Recovery of Chemicals from Pressmud – A Sugar Industry Waste

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Indian sugarcane crop cultivation forms an important part of the Indian agricultural economy. Production of sugar has shown a phenomenal increase in the last 65 years. One of the byproducts of sugar industry is pressmud, a solid residue, obtained from sugarcane juice before crystallization of sugar. Generally pressmud is used as manure in India. The aim of the present investigation is to recover protein, sugar and wax from pressmud. The amount of protein is estimated to be 3.3%. The percentage of sugar is about 0.8%. Extraction of wax by solvent has resulted in a recovery of about 12%.

The two main sources of sucrose are the sugarcane and the sugar beet. Sugarcane is tall grass having a number of bamboo-like stems, which grows to a height of 4 meters or more. The sugar content in sugarcane is about 10 to 15 per cent. As regards the sugar beet, the juice of the beet contains sugar identical to that found in cane. The sugar beet is found to contain 5 to 6 per cent of sucrose. In improved varieties, a yield of 13 to 17 percent is common and in this respect it compares favourably with sugarcane. [1]

Indian Scenario

Cane crop cultivation and production of sugar has shown a phenomenal increase in India over the last 60 years, since the industry started in an organized manner [2]. The detailed figures are given in Table 1.

The increase in sugarcane and sugar production has inevitably resulted in increased quantity of waste products. It is well known that molasses has found very useful applications in the manufacture of ethanol and potable spirits. The growth of this industry has been equally impressive. The distilleries in their turn have led to the increased availability of effluent, commonly termed as 'spent wash'. The major waste products from sugar processing and alcohol manufacture are:

1. Cane residues left in the field after cane harvesting.
2. Bagasse from the cane crushing operation.
3. Pressmud from the cane juice filtration.
4. Spent wash from distilleries.

Bagasse finds profitable use in the paper industry for the manufacture of wrapping and packing. Certain mills also manufacture paper by employing suitable blends of conventional pulp with that obtained from bagasse. Its use is encouraged by the government by providing subsidies to the manufacturers. Bagasse is also extensively used as a convenient source of fuel in mill boilers, often resulting in availability of excess energy. The other cane residues could probably double the amount of energy availability. Table 2 describes the number of factories in operation, their crushing capacity, area, yield, cane and sugar production since the inception of sugar industry and their contribution to the Indian economy.

Table 1 : Cane Crop Cultivation

Sugarcane	From 35M tonnes in 1930 to 296M tonnes in 1999.
Yield/hectare	From 31 tonnes/hectare in 1930 to 72.5 tonnes/hectare in 1999.
Area under cultivation	From 1.2M hectares in 1930 to 4.1M hectares in 1999.
Sugar production	From 0.1M tonnes in 1930 to 15.5M tonnes in 1999.

Table 2 : Factories in Operation

Sugarcane	From 36 million tons in 1930 to 296 million tonnes in 1999.
Yield per hectare	From 31 tons in 1930 to 72.5 tonnes in1999.
Area under cultivation	From 1.2 million hectares in 1930 to 4.1 million hectares in 1999.
No. of sugar industries	550
Total cane production	220 million tonnes per year.
Total cane available fro crushing	135 million tonnes per year.
Total sugar production	13.5 million tonnes per year.

Pressmud

Pressmud from the sugar mills is a very useful source of fertilizer as well as some chemicals. The major use that has recently been developed in India is in biocomposting (usually trade named as Bioearth) where it is treated with the spent wash from the distillery [3]. The composition of pressmud is given in Table 3. Its usefulness as fertilizer is based on the nutrient content of the mud and the spent wash as shown below:

Pressmud – N- 1.15 to 3.0%; P- 0.60 to 3.50% and K- 0.30 to 1.80%.

Spent wash – N-2630 mg/l; P- 201 mg/l and K- 222 mg/l.

The bio-compost is produced by spraying spent wash on stacks of pressmud called windrows. The period required to produce usable fertilizer varies with the process used. A typical 45-day process includes the following steps:

1. Formation of windrows and reduction of moisture content from 70% to 50% in five days.
2. Inoculation of microbial culture.
3. Spraying of spent wash and homogenization of windrows for 30 days.
4. Maturation period of 10 days to reduce moisture to 30%.

