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Study and Analysis of the Industrial Processing of Molasses, Bagasse, and Press Mud

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Abstract - The sugar industry plays a crucial role in the global economy, producing not only sugar but also a variety of by products that hold significant industrial and environmental value. Among these by products, molasses, bagasse, and press mud are particularly important due to their multiple applications in various sectors, including energy, agriculture, and biotechnology. Molasses as a key raw material in bio refineries, contributing to the development of bio fuels and renewable chemicals. Modern processing techniques, such as fermentation, distillation, and enzymatic hydrolysis, are explored to enhance efficiency and optimize molasses utilization. Bagasse, the fibrous residue left after sugarcane crushing, is a major biomass resource with high calorific value. Traditionally used as a fuel for cogeneration plants, bagasse contributes crucially to the energy needs of sugar mills, reducing dependence on fossil fuels. Press mud, the solid residue obtained during the juice clarification process, is a nutrient rich organic material widely utilized in bio composting, organic fertilizers, and biogas production. Rich in calcium, phosphorus, and organic matter, press mud enhances soil fertility and promotes sustainable agriculture.

Keywords: Molasses Processing, Bagasse Utilization, Press Mud Management, Sugarcane By-products, Renewable Energy

1. INTRODUCTION

India is the second largest producer of sugar in the world after Brazil and produces more of cane sugar. In India, 78 percent of sugarcane is used for sugar production, 15 percent of the crop is used to produce various other sweets and the remaining is used for bio fuel production. Sugar production in India is concentrated in nine major states with Maharashtra and Uttar Pradesh leading with 27 percent and 30 percent of the total production.The Sugar Production in India is shown in figure 1. More than 50 million farmers and their families are dependent on sugarcane for their livelihood.

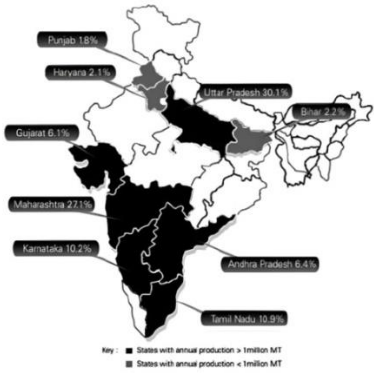

Figure 1 Sugar Production in India

Explored the potential of press mud ash as an adsorbent for treating stabilized landfill leachate. Landfill leachate is a highly contaminated liquid generated from waste decomposition in landfills, containing high concentrations of organic matter, heavy metals, and persistent pollutants. The treatment of stabilized landfill leachate is particularly challenging due to its complex composition and the presence of recalcitrant compounds that resist conventional biological treatment. Adsorption is one of the most effective methods for removing pollutants from leachate, and researchers have been investigating various low cost and sustainable adsorbents to improve treatment efficiency.

The sugar industry caters to an estimated 12 percent of rural population in these nine states through direct and indirect employment. Effectively, each farmer contributes to the production of 2.9 MT of sugar every year. Globally, [2] Explored the potential of improving press mud through organic amendments and its impact on soil quality and the growth performance of Capsicum annum. we have seen high correlation between sugar production and sugarcane productivity. Several countries improved sugar recovery rate by increasing yield of sugarcane. In India, sugarcane productivity is low. As evident from the figure below, while, India is amongst the largest producer of sugarcane, average yield of sugarcane is amongst the lowest globally. The landholding size of 10 hectares or more is present in only 25 percent of the area under sugarcane cultivation.

