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Reuse and recycling of by-products of sugar industry: pressmud and bagasse flyash

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Abstract

Sugar Industries produce a huge chunk of waste which is organic and nutrient rich in nature. Owing to its nutrient enrichment, an effort has been made to suggest the best solutions for the two by-products of sugar industryi.e Press mud and Fly Ash. Out of the four by products of the sugar industry, worst nuisance is bagasse fly ash which adds to the burden of air pollution specifically in agro-based economies.The nutrient values of the press mud and fly ash were analyzed. Six samples of the two byproducts of sugar industry were collected every second month from three sugar industries i.e. two samples from each industry during the cane crushing season i.e. October – March.The samples were analyzed for N, P and K. and to compare their nutrient values with the soil conditioners, six samples of the locally available commercial fertilizers and municipal solid waste compost (3 each) were also collected.Press mud, which is used as a fertilizer,exhibited the average N, P and K valuesin the range of 1-2%. Fly ash on average showed nil Nitrogen and minute percentages of P and K. Thus fly ash was mixed with press mud in different ratios and a ratio of 95:05 was yielded the optimum values of N, P and K to be used as soil conditioner. When compared with therest of the soil conditioners, this mixture was found to be very much cost effective, time saving and of better nutritional value.

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Introduction

Pakistan is ranked 9th in terms of global sugar producers according to 2013 estimates. The sugar industry is the second largest and one of the well-organized industrial sectors in Pakistan after textile. It plays a vital role in the development of agriculture as well as industrial sectors because of its agro-based origin and directly or indirectly employs over 1.5 million people (LCCI, 2013).The geographical distribution of the sugar manufacturing units is diverse in Pakistan. All the sugar producing units are operating in the private sector (Nadia and Mahmood 2006). Sugarcane is the basic raw material for the industry and only 0.6% of sugar is produced from beet. Thus, sugarcane crop has assumed greater importance over the years (PSMA, 2007).

The environmental challenge for the local sugar mills is associated with liquid waste, gaseous emission and solid waste (Fig. 1). There are three major departments in sugar manufacturing i.e mill house, process house and boiler house. Main sources of solid waste are from mill house (bagasse), process house (press mud and molasses), and boiler house (fly ash) (ETPI, 2001). Apart from other wastes, for every 100 lac tons of sugar produced the sugar industry produces 32.1 lac tones of press mud and 333 lac tones of bagasse. Bagasse fly ash is a major source of air pollutant from the sugar industry. 55 kg of fly ash is produced per ton of sugar cane (PSMA, 2007).

Press mud is produced as a result of vacuum filtration. The precipitated impurities contained in the cane juice, after removal by filtration, form a cake of varying moisture content called press mud or filter mud. This cake contains much of the colloidal organic matter anions that precipitate during clarification, as well as certain non-sugars occluded in these precipitates (Tamilselvan *et al.*, 2006). Filter mud contains, on a dry basis, about 1 percent by weight of phosphate (P_2O_5) and about 1 percent of nitrogen. As a result, it has been used as a fertilizer (Soares *et al.*, 2006). Most of the sugar mills use bagasse as a fuel in boilers. The burning of bagasse in boilers produces particulate matter, oxides of nitrogen, carbon, sulphur and water vapour. Except for particulate matter (PM), other emissions of bagasse fired boilers remain within the limits prescribed by the pollution control authorities. The PM, usually referred to as fly ash, consists of ash, unburnt bagasse and carbon particles (Boris and Druce, 2005). Hot Flue gas generated as one of the waste from the boiler house contains 4500mg/m^3 of fly ash on an average. This is a visual nuisance as well as a health concern (Rahman and Tahir, 2009).

Studies have been carried out on the usage of Press mud as an organic fertilizer but not in combination with the bagasses ash (Md. Moshfekus *et al.*, 2012; Rehmat *et al.*, 2015;Amit*et al.*, 2015).Bagasse dust and fly ash are particular health irritants in sugar mills. Excessive exposure to fly ash and bagasse dust may cause irritation to eyes, asthma, and other respiratory diseases including bagassosis (a lung disease caused by inhalation of bagasse dust). Bagasse ash can be conveniently collected from the source by spraying water mist on it and thus collecting it on a conveyor belt.

The present study has been undertaken to highlight the purposeful utilization of the two by-products of the cane sugar industries of Pakistan, namely press mud and bagasse ash owing to their nutritional values for soil. The purpose was to assess the macronutrients required by the soil (N, P and K) in both the bye products and then compute their suitability of usage as soil conditioner on a commercial scale in comparison to the rest of the organic and inorganic soil conditioners available in the market.