The benefits that accrue are:

1. Very low power requirement.
2. Zero discharge to inland water resourses and freedom from river or ground water pollution.
3. Organic fertilizer produced is rich in micro-nutrients and can reduce the requirement of chemical fertilizers. It also provides bacteria for nitrogen fixing, solubilisation of phosphates, humus that will keep the soil healthy and develop the self-reclamation cycle.

Since biocomposting is accompanied by a rise in temperature, chances are that the fertilizer is free from all pathogens, harmful bacteria, weeds and seeds. Fertilizer is free flowing, easy to handle, to pack and transport. The biocompost contains 25-30% organic carbon, 1.2-2.0% nitrogen, 1.5-2.0% phosphorous and 2.5-3.0% potash.

The shortcoming of this operation is the limited period of operation of sugar plants. The pressmud has to be stored in large open areas and large lagoons are to be set up to store the spent wash. However, the long-term effects of application of this fertilizer remain to be studied.

Table 3 : Composition of Pressmud

Crude wax	5-14%
Fiber	15-30%
Crude Protein	5-15%
Sugar	5-15%
SiO	4-10%
CaO	1-4%
PO	1-3%
MgO	0.5-1.5%
Total ash	9-10%

Chemicals from Pressmud

Pressmud can be a useful source of chemicals. Work has been done at the laboratories of the Anna University at Chennai to recover the chemicals. It is to be noted that the total quantity of pressmud from the sugar industry in India could be as much as 35,000 tonnes per day. [4]

Experimental

Recovery of Protein

Protein being soluble in water, double distilled water was used to separate it from pressmud. Protein was separated from aqueous phase by precipitation with ammonium salts. A Hitachi, U-2000, double beam UV visible spectrophotometer was used to measure the absorbance. Estimation of protein was done by Lowry's method using sodium carbonate, sodium potassium tartarate and ammonium salts.

Recovery of Sugar

Sugar left in the aqueous phase after the recovery of proteins was recovered by evaporation. A Hitachi, U-2000, double beam UV visible spectrophotometer was used to measure the absorbance of the sugar solution using anthrone reagent.

Recovery of Wax

Several solvents such as benzene, toluene and hexane were tried for recovery of wax from the solids left behind after the recovery of proteins and sugar. Crude wax was separated from the wax-laden solvent by deep freezing.

Results

Effect of pH on Protein Recovery

The percentage recovery of protein, sugar and wax from pressmud is given in Table 4. The amount of protein present in pressmud was about 3.3%. The percentage recoveries of protein at different pH levels are shown in Table 5. From the table, it was found that percentage recovery of protein increased as pH of the pressmud solution increased. The maximum amount of protein, i.e., 3.3% was recovered at a pH

Table 4 : Recoeries from Pressmud

Protein	3.3 %
Sugar	0.8 %
Wax	12 %

Table 5 : Percentage Recovery of Protein

pH	%protein
5.5	2.59
6.0	2.62
7.0	3.00
8.0	3.13
8.5	3.30

of 8.5. The sugar left after the separation of proteins was recovered by evaporation. The percentage of sugar was about 0.8% in pressmud.

Model for Wax Recovery

The wax recovered from pressmud was about 12%. It had a melting point of 79°C and a density of 0.96. The following mathematical expression was used to model the recovery of wax [5] :

$$E = Emax\ \theta/(\theta + k) \quad \ldots 1$$

Where, E_{max} and k are characteristic constants for given system, q represents the time of extraction and E represents the weight of wax. Fig. 1-3 show the recovery of wax in weight (g) as time proceeds using the solvents toluene, toluene and benzene (50%) and hexane, respectively. The maximum recovery of wax (0.1 mm particle size) was 2.7, 1.58 and 2.9 using toluene, toluene and benzene (50%) and hexane respectively. The maximum recovery of wax (0.5 mm particle size) was 1.2, 1.64 and 2.78 using toluene, toluene and benzene (50%) and hexane respectively. The maximum quantity of wax was recovered by using hexane as solvent. The results are reported in Table 6.

