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Studies on the composting and recycling of sugar industrial waste

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Abstract

In India, Sugarcane is one of the most important cash crops with 400 sugar mills ranks it is the second major agro-industry. Pressmud a by-product of sugar-mill is produced at 3% per ton and molasses 2.5% per ton of cane crushed. Molasses serves major raw material for production of alcohol. In India nearly 2.7 billion litres of alcohol in every year and 45 billion litres of spentwash were produced following sulphidation and carbonation process respectively . Present study was undertaken to analyze the physical and chemical characteristics of raw pressmud and spentwash. Biocompost were prepared by using *Bacillus sphaericus, Aspergillus fumigatus* and *Trichoderma reesei*. Follow eight test combination are carried out the composting process and while comparing physical and chemical characteristics, it was found that T7(*Bacillus sphaericus + Aspergillus fumigatus + Trichoderma reesei*)have lower temperature, water holding capacity, pH and carbon content but heigher electrical conductivity, available phosphorus and moisture content as compared to other pressmud compost. Pressmud and Spentwash may be used to produce rich organic manure in an eco-friendly way and avoid land water pollution. They Improved compost quality and applied in sunflower various factors like germination of seed, seedling height and vigour index were analysis.

Keywords: *Sulphitation pressmud, composting methods,T7 – Test compost 7 - Bacillus sphaericus, Aspergillus fumigatus* and *Trichoderma reesei.*

Introduction

Sugarcane is one of the most important cash crops capable of producing high biomass yielding energy in the form of sugar, power and alcohol. India has the largest area of sugarcane, 4.23 million ha and yielding about 299 million tonnes of sugarcane and 15 million tonnes of sugar. Sugar industry also produces 7.5 million tonnes of molasses. Molasses serve as a raw material for alcohol production yielding 2.70 billion litres of alcohol by releasing 45 billion litres of spentwash possessing very high BOD. The sugar industry is one amongst the largest agro based industries in India letting out huge quantities of solid and liquid wastes causing environmental concern (Rajukannu *et al.*, 1996).Pressmud waste forms 3 per cent of total cane crushed accounting for 18,000 tonnes per year from each sugar factory with a crushing capacity of 25,000 tonnes per day. The value of pressmud as an organic manure has been well recognized for utilizing in agriculture as it contains valuable plant nutrients in organic form besides being a very effective soil ameliorant and soil conditioner (Rai *et al.*, 1980). Spentwash is a dark coloured, turbid liquid containing large amount of dissolved salts with very high BOD and COD values. The plant nutrients

like N, P and K are also present in the effluent. The disposal of such a large volume of effluent causes environmental pollution in the receiving ecosystems.
Distillery also generates about one million tonnes of yeast sludge as solid waste (Senthilkumar 1997). This waste by-product is also referred as molasses soluble, molasses sludge, molasses stillage or slop and rum distiller's stillage. Dried form of yeast sludge is a promising source of protein and nutrients like B-complex vitamins. However, it has become a challenge to dispose off this sludge in an eco-friendly way. In the entire areas of waste recycling, composting technology emerges as one of the most widely acceptable methods for handling diverse wastes (Tandon, 1995a). Blended solid industrial wastes which are rich in nitrogen with crop residues, having adequate C/N ratio, provides an effective, environmentally acceptable option for waste disposal and simultaneous generation of valuable agricultural inputs. Spentwash released as such to the environment cause lot of concern on soil physico-chemical properties, soil health, soil nutrient uptake and soil productivity. At present, the technology followed in the spentwash disposal by mixing with pressmud and developing a biocompost as organic nutrient input lacks a scientific approach and well furnished data on the quality of compost produced by sugar factories. Hence there is an immediate need to perfect this technology and to generate valuable data to show as it has no impact on soil and at the same time it is a valuable organic nutrient input in agriculture. The existing method of disposing the solid and liquid wastes from sugar factories including distillery needs a scientific approach in order to reduce the hazardous effect on the environment, to reduce the period of composting and to improve the via.

Materials and Methods

The methods of cleaning glassware preparations, dispensing media and steam sterilization procedures were as per the standard techniques in microbiology. The chemicals used in the experiments were L.R/A.R grade and glass distilled water was used throughout the study.

Compost site and sampling

Organic fraction of pressmud compost was sampled in small scale composting plant in Landfill. The waste was processed in open windrows of about 15 m length, 2m of width and a height of 1m. The windrows were turned two times per month with a compost turner. Samples were taken daily the first four days and weekly during rest of the time (26 weeks) at a deep of 15cm below the surface, according to Olynciw (2002). From each pile three samples were taken from separated positions (about 5m distance), each of these samples was composed of three subsamples that were bulked after sieving (<8mm mesh).Samples were transporter to the laboratory rapidly and all the trials were made in the same day.

