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BIOCONVERSION OF PAPER AND PULP MILL SOLID WASTES

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ABSTRACT

Begasse pith (BP) is solid waste discharged from bagasse based paper and and pulp industry. It contains high quality of cellulose and lignin. An attempt has been made to convert the bagasse pith into biomanure for land application using activated sludge (AS) and ETP sludge (ETPS) which are solid wastes obtained from the same factory rich in essential plant nutrient. The AS and ETPS were mixed with BP in different properties to maintain the optimum C : N ratio and nutritional requirement of microorganisms during composting. In order to enhance the composing process, an external source of inocula *viz., Pleurotus sajor-caju* (250kg), *Trichoderma viride* (0.4%) and a new bacterial culture, EM 4 (500ml) were added per 100 kg of substrate. The NPK were increased invariably in all treatments and the C/N ratio was reduced to a level suitable for land application within a period of 10 weeks. Mixing BP with AS and ETPS in 2:1:1 ratio produced a better quality compost than mixing BP with AS at 1:1 ratio.

KEYWORDS: Bioconversion, Paper mill solid wastes.

Growing literacy and high standard of living have increased the paper consumption, resulting in more pollution from paper industry. At present there are 75 paper and pulp industries in India with an installed capacity of 1.127 million tonnes per annum (Pandey, 1997) and many are going to be established in near future, capable of discharging large quantity of lignocellulosic waste materials. Being the second largest sugarcane growing country in the world, bagasse is a promising raw material for such industries in India. In the case of paper mill using bagasse as the raw material, bagasse pith which constitutes 30 per cent of bagasse is another source of pollution.

Other types of solid wastes are also generated during the mechanical and activated sludge treatment of pulp and paper mill waste waters. Activated Sludge (AS) which accounts for 10 - 50 per cent of total sludge (Rintala and Puhakka, 1994) is high in nutrients and a good source of microbial inoculum. Due to high content of organic matter in paper mill sludges, composting and land application are attractive alternatives for disposal (Bellamy et al., 1995) but high carbon content tends to lock up soil nitrogen when directly applied to the land (Dolar *et al.*, 1972). However a very few attempts have been made so far to utilize begasse pith for crop production. Because of high cellulose, lignin and C/N ratio, it cannot be applied directly to the land. Therefore an attempt was made to convert bagasse pith as a biomanure through aerobic composting using suitable microbial consortia.

MATERIALS AND METHODS

As experiment on aerobic composting of BP was taken up at Tamil Nadu Newsprint and Papers Limited (TNPL), Kagithapuram. The BP, AS and ETPS (Effluent Treatment Plant Sludge) collected from the factory were mixed in different properties and were subjected to aerobic composting using a combined inocula to hasten the composting process. The differnet treatment combinations include TI - BP alone, T2 - BP + CI (CI - Combined inocula of *Pleurotus sajor-caju* (250g), *Trichoderma viride* (0.4%) and EM-4, a bacterial culture (500 ml) for 100 kg substrates), T2 - BP + CI, T3 - Activated Sludge (AS) + CI, T4 - BP + AS @ 1 : 3 ratio + CI, T5 - BP + AS @ 1 : 1 ratio + CI, T6 - BP + AS @ 3 : 1 ratio + CI, T7 - ETPS + CI, T8 - BP + ETPS @ 1 : 1 ratio + CI, T9 - BP + AS + ETPS @ 2:1:1 ratio + CI, T10 - BP + AS + ETPS @ 6:1:1 ratio + CI and T11 - Farm Yard Manure (Control).

Urea (0.5kg) and rock phosphate (1kg) were used as mineral nutrient sources for adjusting the C/N and C/P ratio respectively. All these were mixed thoroughly and heaped under shade for aerobic composting. Moisture was maintained at 60 per cent throughout the composting period. Weekly turning was given and the samples were periodically drawn and analysed for N, P, K organic carbon (OC) and microbial biomass by employing standard methods.

RESULTS AND DISCUSSION

The solid waste materials used for composting were analysed for nutrient concentration, OC, EC and pH (Table 1). Bagasse pith and ETPS were found to be lowr in nutrient status besides with

Table 1. Characteristics of solid wastes

Parameter	Bagasse pith	Activated sludge	ETP sludge
Organic C (%)	46.8	26.80	38.8
Total N (%)	0.36	0.88	0.46
Total P (%)	0.03	0.29	0.05
Total K (%)	0.14	0.20	0.19
C/N ratio	130.62	32.72	83.85

high C/N ratio, whereas AS was found to be rich in essential plant nutrients with low C/N ratio.