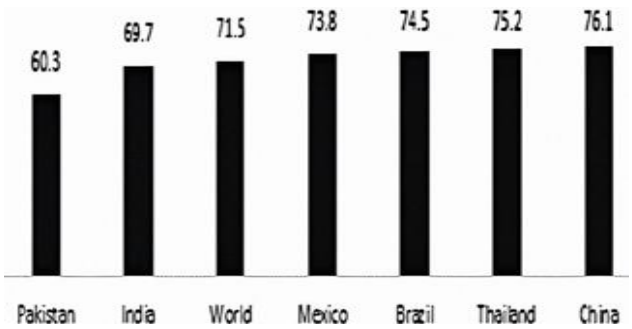

Figure 2 Average Yield of Sugarcane in India

The bulk of the land under sugarcane is between 1 and 10 hectares. The Average Yield of Sugarcane in India is shown in figure 2. This land holding structure is a key structural feature of the sugar industry in India. The small land holding limit the extent of mechanization and reduces the ability of farmers to invest in farm productivity. The ability of a farmer to sustain himself in the event of a crop failure or lack of crop off take or nonpayment of dues is also limited by the size of the land holding. [3] explores the co-digestion of press mud, distillery wastewater, and sugarcane bagasse for improved biogas production. Press mud, a byproduct of sugar mills, is rich in organic matter, making it a potential feedstock for anaerobic digestion. However, its high solid content and slow degradation rate pose challenges for efficient biogas generation. Distillery wastewater, another byproduct from sugarcane-based ethanol production, contains high concentrations of organic compounds and nutrients that can enhance microbial activity during anaerobic digestion. Sugarcane bagasse, the fibrous residue left after juice extraction, provides structural support and helps maintain the balance between solid and liquid phases in the digestion process. Several studies have investigated the anaerobic digestion of sugar industry waste, emphasizing the potential of co-digestion to improve biogas yield. [4] Explored the potential of press mud as a renewable resource for hydrocarbon and chemical production through thermal pyrolysis.

Press mud, a byproduct of the sugar industry, is rich in organic matter, making it a promising feedstock for energy recovery and value added chemical production. Thermal pyrolysis is a process that decomposes organic materials in the absence of oxygen, breaking down complex molecules into simpler hydrocarbons, bio char, and gaseous products. This technique has gained attention as a sustainable waste management strategy, offering an alternative to fossil fuels while reducing the environmental impact of organic waste disposal. The study examined the pyrolysis behavior of press mud under different temperature conditions to optimize the yield of liquid hydrocarbons. The results indicated that press mud undergoes significant thermal degradation, producing bio oil with a composition similar to conventional petroleum-derived fuels.

One of the primary commercial uses of sugarcane is in sugar production. Sugarcane juice is processed to extract raw sugar, which is further refined into white sugar, brown sugar, and other sweeteners. The Commercial Uses Sugarcane is shown in figure 3. The sugar industry relies heavily on sugarcane as a raw material to meet global demand for sweeteners in confectionery, beverages, and processed foods. Additionally, sugarcane derived molasses is used in baking, candy making, and alcoholic beverage production such as rum. The bio fuel industry also benefits significantly from sugarcane. Ethanol, a renewable energy source, is extracted from fermented sugarcane juice and used as an alternative to fossil fuels. Many countries, especially Brazil, use sugarcane ethanol as a bio fuel to reduce carbon emissions and reliance on petroleum based fuels. Bagasse, the fibrous residue left after juice extraction, is further used in power generation, making sugarcane a key contributor to sustainable energy.

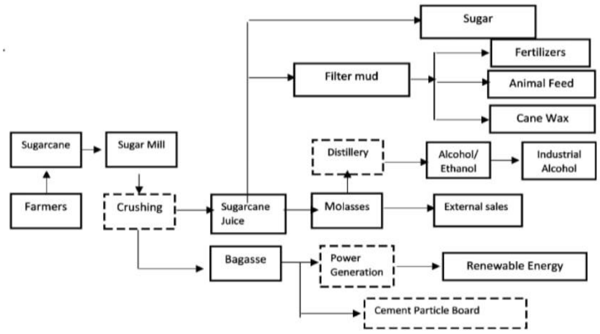

Figure 3 Commercial Uses Sugarcane

Press mud, a nutrient rich byproduct of the sugar industry, has been widely recognized for its potential as an organic fertilizer. However, its direct application to soil presents challenges due to its high moisture content, imbalanced carbon to nitrogen (C/N) ratio, and slow decomposition rate. The study aimed to enhance the agronomic value of press mud by incorporating organic amendments, improving its physicochemical properties, and assessing its effects on soil fertility and plant growth. Organic amendments such as farmyard manure, compost, and microbial inoculants have been extensively studied for their role in accelerating decomposition and enriching organic matter. [5] Investigated the environmental consequences of using tannery effluent for irrigation, particularly its effects on heavy metal accumulation in soil and groundwater in Kanpur, India. Tannery industries generate large volumes of wastewater containing high concentrations of heavy metals such as chromium (Cr), lead (Pb), cadmium (Cd), and nickel (Ni), along with organic pollutants. Due to water scarcity, untreated or partially treated tannery effluent is often used for agricultural irrigation, raising concerns about its long-term environmental and health impacts. The study aimed to assess the extent of heavy metal contamination and evaluate its potential risks to soil fertility and groundwater quality. Previous studies have established that industrial effluents containing heavy metals can significantly alter soil properties, reduce microbial diversity, and pose risks to human health through food chain contamination.

