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RECYCLING OF SUGARCANE INDUSTRIAL WASTE AS A BIOFERTILIZER THROUGH COMPOSTING

Muhammad Anwar Arain[a] ***and Fatima Qamar***[*b]

[a] *Southernzone Agricultural Research Center, PARC, Karachi University Campus, Karachi - 75270, Pakistan*

[b] *FMRRC, PCSIR Laboratories Complex, Off University Road, Karachi - 75280, Pakistan*

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About 500 tons of industrial wastes (liquid and solid) being discharged daily from sugar factory during crushing season and presently dumped in vicinity of the sugar factory. The quantity of wastes, however, depends on the crushing capacity of sugar mills. Studies for recycling and composting of sugarcane industrial waste press mud, boiler ash and distillery waste water, as a biofertilizer, was carried out at Habib Sugar Mills Ltd., Nawabshah, Sindh, Pakistan. Samples of waste were collected for analysis from dumping ground. By mixing the heaps of press mud and boiler ash, 3:1 ratio was formed. Each heap was sprinkled with distillery waste water for two months with regular interval of one day. Two manual turning of heaps were done to maintain the temperature during the curing period and thereafter allowed for 3 months for decomposition and humus formation. Based on physico-chemical analysis of finished product, it is estimated that each ton of biofertilizer contains value-added nutrient of Rs.2897/= when compared with chemical fertilizer other than the soil amendment characteristic. The cost effectiveness of the biofertilizer for millers and farmers were about Rs.1:4 and Rs.1:12, respectively.

Key words: Sugarcane industrial waste, Compost, Biofertilizer, Press mud, Bioler ash, Distillery waste water.

Introduction

Urbanization, modernization and industrialization have increased solid waste generation, one of the major environmental problems being faced by the world today. This situation leads to solid waste management to cope with the situation that generally starts with the possible reduction of waste generation at source, then to reuse and recycle waste materials if possible. The left over material, at the end, is subjected to disposal. Generally, solid waste is disposed off in three ways i.e. incineration, sanitary landfill and composting.

Composting is a process in which biodegradable organic material is converted into soil conditioner that can be used to improve soil fertility. Developing countries like Pakistan can afford landfill and composting techniques to dispose off solid waste. Preferably, the biodegradable solid waste should undergo composting that results not only into the solid waste disposal but also provides useful product that can improve soil condition and will reduce expensive chemical fertilizer use. Use of chemical fertilizer has number of environmental problems that can be limited in this way (Khan 1996). To improve the soil fertility, the use of organic manure has a vital importance, but unfortunately farmers rarely applied the natural manure mostly due to unavailability and lack of knowledge.

In Pakistan, 74 sugar manufacturing industries are involved in sugarcane crushing and produced 3.2 million tons of sugar during 1998 - 1999 (Anonymous 1999). It was reported that the average amount of nutrient, i.e. N, P, K, Ca, Mg, S, Fe, Mn, Zn and Cu removed by 100 MT of cane were 148.00, 123.00, 238.00, 42.00, 39.00, 38.00, 7.50, 4.12, 0.50, and 0.10 kg, respectively (Calcino 1995). Since millions of tons of sugarcane industrial wastes (filter cake, boilers ash and distillery waste water) is being discharged each year and dumped in the vicinity of factories. These wastes carry sufficient amount of macro and micronutrients (Subba 1985). These nutrients could be effectively recycled for soil improvement (Hussein and Anjum 1999). Organic materials not only improve the soil fertility but also lessen the demand of chemical fertilizer. The major factor behind this low yield is seemed to be unbalanced fertilizer. Since last couple of decades growers mostly depend on NPK chemical fertilizers for crop production. This indiscriminate use of chemical fertilizer has led to massive depletion of organic matter, accumulation of deleterious salts and increased the soil pH as well (Arain *et al* 2000).