Comparative analysis of compost samples showed a marked reduction in OC contei invariably in all treatments ranging from 14 per ce in AS alone to 26 per cent in treatment BP + A. ETPS at 2:1:1 ratio combinations. Significan reduction in C/N ratio was observed at the end o composting period invariably in all treatment except AS + CI, ETPS + CI and BP alone. Amon the various treatment combinations, BP + AS @ 1:1 ratio (16.78), BP + AS + ETPS at 6:1:1 ratio (15.25) and BP + AS + ETPS at 2:1:1 ratio (14.39) were found to be superior in terms of low C/N ratio (Table 2). The optimum C/N ratio for land application in the above treatments was achieved wihtin a peirod of 10 weeks. This is achieved as a consequence of elite microbial inoculation, rapid

Table 2. Changes in nutrient content, organic carbon and C/N ratio during composting

Treatment	N(%)		P(%)		K(%)		Organic Carbon (%)		C/N ratio	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
T1	0.40	0.62	0.04	0.11	0.14	0.22	46.8	43.6	117.0	70.30
T2	0.42	0.70	0.04	0.14	0.15	0.26	45.5	39.4	108.3	54.35
T3	1.40	1.55	0.26	0.30	0.21	0.30	28.8	26.9	20.57	17.40
T4	1.22	1.52	0.16	0.30	0.20	0.37	34.2	26.8	28.03	17.63
T5	1.14	1.83	0.08	0.21	0.16	0.37	39.2	30.7	34.38	16.78
T6	1.09	1.78	0.07	0.17	0.37	41.9	35.6	38.44	20.11	
T7	1.12	1.69	0.07	0.12	0.17	0.45	38.8	34.2	34.64	20.20
T8	1.03	1.68	0.06	0.16	0.15	0.45	42.9	33.5	41.65	19.94
T9	1.11	2.23	0.08	0.22	0.16	0.49	43.6	32.1	39.27	14.39
T10	1.04	2.19	0.06	0.21	0.15	0.51	45.8	33.4	44.04	15.25
T11	1.23	1.32	0.14	0.17	0.13	0.18	32.3	28.5	26.26	21.59
CD (P=0.05)	0.82	0.47	0.10	0.12	0.45	0.18	7.40	8.84	12.40	18.43

Table 3. Biological activity during the process of composting

Treatment	CO_2 evolution (per g)					Microbial population: Bacteria (x 10^6)			Fungi (x 10^3)			Actinomycetes		
	Wk 2	Wk 4	Wk 6	Wk 8	Wk 10	Ms	Th	Ma	Ms	Th	Ma	Ms	Th	Ma
T1	4.84	3.96	2.20	2.20	0.81	11	10	15	19	18	19	29	11	29
T2	5.96	4.84	3.52	3.08	2.64	16	13	14	28	24	21	31	15	33
T3	6.16	5.28	2.64	1.32	0.88	10	5	6	52	33	17	38	20	21
T4	7.56	5.72	2.64	3.08	2.20	16	13	15	42	45	31	31	22	34
T5	6.82	5.72	3.08	2.20	1.76	19	15	13	44	51	28	28	19	31
T6	8.80	6.60	3.96	3.06	2.20	17	12	14	51	48	20	20	18	25
T7	9.8	8.80	7.48	4.40	3.06	15	14	19	38	35	28	28	18	26
T8	9.4	8.36	5.28	4.40	3.52	14	13	15	30	41	40	27	21	33
T9	9.16	7.04	4.84	4.84	4.40	16	14	17	28	36	41	35	17	36
T10	8.80	7.48	5.28	3.96	3.06	12	11	14	31	33	42	33	16	34
T11	8.56	4.52	1.76	0.88	0.88	4	4	4	15	20	12	9	12	11

	CD(P=0.05)	CD (P=0.05)	CD(P=0.05)	CD (P=0.05)
Treatments	2.50	4.1	3.8	7.8
Weeks	3.10	NS	4.2	8.9
Interaction	3.98	NS	5.6	10.3