Physical and chemical parameters measured

Temperature of the piles was monitored daily during the process using composting thermometers inserted at different heights in the piles. The water content was determined by drying of samples at 105ºC for 48 h. For pH and electric conductivity measurement, a solid-liquid extraction was carried out: compost samples were diluted 1:10 in distilled water, placed in a shaker for 24 h and finally a vacuum filtration was made.

Isolation of microbial cultures from compost

The compost sample (5g) was diluted in 45 mL of buffer solution (0.06MNa2HPO4/NaH2PO4) (1/9 v/v), pH 7.6. Decimal serials dilutions (10-1 to 10-10) were made and inoculated aseptically in Petri dishes (10 µL for plate) with different culture media: Potato Dextrose Agar (PDA), Nutrient Agar (NA) and Starch Ammoniacal Agar(SAA); in order to facilitate the growth of fungi, bacteria and actinomycetes respectively. Petri dishes were incubated at 30°C (mesophilic microorganisms) and 50°C (termophilies) for 72h (PDA), 37°C or 50°C for 24h (NA) and 37°C or 55°C for 120 h (SAA), according to the phase were the isolation was carried out. After incubation isolated colonies of bacteria, fungi and actinomycetes were selected. The evaluation of cellular concentration in a compost samples was determined by plate counting of serials dilutions according to equation 1:CFU/g = Colonies Numbers • dilution •100 (Eq.1)

Characterisation of isolates

Conventional morphological criteria and biochemical test were made to pure culture of bacteria and actinomycetes according to Bergey's Manual (1994).

2.1.Isolation and screening of cellulolytic micro-organisms

Cellulose degrading fungi and bacteria were isolated from pressmud. For isolation, pressmud was taken in sterile distilled water, made into slurry and kept in a shaker for 15 min. An aliquot of this sample was serially diluted with dilution blanks and plated on cellulolytic medium containing 0.5 per cent cellulose and for bacteria in modified nutrient agar medium. For fungi, 1 per cent cellulose and 1 ml of 100 ppm streptomycin sulphate incorporated in modified Sabouraud dextrose agar medium (Smith and Dawson, 1994) was used. After incubation, the isolated bacteria were purified by streak plate technique and fungal cultures were purified by single hyphal tip method (Ricker and Ricker, 1936) and maintained in modified cellulose agar slopes under refrigerated condition and subcultured once in a month.

2.2. Characterization of fungal isolates

Purified fungal cultures were characterized by their morphology, hyphal characteristic, presence or absence of asexual spores, arrangement of conidia and reproductive structures (Alexopoulos and Mims, 1979; Beisher, 1991).

2.2.1. Morphological characterization

Morphological characterization of the fungal isolates was studied without disturbing the arrangement of spores and conidia with microculture technique (Beisher, 1991). Sabouraud dextrose agar medium was poured (Appendix I) into the sterile Petri plates and allowed it to solidify. From that plate micro culture agar block was cut, made sure that the slide was balanced horizontally across the bend glass rod. Then 1 cm square Sabouraud dextrose agar block was cut and lifted using sterilized spatula and placed on the slide, inoculated all the four upper edges of the block with spores of fungal culture. Then, sterile cover slip was placed on top of the inoculated agar block, placed the moistened filter paper into the bottom of the micro culture plate. Replaced the petridish lid and incubated right side up in room temperature (28°C) for 3-6 days. During incubation, the slide was observed frequently under low power and high power objectives of the phase contrast microscope.

2.3. Analysis of treated distillery spentwash

2.3.1. Collection of spentwash samples

The spentwash samples were collected periodically from M.R.K.Co-operative Sugars Ltd., Sethiathope. The treated spentwash were periodically assessed for their physical, chemical and biological properties. Spentwash for the estimation of microbial diversity was collected in 250ml sterilized bottles. The sampling bottles were closed with a ground glass stopper having on overlapping rim. The stopper was relaxed by an intervening strip of paper to prevent breakage during sterilization. The bottles were protected by covering with aluminum foil and sterilized in an autoclave at 20 lbs for 15 minutes. The bottles were opened only at the time of sampling.

2.3.2. Preservation of spentwash sample.

The spentwash for the analysis of dissolved oxygen (DO) was added with one ml of manganese sulphate solution and one ml of potassium iodide solution as given under the procedure for the estimation of dissolved oxygen. Samples for the determination of biochemical oxygen demand (BOD) were preserved by adding five ml of washed chloroform (Chloroform and distilled water were taken in a separating funnel. Shaken well and the water layer was discarded) per liter of the sample (Anon, 1989).