Materials and methods

Location of study areas

The present study was conducted in three sugar industries located in the Punjab province, Pakistan. The raw material being utilized in all of the three sugar mills was sugarcane. In addition to this the three selected sugar mills were utilizing bagasse to produce electricity thus resulting in the production of fly ash.

First sampling point

The first sugar mill visited is located 35 km from the district of Mandi Bahaudin in the tehsil of Phalia. The mills major operations included the conversion of sugarcane into refined sugar and the production of ethanol from the refined sugar waste. It was a large scale mill with a crushing capacity of 8 tons per day and a distillery plant capacity of 125,000 liters per day of ethanol.

Second sampling point

The second sugar mill visited is situated in a rural setting of district Dera Ghazi Khan. The area has no significant industry nearby. It has a crushing capacity of 8 tons/day. The mills major operations included the conversion of sugarcane into refined sugar.

Third sampling point

The third sugar mill visited is situated in semi urban setting of district Kasur. It has a name plate crushing capacity of 6 tons/day. The mill is located on the main GT Road. The nearby major cities are Pattoki, Bhai Pheru and Okara, Sahiwal and Lahore. The mills major operations included the production of refined sugar from the sugarcane.

Sampling plan

The sites were subsequently visited in the month of October, November and December i.e., during the cane crushing season, which generally lasts from October to March. During the visits, detailed studies of the sugar manufacturing plants were conducted and samples of the by-products were collected from their point of production during the sugar-making process simultaneously. Grab samples were taken for the two by products.

The samples of press mud/filter cake were taken from the production house in sterilized plastic containers and the sample of bagasse ash was collected by using a Particulate Matter (PM) Suction Pump. The PM Suction Pump with an appropriate filter paper was placed for ten minutes outside the power houses of the three sugar mills, which were burning bagasse to generate electricity. After ten minutes, the filter paper with the collected bagasse ash was removed from the pump and sealed in a sterilized plastic cover and was transported to the laboratory for further analysis.

In addition to this, for the comparison purposes, the samples of locally available inorganic fertilizers and municipal solid waste compost samples (3 each) were also collected and brought to the laboratory for further analysis. Table 1 gives methods that were adopted for the analyzing the nutrient value of the collected samples.

Results and discussion

The results are based on the average values obtained from the analysis of the samples from three sugar industries (Table 2).

Comparison with respect tofertility value (average analysis)

Table 2 confirms that the samples of press-mud on an average contain almost the same amount of NPK (macronutrients) as that of the compost samples. While P and K were also found in Fly Ash Samples. Farmers generally use fertilizers to correct soil deficiencies.

Fertilizers contaminate the soil with impurities, which come from the raw materials used for their manufacture. Mixed fertilizers often contain ammonium nitrate (NH_4NO_3), phosphorus as P_2O_5, and potassium as K_2O. For instance, As, Pb and Cd present in traces in rock phosphate mineral get transferred to super phosphate fertilizer. Since the metals are not degradable, their accumulation in the soil above their toxic levels due to excessive use of phosphate fertilizers, becomes an indestructible poison for crops (Ju *et al.*, 2007). The results in table 2 imply that both of the bye products if collected efficiently and applied to the soil in mixture can be used as a source of fertilizer and can also reduce the dependency of farmers on inorganic fertilizers to some extent.

Table 1. Laboratory techniques used for the analysis of nutrient value of the samples

Sr. No.	Sample Type	Parameters Analyzed	Standard Method No./Instrument
1.	Press Mud	Moisture Content	ASTM D 2216
		pH	pH meter
		Nitrogen (N)	Kjeldahl Method
		Potassium (K)	Flame Photometer
		Phosphorus (P)	Spectrophotometer
2.	Fly Ash (unburnt carbon from bagasse)	Carbon (C)	LOI (Loss of Ignition Test)
		Nitrogen (N)	Kjeldahl Method
		Potassium (K)	Flame Photometer
		Phosphorus (P)	Spectrophotometer
3.	Locally available Inorganic Fertilizers	Nitrogen (N)	Kjeldahl Method
		Potassium (K)	Flame Photometer
		Phosphorus (P)	Spectrophotometer
4.	Municipal Solid waste Compost	Nitrogen (N)	Kjeldahl Method
		Potassium (K)	Flame Photometer
		Phosphorus (P)	Spectrophotometer

Table 2. Average nutrient values of the collected samples (Pressmud, Flyash, Inorganic Fertilizers and Municipal solid waste compost).