2. MANUFACTURING PROCESS OF MOLASSES

Molasses is a thick, viscous by product obtained during the sugar manufacturing process from sugarcane or sugar beets. The process begins with the harvesting and crushing of sugarcane, where large mills extract the sugar rich juice. This juice contains impurities such as soil particles, fibers, and organic matter, which must be removed before further processing. The crushed sugarcane also produces bagasse, a fibrous residue that is often used as a fuel source for boilers in sugar mills. Once the juice is extracted, it undergoes clarification, where it is heated and treated with lime (calcium hydroxide) to neutralize acidity and aid in the removal of unwanted impurities. This process helps in coagulating and settling out non sugar substances, which are then removed through filtration or sedimentation. The clarified juice, now free from most impurities, is directed to evaporators, where it is concentrated by removing excess water.

Manufacturing Process of molasses is classified into three stages,

- Fermentation

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- Distillation and
- Effluent treatment and disposal

1. Fermentation

Fermentation is carried out in the fermentation vessels under controlled conditions of temperature and PH. The propagated yeast biomass is transferred to the main fermenters keeping volume at 10 to 15% of the total fermenter volume. The rest is filled with diluted molasses. After filling the fermenter, it is left for fermentation. This process occurs under anaerobic condition. Under these conditions, the glucose molecule breaks down to produce ethyl alcohol and carbon dioxide.

The fermentation process is understood to be completed when the effervescence stops. The Fermentation Flow Chart is shown in figure 4. Other measurement like specific gravity etc., are also taken to assess the completion of fermentation process. Fermentation is an exothermic reaction. Hence, the temperature rises during the fermentation process. To maintain the temperature at 36 degree celsius., the fermenter vessels are required to be cooled with fresh water, through plate type heat exchanger. The yeast sludge along with solids present in molasses is collected at the bottom of the fermenter vessels.

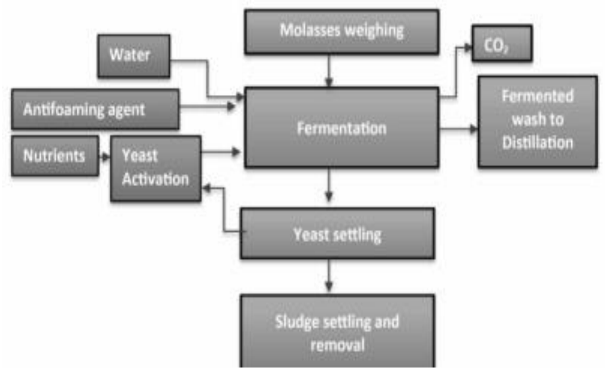

Figure 4 Fermentation Flow Chart

These solids need to be removed to make the fermenter vessels ready for another batch of fermentation process. The sludge is washed off by water. The washed sludge called fermenter washing constitutes a waste along with some alcohol. The fermenter washing is centrifuged in a high speed centrifuge machine, which separates solid and liquid the liquid containing some alcohol is sent for distillation while the solid contained biomass and other solid is sent for bio composting. The fermentation consists of following steps,

- Molasses weighing
- Dilution
- Yeast Propagation
- Pre fermentation
- Fermentation

2. Distillation

The first operation, which is carried out on molasses is dilution. In dilution operation molasses, from the storage tank is diluted with raw water. The diluted molasses is used for subsequent unit operations yeast propagation & fermentation. The dilution ratios required for yeast propagation and fermentation are different. For requirement of yeast propagation, molasses is diluted to keep the sugar percentage of 8 – 9% while for fermentation molasses is diluted to keep the sugar 16-18%. The distillation consists of following column.