2.4. Analysis of physico-chemical and biological properties of spentwash samples

The physical, chemical and biological characteristics of the spentwash samples were analysed as per the methods described under.

2.7.1. Physical properties

S.No.	Parameters	Method	Reference
i	Color and foam	Assessed by visual comparison with distilled water	Anon (1989)
ii	Suspended solids	A known quality of the effluent was filtered using whatman No.1 filter paper and the residue was dried at 105°C to a constant weight	Anon (1989)
iii	Dissolved solids	The filtrate obtained from the suspended solids was evaporated and dried at 105°C to a constant weight	Anon (1989)
iv	Total solids	The sum of suspended and dissolved solids gave the total solids.	Anon (1989)

2.7.2. Physico chemical properties

S.No.	Parameters	Method	Reference
I	pH	Using a digital pH meter 335 with glass electrode	Jackson (1973)
II	Electrical conductivity (EC)	Using a CM 180 ELICO conductivity meter	Jackson (1967)
III	Dissolved oxygen	By azide modification of iodometric method	Anon (1989)
IV	Biochemical oxygen demand (BOD)	Iodometric method	Young *et al.* (1981)
V	Chemical oxygen demand (COD)	Open reflux method	Moore *et al.* (1949)
VI	Organic carbon	Chromic acid wet digestion method	Walkley and Black (1934)
VII	Nitrogen	Bremner method	Jackson (1973)
VIII	Phosphorus	Calorimetrically	Jackson (1973)
IX	Potassium	Using EEL flame photometer	Jackson (1967)
X	Chloride	Mohr's method	Jackson (1967)
XI	Sulphate	Trubidometric method	Tandon (1995b)
XII	Calcium and magnesium	Versenate method	Jackson (1973)

2.8. Analysis of pressmud

2.9.1. Collection of pressmud wastes

Pressmud samples were collected from M/s. M.R.K. Co-operative Sugar Ltd., Sethiyathope, Cuddalore District, (Tamilnadu).

2.9.2. Preparation of samples

The pressmud samples were collected periodically from M/s. M.R.K. Co-operative Sugar Ltd., Sethiyathope, Cuddalore District of Tamil Nadu were stored in polythene bags and were analysed for its physical, chemical and biological properties

2.9.3. Standard methods followed for the chemical and Biochemical analysis of pressmud wastes

S.No	Estimation	Method	Author
1.	pH	1:10 solid waste: distilled water using pH meter	Falcon *et al.* (1987)
2	Electrical conductivity (EC)	1:10 solid waste: distilled water using conductivity fridge	Falcon *et al.* (1987)
3	Total organic carbon	Using heating at 550-600°C in a muffle furnace	Gaur (1987)
4	Total nitrogen	Using Sani automatic kjedahl apparatus.	Bremner (1965)
5	Total phosphorus	Vanadomolybdic colorimetric method	Jackson (1973)
6	Total potassium and sodium	Neutralization of triacid with ammonia method and reading in an ELICO CL-360 flame photometer	Jackson (1973)
7	Total micronutrients	Using atomic absorption spectro photometer	Lindsay and Norvell (1978)
8	Cellulose	Anthrone reagent, colorimetric method	Updegraph (1969)
9	Bacteria,Fungi Actinomycetes	Standard serial dilution plating technique	Jenson (1968).

2.10. Composting of pressmud and distillery spentwash

Composting was initiated during the month of December 2009 at M/s. Agro Science Laboratories, Shri Dhanalakshmi Industrial Garden, Santhavelipet, Vadalur, by following the windrow method of composting. Samples were withdrawn at periodical intervals for analyzing the physico-chemical properties, nutrient content and microbial diversity.

2.10.1. Composting

Pressmud and distillery spentwash was composted by employing cellulose and Hemicellulose degrading microbes *viz*., *Bacillus spheroticus*, *Aspergillus fumigatus* and *Trichoderma reesei* isolated from pressmud wastes, distillery spentwash and yeast sludge waste obtained from M/s. M.R.K. Co-operative Sugar Ltd., Sethiyathope, Cuddalore District and Chemplast Chemicals, Kadampuliyur, Panruti, Cuddalore District. The treatment details are as follows.