Table 6 : E_{max} and Values

SYSTEM	Emax (g)	K (min)
Toluene (0.1 mm)	6.67	0.17
Toluene (0.5 mm)	3.33	0.17
Toluene + Benzene (0.1 mm)	4.00	0.56
Toluene + Benzene (0.5 mm)	2.50	0.25
Hexane (0.1 mm)	7.23	0.8
Hexane (0.5 mm)	3.87	0.79

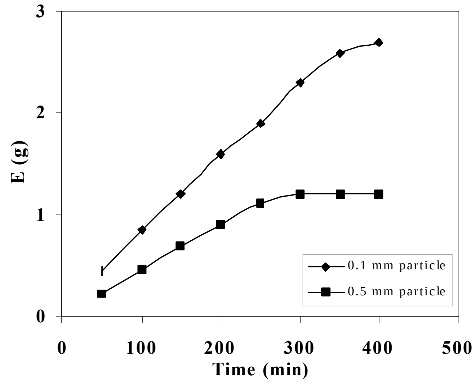

Fig. 1 : Extraction of Wax by Solvent Toluene

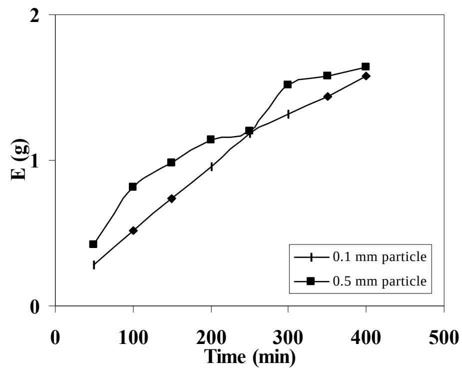

Fig. 2 : Extraction of Wax by Solvent Toluene and Benzene

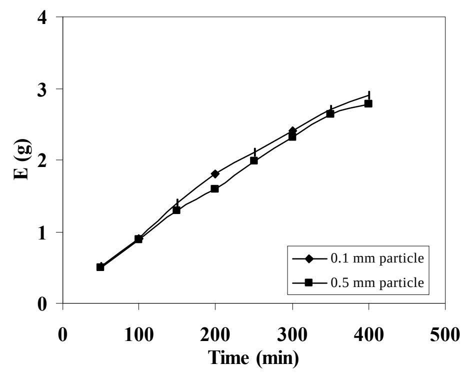

Fig. 3 :Extraction of Wax by Solvent Hexane

Conclusion

In conclusion, one could positively derive wealth from the sugarcane and sugar industry wastes. Studies are also done to model the Indian sugar industry with precise mathematical approaches and to forecast its performance in future. The amount of protein was estimated to be 3.3%. The percentage of sugar was about 0.8%. Extraction of wax by solvent resulted in a recovery of about 12%.

Acknowledgement

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Nomenclature

E_{max} Characteristic constant for given system
k Characteristic constant for given system
q Time of extraction, min
E Weight of wax, g

APPENDIX

Estimation of Protein

Estimation of protein was done by Lowry's method. The principle behind the method is the aromatic amino acids, tyrosine and trytophan present in the protein reacts with Folin-Phenol reagent (contains phosphomolybdic acid and tungstate) and produce a dark blue colour. The reagents prepared were sodium carbonate solution, sodium potassium tartarate solution and Folin-Phenol reagent. Standard protein solution was pipetted out into clean test tubes. Reagents were mixed and the blue colour at 650 nm was read in a spectrophotometer. From the standard graph, the concentration of unknown was obtained.

Estimation of Sugar

For estimation of sugar, anthrone reagent was used. The concentration of sugar was estimated with the help of a spectrophotometer.

Estimation of Wax

After the removal of proteins and sugar from the aqueous solutions, the remaining wax was repeatedly extracted with solvent hexane. Crude wax was separated from the wax laden solvent by chilling. The resulting wax was dried and weighed. The melting point of wax was found to be 79°C and specific gravity 0.96.