- Analyzer Column
- Degasifying Column
- Extractive distillation column
- Recovery Column
- Rectifier cum Exhaust Column
- MSDH column

3. Effluent treatment and disposal

The molasses manufacturing process, a by product of sugar production, generates significant amounts of wastewater and effluent containing organic and inorganic contaminants. If not treated properly, these effluents can lead to severe environmental pollution, affecting soil, water bodies, and aquatic life. Effluent treatment and disposal in molasses based industries are critical for maintaining environmental sustainability and regulatory compliance. Effluent treatment in molasses based industries typically follows a multi-stage process to remove pollutants effectively. Primary treatment involves screening and sedimentation to remove large solids and suspended particles. Secondary treatment, often biological, includes anaerobic digestion or activated sludge processes to break down organic matter. In many cases, advanced tertiary treatment methods such as membrane filtration, reverse osmosis, or oxidation processes are used to further purify the wastewater before disposal or reuse.

3. MANUFACTURING PROCESS OF BAGASSE

Bagasse is the fibrous byproduct left after sugarcane is crushed to extract juice in sugar mills. It primarily consists of cellulose, hemi cellulose, and lignin, making it a valuable raw material for various industries. Instead of being discarded as waste, bagasse is widely used for power generation, paper production, biodegradable packaging, and even bio ethanol production. The manufacturing process of bagasse begins with the crushing of harvested sugarcane, where juice is extracted for sugar production. The remaining fibrous material, bagasse, is separated and typically contains around 45-50% moisture. To enhance its usability, it undergoes drying or further processing based on its intended application. One of the most significant uses of bagasse is as a bio fuel. Sugar mills burn it in boilers to produce steam, which powers turbines for electricity generation. This helps sugar industries become self sufficient in energy and reduces reliance on fossil fuels.

Manufacturing Process of bagasse is classified into four stages,

- Sugarcane Crushing
- Bagasse Separation
- Drying and Processing

1. Sugarcane Crushing

After harvesting, sugarcane is transported to the sugar mill via trucks, tractors, or conveyor belts. The transportation process must be quick, as any delay can lead to sugar deterioration due to fermentation. Upon arrival, the sugarcane is weighed to record the total quantity received. The Sugarcane Arrival and Unloading at the Mill is shown in figure 5.

Figure 5 Sugarcane Arrival and Unloading at the Mill

2. Bagasse Separation Process in Sugar Mills

The bagasse separation process is a crucial stage in sugar production, where the fibrous residue left after juice extraction is efficiently separated and processed for various applications. This process begins immediately after the multiple stage crushing of sugarcane, where the cane passes through several milling units to extract the maximum possible juice.

Figure 6 Separation Process in Sugar Mills

Once the cane has undergone the final crushing stage, the bagasse emerges as a fibrous, moist material with a moisture content of around 45-50%. To further reduce moisture and improve handling efficiency, the bagasse is passed through dewatering mills, where additional pressure is applied to remove excess liquid. The Separation Process in Sugar Mills is shown in figure 6.

These mills consist of heavy duty rollers that squeeze the bagasse, reducing its moisture content and ensuring that the maximum amount of juice is recovered for sugar production.

3. Bagasse Drying Process in Sugar Mills

The bagasse drying process is a critical step in ensuring the efficient utilization of bagasse as a fuel source, raw material for paper production, and biodegradable product manufacturing. Bagasse, the fibrous residue left after sugarcane crushing, typically retains 45-50% moisture, which reduces its calorific value and limits its efficiency as a combustion fuel. Drying bagasse helps improve its burning efficiency, storage stability, and usability in various industries. The Drying Process in Sugar Mills is shown in figure 4.4. The process involves mechanical dewatering, hot air drying, and thermal drying methods to reduce the moisture content to a more manageable level, typically below 30%.

4. MANUFACTURING PROCESS OF PRESS MUD

Press mud, also known as filter cake, is a byproduct of the sugarcane industry, primarily generated during the clarification of sugarcane juice in sugar mills. It is a rich organic material containing a mixture of fibrous residue, coagulated colloids, inorganic impurities, and other suspended matter removed from cane juice. The manufacturing process of press mud begins with sugarcane crushing, where the extracted juice undergoes purification using lime and other clarifying agents.