Treatment details

T_1. ***Bacillus sphaeroticus***
T_2 ***Aspergillus furnigatus***
T_3 ***Trichoderma reesei***
T_4 ***B. sphaeroticus* + *A. fumigatus***
T_5 ***B. sphaeroticus* + *T. reesei***
T_6 ***A. fumigatus* + *T. reesei***
T_7 ***B. sphaeroticus* + *A. fumigatus* + *T. reesei***
T_8 **Control (uninoculated)**

Design: Randomized Block Design (RBD) with three replicates

2.11. Composting technology

Composting experiment was carried out at M/s. Agro Science Laboratories, Shri Dhanalakshmi Industrial Garden, Santhavelipet, Vadalur, Tamil Nadu. The basic raw material used for composting is pressmud and spentwash. The composting trial was carried in aluminium foliar cups having size of 20 cm x 10cm. The basic raw material used for composting were spent wash and pressmud. Spentwash was added at the rate of one part with two parts of Agro industrial waste. The size of the windrow with dimension of 25 meter length, 2.5 meter width at the base and 1.5 meter height. Microbial inoculants/consortia were added at the rate of (0.2%) of broth culture kg^{-1} of pressmud on 7^{th} day. From 7^{th} day onwards measured quantities of treated distillery spentwash was added at the rate of 1:1 (w/v) pressmud-effluent ratio from once in 2 days interval upto 45 days to maintain moisture. After each addition of effluent to aluminium foiler cups. The pressmud and effluent were thoroughly mixed. The waste material were mixed thoroughly by manual mixing the pressmud and distillery spentwash and optimum moisture level of 50 to 60% was maintained through the period of compost.

2.12. Collection and analysis

Three replicates of samples were collected periodically at an interval of 15 days upto 45 days. The collected samples were air-dried, ground and sieved using 2 mm sieve and stored inpolythene bags for various physico-chemical characteristics using standard procedures. The microbial population dynamics was also assessed by standard protocols.

2.12.1. Physico-chemical and microbial analysis of pressmud compost

S. No	Parameters	Method	Reference
1	Temperature	Using thermometer	Bhoyar *et al*. (1979)
2	Moisture	Drying the sample at 105°C to constant weight	Yaduvanshi, *et al* (1990)
3	pH	Compost water suspension at 1:5 ratio by using pH meter	Yaduvanshi, *et al* (1990)
4	Electrical conductivity	Compost water suspension at 1:5 ratio by using conductivity bridge	Yaduvanshi, *et al* (1990)
5	Nitrogen	Microkjeldhal's method	Jackson (1973)
6	Phosphorus	Vanadomolybdate yellow color method	Jackson (1973)
7	Potassium and sodium	Flame photometer	Jackson (1973)
8	Calcium and magnesium	Tri acid extract	Tandon (1995b)
9	Total micronutrients (Cu, Zn, Mn and Fe)	Atomic absorption spectrophotometer	Jackson (1973)
10	Organic carbon	Chromic acid wet digestion method	Walkey and Black (1934)
11	Enumeration of bacteria, Fungiand Actinomycetes	Serial dilution and plating technique	Jenson (1968)
12	Compost maturity	Germination test. Color, odour. C:N ratio	Lossin (1971)

2.13. Biometric observations

From each treatment, three replications were chosen for measuring and recording the biometric observations. Plants were observed at periodic intervals *viz*., 10 DAS and 20 DAS. The biometric observations like plant height of sunflower were recorded.

2.13.1. Germination percentage

The counts were taken as per the ISTA rules (1993) and expressed in percentage.

2.13.2. Vigour index

2.13.2.1. Root length

Root length was measured from collar region to the tip of the primary root and expressed in cm plant^{-1}.

2.13.2.2. Shoot length

The seedlings were again measured for the distance between collar and tip of the primary shoot. The mean value of the shoot length was recorded and expressed as cm plant^{-1}.

Vigour index (V1) calculated for each replication by using the formula suggested by Abdul-Baki and Anderson (1973).

VI = (Root length + Shoot length) x Germination (per cent)

2.13.2.3. Plant height

Plant height in cm was recorded at 10 DAS and 20 DAS. lue of biocompost.

3. Results Discussion

3.1.Physico-chemical properties of pressmud used for composting

Pressmud is a soft, spongy, amorphous and dark brown to brownish material, which contains sugars, fibre and coagulated colloids, including cane wax, albuminoides, inorganic salts and soil particles. The composition of pressmud varies and depends upon the quality of cane and process of cane juice clarification followed. The composition of the pressmud collected from M/s. M.R.K. Co-operative Sugar Ltd., Sethiyathope, Cuddalore District, (Tamilnadu) used for composting in the current study is presented in Table 1.