Sugarcane is one of the major cash crops of Pakistan. The total area under cultivation of sugarcane during 1998 - 1999 was 1.155 million hectare and the estimated yield was 55.19 million tons (Anonymous 1999). In this way, per hectare yield is about 48 tons / ha. The yield is quite low as compared to

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* Author for correspondence

other developing countries (Khushk 1999). The present study leads to develop a procedure for recycling of sugarcane industrial waste and to sustain the soil and nutrient requirement of sugarcane and other crops. The study also aims to determine the quantity of macro and micronutrients in the finished product or compost.

Materials and Methods

Analysis of industrial wastes. Studies were carried out at Habib Sugar Mills (Pvt) Ltd, Nawabshah from November 1998 to March 1999 to evaluate the physico-chemical properties of the press mud, boiler ash and distillery waste water. This sugar mill is equipped with distillery unit and boiler ash collection facilities. Approximately, 300 - 500 tons of industrial waste (solid and liquid) is being discharged daily, depending upon the crushing capacity of the factory. Fifty primary samples of each having weighed about one kg were collected randomly from the dumping ground. The samples were mixed together thoroughly and three laboratory samples were taken by a divider. These laboratory samples were kept in plastic bags, tagged and sent to the laboratory for analysis. The reference samples of the lots were also taken to maintain the record of physico-chemical contents. The sampling of industrial waste were taken four times during crushing season by adopting same procedure.

The nitrogen content was determined by oxidizeable carbon and organic matter content and C/N ratio were determined by dichromatic method (Rowell 1994). The fumigation and extraction method were used for determination of microbial population (Rowell 1994). The phosphorous content in the waste were extracted with sodium carbonate solution (Olson method) and phosphate content of solution by spectrophotometric method, potash and sodium by flame photometric method while calcium, magnesium and other micronutrients were measured by atomic absorption spectrophotometric method (Rowell 1994). The pH of industrial wastes was measured by using Orion meter (Model 201). The temperature of the heaps was recorded by installing the thermocouple leads in the bottom center and peripheral layers to ensure the proper composting. The Telethermameter Model 441/D series 63/18 was used for this purpose.

Following two equations can be used to compute moisture content and carbon - nitrogen ratio for three components system:

$$G = \frac{M1 \times Q1 + M2 \times Q2 + M3 \times Q3}{Q1 + Q2 + Q3} \quad (1)$$

Where Q = mass of material
G = required moisture in the pile (%)
M= moisture (%)

1.
$$R = \frac{Q1(C1x\ (100 - M1)) + Q2(C2x\ (100 - M2)) + Q3(C3x\ (100 - M3))}{Q1(N1x\ (100 - M1)) + Q2(N2x\ (100 - M2)) + Q3(N3x\ (100 - M3)}$$

Where

R = Required C/N ratio in the pile
C = Carbon %
N = Nitrogen %

Contents in the industrial wastes. The data presented in the Table 1 indicated the contents of industrial wastes.The filter cake contained 33.65 organic matter with 30:1 C/N ratio. The average nitrogen, phosphorous, potash, calcium and sulfur content were found to be 1.50, 2.68, 2.25, 2.72 and 1.47%, respectively. The micronutrient such as magnesium, iron, zinc were also present but relatively in less quantity. The pH of filter cake was 7.46 and moisture content was 53.85%. Filter cake as a manure in combination with chemical fertilizer sustained the soil fertility and crop productivity has been cited by earliers (Yadava 1991). Singh and Solomon (1995) showed an equal yield of sugarcane with application of 10 tons/ha press mud with 75 kg/ha as compared to 150 kg N/ha alone. Filtered press mud plays positive role in reclamation of saline alkaline and saline sodic soils and successfully decreases the soil pH. Approximately, millions of tons of filter cake is being produced annually in Asia and Pacific region having potential to recycle about 0.90 million tons of N, 1.08 million tons of phosphorous and substantial quantity of other essential minerals(Yadava 1991).