Sample Type	Components					
	N	P	K	C	pH	Moisture Content
Press Mud	1.81%	1.95 %	1.26 %	0.45%	7.6	90.62%
Fly Ash	Nil	0.011%	0.021%	2.25 %	9.2	ND
Local Inorganic Fertilizers	23%	23%	Nil	Nil	ND	ND
Municipal Solid waste Composts	1.94%	0.90%	2.04%	22.6 %	7.5	29.5%

ND = Not Detected

Table 3. Range of values obtained from the laboratory analysis of Pressmud + Flyash mixtures

Sr. No.	Component	Percentage
1.	N	0.8 -1.8%
2.	P	1.4 -2.5%
3.	K	0.66-1.7%

Press mud + fly ash

In order to assess the technical rationale of mixing and using them as soil conditioner, pressmud and fly ash from three different sugar industries were mixed and samples were analyzed. The analysis of press mud and fly ash mixture yielded a healthy Nitrogen, Phosphorus and Potassium values (Fig. 2, Fig. 3, Fig. 4).

It can also be used as an amendment in sugar cane growing areas as potassium depletes in those are as due to continuous cultivation of sugarcane crop. The optimum mixing ratio of press mud and bagasse fly ash was found to be 95:05. Table 4 concludes that the press mud and fly ash mixture of 95:05 is of almost equal nutrient value as that of municipal soil waste compost.

Table 4. Comparison of the average values of available soil conditioners

Component	Local Fertilizer	Compost	Press Mud	Fly Ash	Press Mud + Fly Ash (95:05)
N	23%	1.94%	1.81%	Nil	1.25%
P	23%	0.90%	1.95%	0.011%	1.9 %
K	Nil	2.04%	1.26%	0.021%	1.23 %
pH	-	7.5	7.6	9.2	7.9

Table 5. Comparison of the available soil conditioners W.R.T Availability

Component	Availability
Local Fertilizer	Available Everywhere
Compost	Available almost Everywhere
Press Mud + Fly Ash	Available in localities around sugar industries

Table 6. Comparison of the available inorganic fertilizers W.R.T price

Fertilizer	Price (Rs)/40 kg
DAP	2500
Urea	850
Potash	2700
Single Super Phosphate	500

The over use of NPK fertilizers reduce quantity of vegetables and crops grown on soil over the years. It also reduces the protein content of wheat, maize, grams, etc., grown on that soil. The carbohydrate quality of such crops also gets degraded (Lehesranta *et al.*, 2007). So it is the need of the hour to find a natural means of improving the soil fertility without degrading its sustainable quality. Thus the world especially the agrarian economies are now focusing on using the organic fertilizers either wholly or partially i.e in combination to the inorganic fertilizers. This effective use of these two bye products of the sugar industries can convert the wastes into the resource.

Table 7. Price Rates of Different Soil Conditioners.

	Local Fertilizer/40 kg	Compost/1200 kg	Press Mud + Fly Ash/1200kg
Price	500-2700 Rs	800 Rs	600 Rs

Comparison with respect to availability

With respect to the availability issue, this mixture of press mud and fly ash will be available in the localities around the sugar industries like in most of the areas of Punjab and Sindh (Table 5). Transportation cost will be included if this mixture is required in areas away from the sugar industries.

Comparison with respect to Price

Prices of four different types of fertilizers vary from SSP that is 500 Rs/40 kg to Potash that is 2700 Rs/ 40 kg.

In between are Urea that is Rs 850/40 kg and DAP that is Rs 2500/40 kg(Table 6). The price wise comparison of all the three soil conditioners indicates that the mixture of press mud and fly ash has the least price.