Organic carbon in the pressmud was found to be 32 per cent that includes major hemicellulosic fibre of 20.24 per cent followed by cellulose (13.74%) and lignin (13.46%). The pH (1:10 w/v) of 6.3, EC (dSm^{-1} 1:10 w/v) of 2.92 and total phenols of 22.18 (mg 100 g^{-1}) was recorded. The inorganic constituents, in terms of percentage was 1.26 for total nitrogen, 1.61 for total phosphorus, 4.25 for total calcium, 1.53 for total magnesium, 1.24 for total sulphur and 0.92 for total potassium. The trace elements in terms of mg kg^{-1} were 130 for total Zinc, 1450 for total iron, 115 for total manganese and 52 for total copper.

Table 1 Physico-chemical properties of pressmud used for composting

Sl. No.	Parameters	Content
1.	pH (1:10 w/v)	6.30
2.	EC (dSm^{-1}) 1:10 w/v	2.92
3.	Organic carbon (%)	32.0
4.	C:N ratio	27.17
5.	Total nitrogen (%)	1.26
6.	Total phosphorus (%)	1.61
7.	Total potassium (%)	0.92
8.	Total calcium (%)	4.25
9.	Total magnesium (%)	1.53
10.	Total sulphur (%)	1.24
11.	Total zinc (mg kg^{-1})	130
12.	Total iron (mg kg^{-1})	1450
13.	Total manganese (mg kg^{-1})	115
14.	Total copper (mg kg^{-1})	52
15.	Cellulose (%)	13.74
16.	Hemicellulose (%)	20.24
17.	Lignin (%)	13.46
18.	Total Phenols (mg kg^{-1})	22.18

3.2. Physico-chemical properties of distillery spentwash

In India, alcohol is produced mainly by the fermentation of diluted sugarcane molasses solution. After fermentation, alcohol is separated by distillation and the residual liquid is discharged as waste water generally known as spentwash. The raw as well treated distillery spentwash collected from M/s. M.R.K. Co-operative Sugar Ltd., Sethiyathope, was analysed for physico chemical properties and used in the present study (Table 2).

Table 2 - Physico-chemical properties of Distillery Spent wash

S,No	Parameters	Untreated	Treated
1.	Colour	Dark brown	Reddish brown
2.	Odour	Unpleasant	Mild molasses
3.	Turbidity	High	High
4.	Temperature	80°C	32°C
5.	pH	4.0	7.6
6.	EC (dSm^{-1})	28.00	13.00
7.	BOD (mg l^{-1})	41,000	3200
8.	COD (mg l^{-1})	90,000	18000
9.	Suspended solids (mg^{-1})	5,500	3400
10.	Total dissolved (TDS) solids (mg l^{-1})	87,000	38400
11.	Total solid (mg l^{-1})	92,500	41,800
12.	Sulphate as SO_4 (mg l^{-1})	50,00	1050
13.	Chloride (mg l^{-1})	9,000	9000
14.	Sodium (mg l^{-1})	400	400
15.	Potassium (mg l^{-1})	10,000	10,000
16.	Magnesium (mg l^{-1})	1,400	900
17.	Calcium (mg l^{-1})	4,100	900
18.	Nitrogen as total N (mg l^{-1})	1,200	1000
19.	Phosphorus as PO_4 (mg l^{-1})	580	400

The COD of untreated spentwash was 90,000 (mg l^{-1}) and that of treated was 18,000 (mg l^{-1}). While, the BOD of untreated was 41,000 (mg l^{-1}) and treated 3,200. The colour, odour and turbidity used to differentiate treated from untreated. The treated spentwash was reddish brown in colour and mild molasses in odour as compared to dark brown, with unpleasant odour in raw spentwash. The pH was found to increase in the treated spentwash from 4.0 to 7.6. The electrical conductivity of the treated spentwash reduced to nearly half the value of raw spentwash from 28 to 13 dSm^{-1}. The untreated spentwash contained total solids of 92, 500 mg l^{-1} whereas the treated spentwash recorded only 41, 800 mg l^{-1}. The microbial load increased in number due to treatment of spentwash. Untreated spentwash has not supported the growth of microorganism but the treated one recorded the population 26 x 10^6 cfu ml^{-1} for bacteria, 16 x 10^6 cfu ml^{-1} for fungi and 18 x 10^6 cfu ml^{-1} for actinomycetes.