Table 1 also shows the composition of boiler ash; an average of 31.330% and 12.000% of silica and black carbon major content, respectively were recorded in boiler ash while calcium and magnesium were 2.880, 1.650 and 0.950%, respectively in ash. The other inorganic contents were found in relative less quantity. Boiler ash also contained sodium, aluminum and manganese in small quantity. Silica, the major component of boiler ash is an essential nutrient for increasing yields of sugarcane and sugar content. Application of 15 tons of silica increases the sugarcane productivity 70 and 125%, respectively in plant and ratoon crop (Gardner *et al* 1985). Lakshmikantham has reported that a ton of cane can remove 11.2 kg of silica as nutrient from the soil (Lakshmikantham 1983). In Australia, it was observed that in soil application of 150 tons/ha boiler ash provides 435 kg calcium, 390 kg potassium, 225 kg magnesium, 120 kg phosphorous and 60 kg nitrogen/ha (Calcino 1995).

The distillery waste water contains potash, calcium and sulfate 1.26400, 1.12400 and 1.16000%, respectively

Table 1
Physico - chemical contents of sugarcane industrial wastes

Parameters	Industrial wastes		
	Press mud	Boiler ash	Distillery waste water
Physico - chemical factors			
pH	7.46 ± 0.60	-	7.12000 ± 0.1300
Moisture (%)	53.85	49.47	92.50000
Organic matter	33.65	-	1.65000 ± 0.1900
C/N ratio	30:1	-	-
Nutrients (%)			
Nitrogen	1.50 ± 0.03	-	0.97000 ± 0.3600
Phosphorous (P_2O_5)	2.68 ± 0.26	-	0.66000 ± 0.0130
Potash (K_2O)	2.25 ± 0.76	2.88 ± 0.15	1.12640 ± 0.1600
Calcium	2.72 ± 0.41	1.65 ± 0.18	1.12400 ± 0.1600
Sulfur	1.47 ± 0.24	-	1.16000 ± 0.0300
Magnesium	0.30 ± 0.11	0.95 ± 0.05	0.47000 ± 0.0160
Iron	0.43 ± 0.10	-	0.12000 ± 0.0150
Zinc	0.33 ± 0.06	-	0.00340 ± 0.0003
Sodium	0.82 ± 0.18	-	0.00160 ± 0.0010
Mangnese	-	0.66 ± 0.07	0.00260 ± 0.0001
Aluminum	-	0.02 ± 0.00	0.00830 ± 0.0001
Silica	-	0.54 ± 0.44	0.00160 ± 0.0200
Boron	-	33.33 ± 0.57	0.00016 ± 0.0005
Cobalt	-	-	0.00010 ± 0.0000
Boiler ash %	-	31.330	-
Silica %		12.000	
Black carbon %	-	12.000	-

(Table 1). The other nutrients like nitrogen, phosphorous, magnesium and iron were found in waste water. The distillery waste water also have some other important micronutrients, zinc, sodium, manganese, aluminum, silica, boron and cobalt in very low quantities with other dissolved organic contents. During fermentation of molasses and ethanol distillation processes, large quantity of distillery waste water (13 liter of water/liter of ethanol) is generally discharged (Liu *et al* 1991). The distillery waste water possesses high manural, soil conditioning properties and also within this range distillery waste water was sprinkled on the heaps for two months to add more nutrients at a regular interval of one day. During this period, two turning was done manually to ensure proper mixing of ingredients. The heaps were then left over for three months for further decomposition and humus formation. Moreover, this will also help in the development of microbial population within the formulated biofertilizer (Maynard 1998).

Temperature. The temperature was recorded daily from different layers of the composting heaps to ensure microbial activity and composting process. Since, all microorganisms have an optimum temperature range for their growth and development. For composting, this range is between 32°C and 60°C (Maynard 1997).