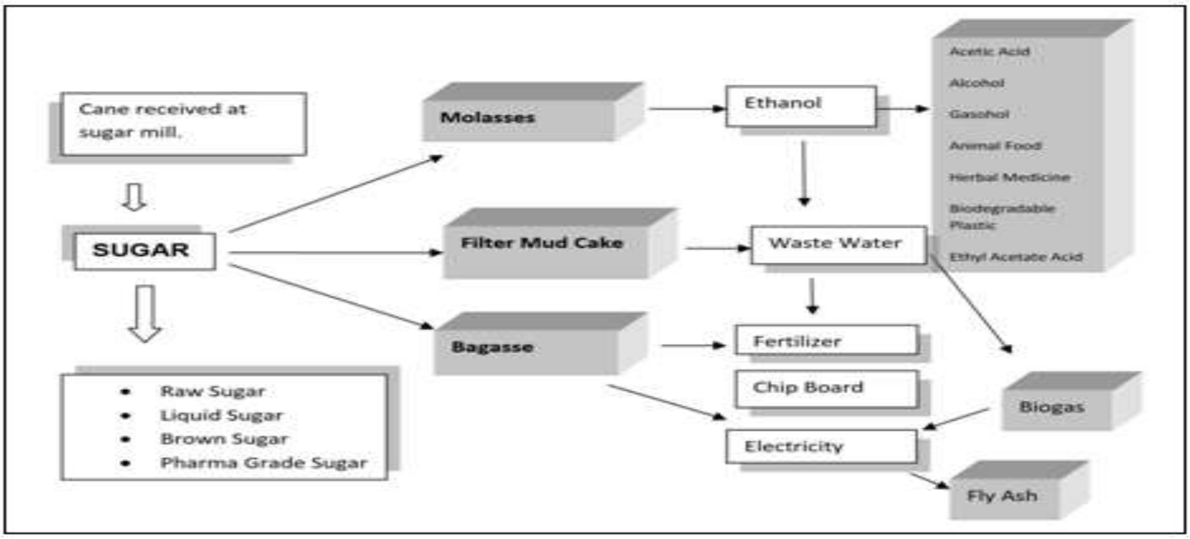

Fig. 1. Utilization and waste production from sugar cane (Author)