3.3. Physico-chemical properties of distillery yeast sludge

Yeast sludge waste is derived after alcohol fermentation and remains as a mass of dead, live and inactive yeast cells and serves as a source of nutrient. The yeast sludge waste collected from M/s. M.R.K. Co-operative Sugar Ltd., Sethiyathope, Cuddalore District, was analysed for physico chemical properties used in the present study (Table 3). The electrical conductivity of yeast sludge waste was 9.30 dSm^{-1} and the pH 4.72. The total organic carbon was 9.52 per cent. The major nutrients such as total nitrogen, total phosphorus and total potassium were 1.67, 0.84 and 4.48 per cent respectively. The calcium 7.62 per cent, magnesium 0.77 per cent and sulphur 0.63 per cent contents were also in appreciable amount. Yeast sludge was rich in iron content and was 1022 mg kg^{-1}. Other nutrients like Zn 147 mg kg^{-1}, copper 44 mg kg^{-1}, and manganese 44 mg kg^{-1} were present considerable quantities.

Table 3 - Physico-chemical properties of distillery yeast sludge

Sl. No.	Parameters	Content
1.	pH (1:10 w/v)	4.72
2.	EC (dSm^{-1}) 1:10 w/v	9.30
3.	Organic carbon (%)	9.52
4.	C:N ratio	5.7
5.	Total nitrogen (%)	1.67
6.	Total phosphorus (%)	0.84
7.	Total potassium (%)	4.48
8.	Total calcium (%)	7.62
9.	Total magnesium (%)	0.77
10.	Total sulphur (%)	0.63
11.	Total zinc (mg kg^{-1})	147
12.	Total iron (mg kg^{-1})	1022
13.	Total manganese (mg kg^{-1})	44
14.	Total copper (mg kg^{-1})	82
15.	Cellulose (%)	6.0
16.	Hemicellulose (%)	5.83
17.	Lignin (%)	4.81
18.	Total phenols (mg kg^{-1})	21.0

3.4. Isolation and characterization of microorganisms from sugar and distillery industrial wastes

Pressmud wastes (PM), Distillery spent waste (DS) and yeast sludge waste (YS) yielded a total of 30 cellulolytic microbial isolates and included 12 from PM, 13 from DS and 5 from YS. The established microorganisms in the treated spentwash samples and pressmud waste (PM). Distillery spentwash (DS) and yeast sludge waste (YS) were isolated for further study. About 18 isolates of Bacteria and 12 of Fungi were isolated and reported in Table 4. These isolates were subjected to various tests as described in the "Materials and Methods" for tentative identification based on the "Bergey's manual of Determinative Bacteriology" for bacteria and "Introductory mycology" by Alexopuolus and Mims 1985 for fungi.

Table 4 - Microbial population in different sugar industrial wastes

Sl.No	Source	Microbial population		
		Bacteria ($x10^6$ cfu g^{-1})	Fungi ($x10^3$ cfu g^{-1})	Actinomycetes ($x\ 10^{-4}$cfu g^{-1})
1.	Pressmud **(PM)**	27.0	16.0	7.0
2.	Treated distillery spentwash **(DS)**	18.0	20.0	6.0
3.	Yeast sludge **(YS)**	15.0	7.0	5.0
4	Total	60.0	43.0	18.0

3.5. Screening of isolates obtained from sugar and distillery industrial wastes

The microbial isolates obtained from the various substrates were screened for their ability to produce cellulases, pectinases and xylanases. These enzymes are able to cleave the major core of pressmud. The ability to cleave substrates is directly correlated to the composting periods. Increasing rates of breakdown decrease composting duration. To minimize the period of composting, there is need to develop a technology, using microbes as source for enzymatic breakdown of complex polysaccharide. The screening of microbial isolates for efficiency is important to develop an effective consortium and also elaborate these enzymes.

3.6. Comparative nutritive status of pressmud compost and improved pressmud compost

Comparative nutritive status of raw pressmud, ordinary pressmud compost and improved pressmud compost were presented in. The nutrient analysis showed an acidic pH of 6.3 in raw pressmud, whereas the pressmud compost and improved pressmud compost showed increased pH of 7.1. The EC (dSm^{-1}) content of 2.96 in raw pressmud and decreased to 2.92 in ordinary pressmud compost further round to 2.52 in improved pressmud compost. The C:N ratio varied from 27.17 to 14.12, of which 14.12 was achieved in the improved pressmud compost and 21.30 in pressmud compost. There is a considerable increase in phosphorous percentage of 2.52 for improved pressmud compost followed by 1.92 for pressmud compost and 1.61 for pressmud. The Ca, Mg and sulphur content were significantly higher in improved pressmud compost compared to pressmud compost and pressmud. The increase in Zn of 2560 mg kg^{-1} was recorded in the improved pressmud compost. The other comparable source is pressmud compost followed by pressmud. The total Cu increase was on par for pressmud compost and improved pressmud compost. There is significant difference between composted material and non composted material in the percentage of cellulose, hemicellulose and lignin content. Among the composted material improved pressmud compost showed the lowest percentage of cellulose, hemicellulose and lignin compared to pressmud. The recorded microbial load was recorded maximum in improved pressmud compost. The bacterial population of 36 x 10^6 cfu g^{-1} was achieved in improved pressmud compost followed by pressmud compost and pressmud. The same trend was recorded for fungi and actinomycetes populations.