Biological process. Microorganisms have the preferences for the type of organic material they consume. When the organic molecules that they require are not available, they may become dormant or die. In this process, the humic acid end product resulting from the metabolic activity of one generation or type of microorganisms may be used as a food or energy source by another generation or type of microorganisms. This chain of succession of different types of microbes continues until there is little decomposable organic material remaining (Maynard 1997). At this point, the organic material remaining is termed compost. It is made up largely of microbial cells, microbial skeletons and by products of microbial decomposition and un-decomposed particles of organic and inorganic origin. Decomposition may proceed slowly at first because of smaller microbial populations, but as populations grow in the first few hours or days, they rapidly consume the organic materials present in the feedstock (Breslin 1995).

Carbon contents of organic material can be determined on the basis of its volatile solid contents. Volatile solids are the components (largely carbon, oxygen and nitrogen) which are burnt from a dry sample in a laboratory at 500 - 600˚C, leaving only the ash (largely calcium, magnesium, phosphorus, potassium, and other mineral elements that do not oxidize). For most of the biological materials, the carbon content is between 45 to 60% of the volatile solids. Assuming 55%, the formula to calculate the carbon content is given below:

%C = %VS x 0.55 where %VS = 100 - %Ash

Results and Discussions

Data presented in Table 2 represent the various physicochemical properties of biofertilizer. The macronutrients were also calculated on dry weight basis while the nitrogen, phosphorus and potash were found 2.6000, 4.1700 and 7.2500% respectively, similarly the calcium, sulfur, silica and manganese contents were 10.8500, 5.1700, 5.2000 and 2.3300%. Iron, copper, zinc, magnesium and aluminum content were recorded as 0.6000, 0.5000, 0.4700, 0.4200 and 0.3200% respectively. The sodium content of biofertilizer was found to be 2.0000%. This is being due to saline soil in the area. The chemical environment is largely determined by the composition of material to be composted. In addition, several modifications can be made during the composting process to create an ideal chemical environment for rapid decomposition of organic materials. Several factors determine the chemical environment for composting, especially (a) the presence of an adequate carbon (food) energy source (b) a balanced amount of nutrients (c) the correct amount of water (d) adequate oxygen (e) appropriate pH, and (f) the absence of toxic constituents that could inhibit microbial activity (Maynard 1994a). Among the plant nutrients (nitrogen, phosphorus, and potash), nitrogen is of greatest concern. The ratio of carbon to nitrogen is considered critical in determining the rate of decomposition. In general, an initial ratio of 30:1 carbon: nitrogen is considered ideal. Higher ratios tend to retard the process of decomposition, while ratios below 25:1 may result in odour problems. Finished compost should have ratio of 15:1 to 20:1. To lower the carbon : nitrogen ratios, nitrogen rich materials such as yard trimmings, animal manures, or bio-solids are often added. Adding partially decomposed or composted materials (with a lower carbon : nitrogen ratio) as inoculumn may also lower the ratio. Attempts to supplement the nitrogen by using commercial fertilizers often create additional problems by modifying salt concentrations in the compost pile, which in turn impedes microbial activity (Maynard 1993a). As temperatures in the compost pile rise and the carbon nitrogen ratio falls below 25:1, the nitrogen in the fertilizer is lost in a gas form (ammonia) to the atmosphere. This ammonia is also a source of odours (Maynard 1993b).

The final moisture content of the compost was maintained at 40% so that the microbial population counts could be managed (Table 2). A moisture content of 50 to 60% of total weight is considered ideal (Maynard 1993b). The moisture content should not be great enough, however, to create excessive free flow of water and movement caused by gravity. Excessive moisture and flowing water from leachate create a potential liquid management problem and potential water pollution and odour problems. Excess moisture also impedes oxygen transfer to the microbial cells. Excessive moisture can increase the possibility of anaerobic conditions developing and may lead to rotting and obnoxious odours (Maynard and Hill 2000). Microbial processes contribute moisture to the compost pile during decomposition. While moisture is being added, however, it is also being lost through evaporation. Since the amount of water evaporated usually exceeds the input of moisture from the decomposition processes, there is generally a net loss of moisture from the compost pile. In such cases, adding moisture may be necessary to keep the composting performing at its peak. Evaporation from compost piles can be minimized by controlling the size of piles (Maynard and Hill 1994). Piles with larger volumes have less evaporating surface per unit volume than smaller piles. The water added must be thoroughly mixed so that all portions of the organic fraction in the bulk of the material are uniformly wetted and composted under ideal conditions. A properly wetted compost has the consistency of a wet sponge (Maynard 1998).