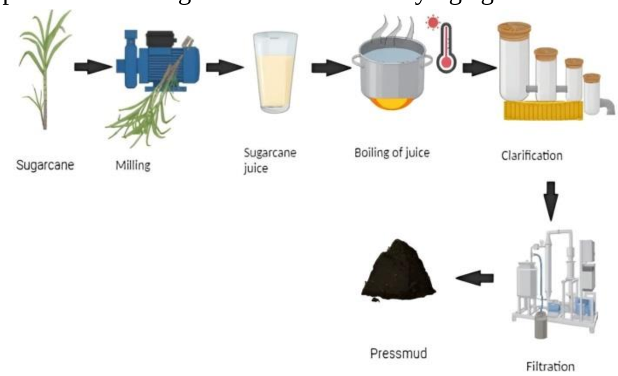

Figure 7 Manufacturing Process of Press Mud

The Manufacturing Process of Press Mud is shown in figure 7. With increasing emphasis on sustainable agricultural practices and waste utilization, press mud plays a crucial role in promoting eco-friendly and circular economy models in the sugar industry.

1. Sugarcane Crushing & Juice Extraction

Freshly harvested sugarcane is sent to mills or crushers for juice extraction. The crushing process involves multiple rollers mill that press the sugarcane stalks to extract the maximum juice. The crushed sugarcane, known as bagasse, is separated and used for power generation or paper production. The extracted juice contains a high amount of impurities, including.

- Small fibers
- Soil particles
- Wax
- Proteins

2. Juice Clarification & Precipitation

The process of press mud formation begins with the extraction of sugarcane juice during sugar production. When sugarcane is crushed in the mill, the raw juice obtained contains various impurities, including fine cane fibers, soil particles, wax, and non sugar organic matter. To remove these impurities, the juice undergoes a clarification process. In this step, lime (calcium hydroxide) and other chemical coagulants such as phosphoric acid or sulfur dioxide are added to neutralize acidic components and help precipitate unwanted materials. The addition of lime causes a reaction that results in the coagulation of colloidal and suspended particles, forming a thick sludge. Heating the juice further enhances the precipitation process, ensuring that the maximum amount of impurities settles out of the solution.

3. Filtration & Separation

Once the juice clarification process is complete, the next step is the filtration and separation of press mud from the sugarcane juice. The sedimentation sludge, now rich in organic matter, calcium, phosphates, and fibrous residues, is processed through filtration systems to remove excess liquid. Various filtration methods are employed, including vacuum rotary drum filters, gravity based filters, or pressure filters, depending on the mill's technology. In vacuum filtration, the press mud is passed over a rotating drum covered with filter cloth, where the liquid component is drawn out by suction, leaving behind a solid cake-like residue.

4. Drying & Processing

After separation, the press mud is still in a semi solid state with high moisture content, which requires further drying to improve its handling and usability. The drying process can be done through natural sun drying or mechanical drying. In open field drying, press mud is spread in large areas where sunlight and wind help reduce moisture content over time. However, this method is weather dependent and can take several days. In modern sugar mills, mechanical drying methods such as rotary dryers, belt dryers, or hot air blowers are used to accelerate the process.

Figure 8 Drying and Processing

Mechanical drying reduces moisture content more efficiently, making the press mud easier to store and transport. Once dried, the press mud becomes a valuable byproduct used in various industries. The Drying and Processing is shown in figure 8. In agriculture, it serves as a nutrient rich organic fertilizer, enhancing soil fertility due to its high organic carbon, nitrogen, and phosphorus content. It is also used in biogas production, where its organic matter undergoes anaerobic digestion to produce methane rich biogas, a renewable energy source. Additionally, some industries process press mud into briquettes or pellets for use as an alternative fuel. Through proper drying and processing, press mud becomes a sustainable and eco friendly resource.

CONCLUSION

The industrial processing of molasses, bagasse, and press mud has transformed the sugar industry into a more sustainable and economically manageable sector. These by products, once considered waste, are now essential to various industries, including bio fuels, energy production, agriculture, and manufacturing. Their proper utilization reduces waste, conserves resources, and enhances industrial efficiency, contributing to a circular economy. Molasses has emerged as a key raw material for ethanol production, playing a crucial role in the bio fuel sector. Bagasse, known for its high calorific value, serves as a primary fuel source for cogeneration plants, allowing sugar mills to generate their own electricity and even supply excess energy to the grid.

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