Table 6 - Comparative nutrient status of pressmud, pressmud compost and improved pressmud compost.

S. No.	Parameters	Pressmud	Pressmud compost	Improved pressmud compost
1.	pH	6.30	7.10	7.10
2.	EC (dSm^{-1}) (1:10 w/v)	2.92	2.96	2.52
3.	Organic carbon (%)	32.0	18.0	14.68
4.	Total nitrogen (%)	1.26	1.96	2.74
5.	C:N ratio	27.17	21.20	14.12
6.	Total phosphorus (%)	1.61	1.92	2.52
7.	Total potassium (%)	0.92	2.92	3.44
8.	Total calcium (%)	4.25	4.96	5.54
9.	Total magnesium (%)	1.53	1.92	2.42
10.	Total sulphur (%)	1.24	1.52	2.10
11.	Total zinc (mg kg^{-1})	130	194	259
12.	Total iron (mg kg^{-1})	1450	1620	2560
13.	Total manganese (mg kg^{-1})	115	147	156
14.	Total copper (mg kg^{-1})	52	81	82
15.	Cellulose (%)	13.74	5.8	3.82
16.	Hemi cellulose (%)	20.24	10.36	7.81
17.	Lignin (%)	13.46	8.30	6.14
18.	Bacteria($x10^6$cfu g^{-1})	8.00	16.00	36.00
19.	Fungi($x10^3$cfu g^{-1})	3.66	12.33	24.66
20.	Actinomycetes($x10^4$cfu g^{-1})	4.33	9.66	14.33

3.7.Effect of improved pressmud compost on germination percentage, seedling height and vigour index of sunflower

The influence of improved pressmud compost on germination percentage reveals that the 75% NPK + 2.0 MT of improved pressmud compost treatment performed for better than rest of the treatments with 92.3 per cent seed germination (Plate 28). The treatment (T_3) with 50% NPK and 25% NPK along with 2.0 MT of improved pressmud compost were on par with treatment (T_2). Application of 2.0 MT of improved pressmud compost treatments with 75%, 50% and 25% NPK performed better than 75%, 50% and 25% with 2.0 MT of pressmud compost. Application of 100% NPK and 75% NPK, 50% NPK + 2.0 MT of improved pressmud compost treatments were on par in seedling height *viz*., 22.50 cm and 22.0 cm respectively, maximum vigour index of sunflower was recorded in 75% NPK + 2.0 MT improved pressmud compost treatment (2030.60). All the treatments performed better than control treatment in germination percentage, seedling height (cm) and vigour index

Table 7 –Effect of improved pressmud compost on germination percentage, seedling height and vigour index of sunflower

Sl. No.	Treatment	Germination percentage	Seedling height (cm)	Vigour index
1.	T_1 - 100% NPK (Recommended dose)	86.5 (68.44)	22.50	1946.25
2.	T_2 - 75% NPK + 2 MT of improved pressmud compost	92.3 (73.89)	22.0	2030.6
3.	T_3 - 50% NPK + 2 MT of improved pressmud compost	89.6 (71.19)	22.0	1971.2
4.	T_4 - 25% NPK + 2 MT of improved pressmud compost	85.0 (67.21)	18.00	1530.0
5.	T_5 - 75% NPK + 2 MT of pressmud compost	86.5 (68.44)	19.00	1643.5
6.	T_6 - 50% NPK + 2 MT of pressmud compost	84.3 (66.66)	18.50	1559.55
7.	T_7 - 25% NPK + 2 MT of pressmud compost	80.3 (63.65)	15.00	1204.5
8.	T_8 - 2 MT of improved pressmud compost	79.3 (62.94)	12.50	991.25
9.	T_9 - 2 MT of pressmud compost	76.4 (60.94)	11.00	840.4
10.	T_{10} – Control	70.6 (57.17)	10.00	706.0
	SE	1.02	0.80	3.10
	CD (p=0.05)	2.10	1.16	6.51

Figures in parentheses are arcsine transformed.