The compost also contained 58.62% organic matter with C/N ratio of 20:100, the microbial population in biofertilizer was 218 x 10^8 per gram and fungal count 125x10^5 per gram (Table 2). The final moisture content was kept at 40% so that the microbial population counts could be maintained. At this point, the organic material remaining is termed compost. It is made up largely of microbial cells, microbial skeletons and by pro-ducts of microbial decomposition and un-decomposed parti-cles of organic and inorganic origin (Maynard 1994b). Mic-roorganisms in the compost process are like microscopic plants; they behave more or less the same nutritional needs (nitrogen, phosphorus, potassium, and other trace elements) as the larger plants. There is one important exception, however, compost microorganisms rely on the carbon in organic material as their carbon/energy source instead of carbon dioxide and sunlight, which is used by higher plants (Maynard 1993a). The carbon contained in natural or human made organic materials may or may not be biodegradable. The relative

Table 2
Physico - chemical analysis of the finished compost by mixing filter cake, boiler ash and distillery water in 3:1:3 ratio and after curing of three months

Factors	Biofertilizer	
	Wet Basis	Dry basis
Physico - chemical factors		
pH	-	7.1000+0.250
Moisture content(%)	58.6200	40.0000
Organic matter	-	35.1700
C / N ratio	-	20:1
Microbial population	-	218×10^8/gm
Fungal count	-	125×10^5/gm
Nutrients (%)		
Nitrogen	2.6000	1.5600+0.2400
Phosphorous	4.1700	2.5000+0.1200
Potash	7.2500	4.3500+0.4600
Calcium	10.8500	6.5100+0.6500
Sulfur	5.1700	3.1100+0.2500
Manganese	2.3300	1.4000+0.0500
Iron	0.6000	0.3600+0.0020
Copper	0.5000	-
Zinc	0.4700	0.2800+0.0200
Aluminum	0.3200	0.1900+0.0700
Sodium	2.0000	1.2000+0.0200
Magnesium	0.4200	0.2500+0.0060
Silica	5.2000	3.1200+0.1300
Boron	0.0030	0.0020+0.0010
Cobalt	0.0002	0.0001+0.0000

Table 3
Nutritional value of the compost per ton

Nutrient	On dry weight basis quantaty of nutrient (kg / ton)	Market Price of nutrients (Rs.)
Macronutrient		
Nitrogen	15.60	234/=
Phosphorus (P_2O_5)	25.00	350/=
Potash (K_2O)	43.50	435/=
Sulfur	31.10	311/=
Calcium	65.10	65/=
Magnesium	14.00	140/=
Micronutrient		
Iron	3.60	43/=
Manganese	2.50	425/=
Silica	31.00	62/=
Zinc	2.80	392/=
Copper	0.40	155/=
Aluminium	1.90	285/=
Sodium	10.00	-
Total	-	Rs. 2897/=

ease with which a material is biodegraded depends on the genetic makeup of the microorganisms present and the makeup of the organic molecules that the organisms decomposes (Maynard 1998). For example, many types of microorganisms can decompose the carbon into sugars, but far fewer types can decompose the carbon into lignin (binding material in wood) and the carbon into plastics may not be biodegradable by any microorganisms (Maynard 1997). Because most municipal and agricultural organics and yard trimmings contain adequate amounts of biodegradable forms of carbon, carbon is typically not a limiting factor in the composting process. As the more easily degradable forms of carbon are decomposed, a small portion of the carbon is converted to microbial cells, and a significant portion of this carbon is converted to carbon dioxide and lost to the atmosphere. As the composting process progresses, the loss of carbon decreases the weight and volume of the feedstock. The less easily decomposed forms of carbon will form the matrix for the physical structure of the final product - compost (Maynard 1995).

