press mud. This can provide a unified solution and a variety of incentives, both monetary and non-monetary. Uttar Pradesh and Bihar are two examples of states taking progressive steps and

have introduced supportive bioenergy policies for CBG plants.

Conclusion

Press mud is identified as a low-hanging fruit for the CBG industry, and it should be harnessed promptly to address waste management issues in sugar mills, create a sustainable energy source, and supply organic fertilizer to the soil.

Specific challenges are faced by press mud. While once considered a disposal issue for sugar mills, its potential for revenue generation has now been recognized by owners. This realization has resulted in a substantial increase in press mud prices over the last two years, rising from Rs 100 per tonne to Rs 500-600 per tonne.

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