Modern agriculture is shifting towards low external input and sustainable agriculture system with higher resources use efficiency. It has been well recognised that continuous use of fertilizers alone is not sustainable and can result in a significant fall in production level. Recycling organic waste and addition of organic manures is a right answer to significantly fulfil the plant nutritional requirement from time to time. Thus, recycling renewable organic waste to meet the challenges of agriculture in the 21st century is of utmost importance. India has got huge potential of recyclable crop residues like sugarcane trash, straw, bagasse and coir pith in addition to other materials like cotton waste, industrial waste, aquatic waste etc., which is not fully tapped. The organic waste available in India estimated to be capable of supplying about 7.1, 3.0 and 7.6 million tonnes of N, P_2O_5 and K_2O respectively (Mishra and Hesse, 1982). Sugar industry produces large quantities of pressmud at the rate of 3 tonnes for every 100 tonnes of cane crushed and its availability in India is estimated to be 5.0 million tonnes.

Distilleries associated with sugar factories generate about 1 million tonnes yeast sludge as solid waste. In addition sugar factory produce 45 million tonnes of bagasse waste (Sentilkumar *et al*., 1997) unless appropriate techniques are evolved, large scale accumulation of these waste will threaten major pollution problems. However, these wastes can be used as a valuable resource for agriculture through the development of eco-friendly techniques of composting. The waste potential can be scientifically recycled into a nutrient source and utilized profitably for sustainable crop production

The yeast sludge was acidic (pH 4.72) in nature and had electrical conductivity of 9.3 dSm^{-1}. Yeast sludge, being rich in nitrogen, resulted in narrowed C:N ratio of 5.7 and contained major nutrients like phosphorus, potassium, calcium, magnesium, sulphur and minor nutrients zinc, iron, manganese and copper.

Blending solid waste which is rich in nitrogen with waste material having wide C:N ratio provides an effective and environmentally acceptable option of waste disposal as it helps to recycle valuable nutrients into the soil and plant system (Crawford, 1983). Composting is a dynamic process in which the physical and chemical changes are caused by rapid succession of mixed microbial population and microbial activity. A technological advancement is needed to reduce the duration of composting, and to determine the physico- chemical properties of matured compost. Because immature compost, which is not sufficiently stabilized in mineralization and humification, may induce higher microbial activity in the soil which reduces soil oxygen concentration and blocks the available nitrogen to crops and are even highly phytotoxic (Inbar *et al*., 1990, Zucconil *et al*., 1981). In the present study an attempt was made to produce good quality matured compost in a shorter time using effectively degrading microbial inoculants.

According to Joshi (2001), the manurial value of spentwash is highlighted by the fact that effluent produced in India in one year can meet the potassium requirement of 1.5 million hectare of land, nitrogen requirement of 0.12 million hectare of land and phosphorus requirement of 0.02 of million hectare of land, if two crops are grown each year. Patil and Shinde (1994) showed the possibility of compost preparation by mixing distillery spentwash with pressmud. The mixing of spentwash with pressmud increased microbial load of bacteria, fungi and actinomycetes. Microorganisms associated with pressmud, spentwash and distillery yeast sludge included 18 species of bacteria and12 species of fungi. The composting process was brought about by several groups of organisms such as bacteria, fungi, actinomycetes and protozoa and may also involve invertebrates such as nematode, earthworm, mites and various other organisms (Taiwo and Oso, 2004).

Singh (1987) however noted that the sole agent of decomposition of carbonaceous material is the heterotrophic microorganisms. The inoculation with cellulolytic microorganisms enhanced composting process (Wani and Shindey, 1998). In the present study the cellulolytic organisms isolated from pressmud were found to be the potential cellulase producers and hence selected for developing inoculants. In composing of pressmud, hydrolysis of polysaccharide constituents by microbially secreted enzymes would be expected to produce a mixture of sugars that could support further development of microbial population. The elaboration of enzymes such as cellulase, dehydrogenase, pectinase and xylanases by the inoculants played an important role in degrading pressmud wastes (Maheswari *et al.*, 2000). Microbial degradation of pressmud waste and application of bio composted pressmud increased the population of *Azotobacter* sp. and actinomycetes in soil (Richardson. (2001).

Application of improved pressmud compost for sunflower crop increased seed germination, seedling height and vigour index better than in all remaining treatments. The higher vigour index could be attributed to increased levels of shoot and root length and better nutritional status of improved pressmud compost. The treatments T_2 and T_3 are on par in germination percentage and vigour index. Abdul-Baki & Anderson (1973) explained the role of organics present in the pressmud compost for improving seed germination and vigour index.

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