Microorganisms are responsible for the degradation of organic material. Peak performance by microorganisms requires that their biological, chemical and physical needs be maintained at ideal level throughout all stages of composting (Poincelot 1975). Microorganisms such as bacteria, fungi, and actinomycetes play an active role in decomposing the organic material. Larger organisms such as insects and earthworms are also involved in the composting process, but they play a less significant role compared to the microorganisms (Maynard 1996). As microorganisms begin to decompose the organic material, the carbon in it is converted to by products like carbon dioxide and water, and a humic end product - compost. Some of the carbon is consumed by the microorganisms to form new microbial cells as they increase their population . Heat is released during the decomposition process (Poincelot 1975).Decomposition may proceed slowly at first because of smaller microbial populations, but as populations grow in the first few hours or days, they rapidly consume the organic materials present in the feedstock (Breslin 1995).

The pH of composted material was found to be about 7.1000 (Table 2). The pH between six and eight is considered optimum. The pH affects the amount of nutrients available to the microorganisms, the solubility of heavy metals, and the overall metabolic activity of the microorganisms. While the pH can be adjusted upward by addition of lime or downward with sulfur, such additions are normally not necessary. The composting process itself produces carbon dioxide, which, when combined with water, produces carbonic acid. The carbonic acid could lower the pH of the compost. As the composting process progresses, the final pH varies depending on the specific type of feed stocks used and operating conditions. Wide swings in pH are unusual. Because organic materials are naturally well buffered with respect to pH changes, down swings in pH during composting usually do not occur. Increasing cost of commercial fertilizer emphasizes the need to find out some alternatives resources and methodology for the improvement of the efficiency of added fertilizer (Twyford 1994). The use of biofertilizer for increasing crop yeild, will help the farmer's community belonging to low income group (Hussain and Anjum 1999). The biofertilizer helps in loosening of clay soil and binding of sandy soil, increasing the availability of oxygen, nutrients at rhizosphere and increases the water holding capacity (Bhatti 1999).

The temperature during composting ranges 50˚C to 60˚C. However, it markedly varies over composting period indicating the biological decomposition. For each group of organisms, as the temperature increases above the ideal maximum, thermal destruction of cell protein kills the organisms. Likewise, temperatures below the minimum required for a group of organisms, affects the metabolic regulatory machinery of the cells. Although, composting can occur at a range of temperatures, the optimum temperature range for thermophilic microorganisms is preferred, for two reasons i) to promote rapid composting, ii) and to destroy pathogens and weed seeds. Larger piles build up and conserve heat, build up and conserve heat is better than smaller piles. Temperatures above 65˚C are not ideal for composting. Temperatures can be lowered, if needed by increasing the frequency of manual turning. Mixing or mechanical aeration also provides air for the microbes. Pathogen destruction is achieved when compost is at a temperature of greater than 55˚C for at last three days. It is important that all portions of the compost material be exposed to such temperatures to ensure pathogen destruction throughout the compost (Maynard 1995). At these temperatures, weed seeds are also destroyed. After the pathogen destruction is completed, temperatures may be lowered and maintained at slightly lower levels 51˚C to 55˚C (Maynard 1996).

Nutritional value added cost of compost. Table 3 reflects the quantities of different macro and micro nutrients in one ton of compost. It was estimated that with each ton of compost contain nutrients worth Rs. 2897/= that could be added to the soil. This cost does not include the other benefits, like enrichment of organic matter, increase in microbial population, lowering of soil pH, improvement of the soil physical properties and also increase in the availability of nutrient to plants etc.