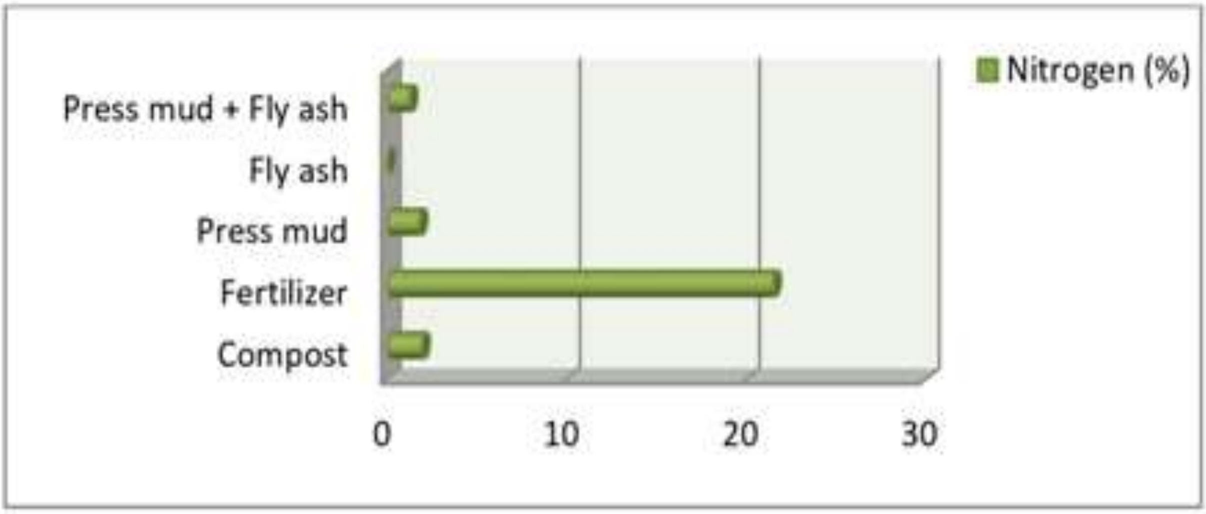

Fig. 2. Comparison of the nitrogen content of available soil conditioners

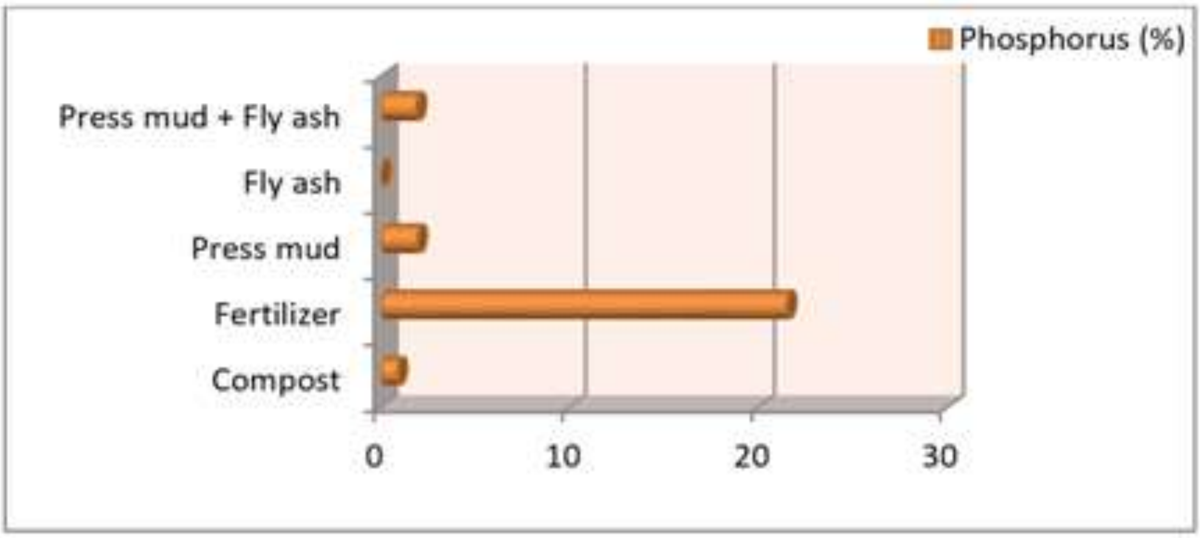

Fig. 3. Comparison of the phosphorus content of available soil conditioners

While the highest price is from the use of inorganic fertilizers followed by the price of compost. The only cost included in the price of press mud and fly ash mixture is that of transportation cost which depends upon the distance of sugar industry from the area where this soil conditioner is needed to be applied. These prices are initially a source of economic burden on the farmer and ultimately on the consumer at the tail end. Table 7 clearly shows that the mixture of pressmud and flyash can play an important role in putting off the farmers from the financial treadmill.

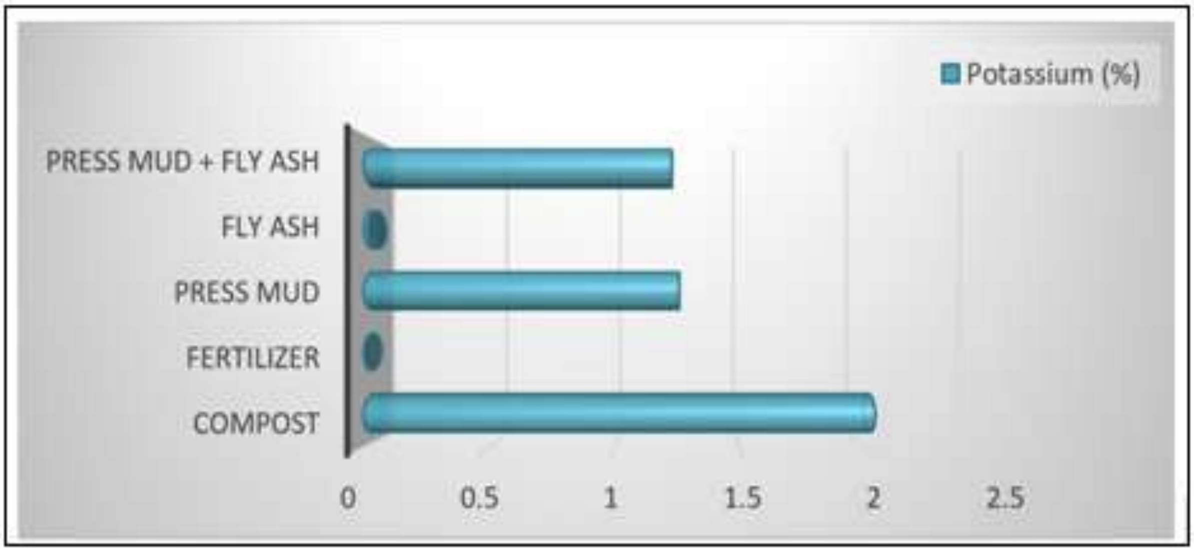

Fig. 4. Comparison of the Potassium content of available soil conditioners.

Conclusion

The undertaken study confirms that the sustainable utilization of the main byproducts of the sugarcane industry does indicate a few priority choices, generally applicable to the Developing Countries. Analysis and literature confirm the nutritive value of press mud for the soil. Analysis and literature also confirm the presence of P and K in the bagasse fly ash. Bagasse fly ash when mixed with press mud in a ratio of 95:05 was analyzed to beoptimal for application. With respect to fertility value, the mixture of press mud and fly ash is almost as good as compost. This mixture of press mud and fly ash will only be available in the vicinity of the sugar industries. Transportation of this mixture to far off areas will require an increase in the transportation cost. With respect to price, this mixture is free of cost as it is a waste for sugar industry and a resource for the farmers. Both the inorganic fertilizers and the compost are expensive when compared to the mixture as both require processing. The solid waste and air emission problems of the sugar industry can be sustainably reduced by the combined use of these two by products.

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