Wk : Weeks, Ms : Mesophilic, Th : Thermophilic, Ma : Maturity

:arbon mineralisation and enrichment of nitrogen ead to reduction of the C/N ratio when different properties of BP + AS + ETPS are composed along with combined inocula. In constrast, the BP alone which was avoid of AS, ETPS and CI, the C/N ratio was at a higher side and the carbon de composition was not achieved due to lack of optimum nutrient ratios essential for microorganisms to decompose the waste materials. Lack of nutrient supply through AS and ETPS were also felt in treatmetn BP + CI. The wide C/N ratio recorded even after 10 weeks of decomposition in BP alone and BP + CI emphasise the need for inoculation of efficeint of decomposition in BP alone and BP + CI emphasise the need for inoculation of efficient cellulytic fungi for the decomposition of BP besides mixing with AS and ETPS which take care of the required nutrient ratios to hasten the process of decomposition. The time of composting for high C/N ratio materials could be reduced by adding nitrogen source such as activated sludge (Gaur, 1982).

Nutrient contents (N, P & K) were also increased during the process of composing. Nitrogen content was found to be the highest in BP + AS + ETPS at 2:1:1 ratio (2.23 percent) followed by BP + AS + ETPS at 6:1:1 ratio (2.19%) and BP + AS at 1:1 ratio (1.83 per cent) With progressive loss in carbon and reduction in the bulkiness of the compost mass, the nitrogen content showed an upward trend with progressive decomposition. The increase was greater in compost mixed with AS and ETPS inoculated with celluloytic fungi. The treatment AS (0.30 per cent) and BP + AS at 1.3 ratio (0.30 per cent) recorded higher concentrations of P invariably because of higher quantity of phosphorous contributed through AS. The K content was found to be the highest in BP + AS + ETPS @ 6:1:1 ratio (0.50%) followed by BP + AS + ETPS at 2:1:1 ratio (0.49 per cent).

Microbial activity showed an increasing trend during initial stages of composting which might have stabilized during maturity phase. The CO_2

evolution and dynamics of microbial load were found to to be more in treatments inoculated with combined inocula besides mixed with AS (Table 3). However CO_2 evolution was found to be higher in treatments having more properties of ETP sludge, during the initial stages because of high cellulosic materials and NPK per cent in ETPS and thus respond to cellulolytic fungi for accelerating the composting process.

The result suggested that the bagasse pith could be converted as biomanure which is suitbale for land application by mixing it with BP with AS and ETPS Sludge at 2:1:1 ratio. Bagasse pith compost is valued as a better product when compared to Farm Yard Manure in terms of nutrient status and C/N ratio Evaluation of bagasse pith biomanure to different crops is in progress.

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SOURCES OF BASAL N AND TIMES OF UREA -N SPLITS ON YIELD ATTRIBUTES AND YIELD OF IRRIGATED LOWLAND RICE

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ABSTRACT

Field experiments were conducted at TNAU, Coimbatore during Nov.'95 to Sept.'96 to study the effect of two sources (green manure and urea) as basal N in combination with different times of urea splits on yield attributes of rice. The conjunctive use of green manure, on equal N basis as basal, was equally effective but did not have any yield advantage over the urea N. Split application of urea at active tillering was vital, when the basal N was applied as GLM, but not for urea N basal. Nitrogen to a medium duration rice variety may be applied in five splits. First top dressing after the basal (AT stage) is vary if basal N is given through green manure without starter N. But, when fertiliser N is applied as basal, an optimum dose of 20 kg N at active tillering is sufficient to maintain the tiller production. Higher N (40 kg) at AT stage increases the biomass production through unproductive tillers and that ultimately leads to poor HI. On the other hand, low N status critically reduces the tillering too. An additional dose of 20 kg a week after AT was found to be beneficial to improve the panicle efficiency and ultimately the grain yield, irrespective of basal N sources. Split application of N at heading stage seems so delicate. Increasing the rate of N more than 20 kg i.e., 30 or 40 kg N /ha resulted in poor grain yield by increased sterility.

Key words : Green leaf manuring, Nitrogen, Urea N, Heading N, Basal N, equal N basis

Among the nutrients essential for rice growth, N is the only nutrient element giving positive response in all types of soil, climate and management. The concept of integrated nutrient management (INM) seeks to sustain soil fertility through an integration of different available sources of nutrients and their application methods that will produce maximum crop yield per unit input use (De Datta *et al.*, 1990). Though there is sufficient research work on integrated N management on partial substitution of fertiliser N with organic N, the substitution of basal fertiliser N (urea) with green manure on equal N basis is rather limited. Therefore, in order to study the