Table 4

Cost effectiveness of biofertilizer

a)	*Farmers cost on application of biofertilizer*		
1.	Cost of 3 tons of biofertilizer per acre @ Rs.150/= per ton	=	Rs.450.00/=
2.	Transport cost per ton @ Rs.100/= per ton within 20km.	=	Rs.300.00/=
	Total Cost	=	Rs.750.00/=
b)	*Cost incurred on prepration of one ton of biofertilizer by miller*		
1.	Operational cost (includes staff salary, machinery, POL, 16% interest on capital etc.)	=	Rs.17.55/=
2.	Waste collection and shifting cost	=	Rs. 5.10/=
3.	Publicity and advertisement	=	Rs. 7.29/=
4.	Land rent	=	Rs. 2.91/=
5.	Miscelleneous	=	Rs. 7.15/=
	Total	=	Rs.40.00/=
c)	*Cost-benefit ratio*		
1.	In respect to biofertilizer application per acre of land (Rs. 8691/= as cost of nutrients, Rs. 750 as transport cost incurred by the farmer)	= or	Rs.750 : 8691 1:11.60
2.	Cost in respect to millers	= or	Rs.120 : 450 1:3.75

It is likely to reduce the 20 to 30 % demand of chemical fertilizer initially (Singh and Solomon 1995). They also reported that continuous use of biofertilizer increases the sugarcane yield by 20% with an additional income of Rs. 3500/=. Mineralization of biofertilizer in the soil improves the population of ammonifying bacteria. The decomposition of biofertilizer in the field supplements the demand of farmyard manure (Bhatti 1999). The population of *Azobacter, Azospirillum* and ammonifying bacteria increases several fold with the continuous use of biofertilizer in the agricultural fields (Singh and Solomon 1995). They also recommended that the application of biofertilizer to the soil provokes the development of soil microbial life, it maintains the soil pH, increases the cation exchange capacity increase the availability NPK and improves the structural stability of soil. Biofertilizer also regulates the release of NPK fertilizer and provides nutrient to sugarcane and other crops as per their requirement (Bhatti 1999). During decomposition of filter cake, heat is generated and may catch fire. Mixing of boiler ash and distillery water that exerts a sponging and buffering effect and allows free exchange of heat and gases can prevent this. The heat generated during decomposition released in air and moist condition enhanced the microbial activity to produce good biofertilizer. The by-products of sugar industry are bagasse molasses, press mud, distillery effluents (Paturou 1982); (Zende and Patil 1988).

Cost economics. Table 4 summarizes the cost economics of recycling of sugar industrial waste into biofertilizer. Keeping in view, the recycling cost at commercial scale it was calculated that each ton costs around Rs.40/= to the millers if the sale price is fixed at Rs.150/= per ton. The cost benefit ratio is about 1:4 in favour of the millers. However, the farmer will have to spend Rs.750/= (Rs.450/= for 3 ton/acre as cost of biofertilizer and Rs.300/= as transport charges) for each acre of the land. By spending Rs.750/= the farmer adds macro and micronutrients worth Rs.8691/= to each acres of his land besides harvesting other important benefits discussed before, therefore, cost effectiveness for farmer is about 1:12. However, the mill owner can give more relaxation to farmers in cost of biofertilizer for improvement of soil health and other environmental and mutual benefits.

Conclusion

Disposal of sugarcane industrial wastes is a big challenge for industrialist because it requires larger area for dumping, as it produces foul smell environmental pollution and health hazard problems in the vicinity. Since synthesis of sucrose in sugarcane involves CO_2 and H_2O, through metabolic process. The huge amount of nutrient transported from soil with sugarcane crop may cause rhizosphere depletion of essential macro and micro nutrients in the field, therefore, the vitality and success of sugar industry were found in recycling sugarcane industrial wastes as biofertilizer. The only use of chemical fertilizer can not solve the nutrient depletion problem of Pakistani soil. Since, chemical fertilizer was developed as nutrient correction factor but it was adopted as a solution for soild fertility. It is, therefore, recommended that each sugar industry should develop sugarcane industrial wastes recycling facilities for sustainable agriculture.

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