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Original Research Paper

Recycling of Pulp and Paper Industry Sludge with Saw Dust by Aerobic Composting Method

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ABSTRACT

Studies were conducted to evaluate the feasibility of bioconversion of pulp and paper industry secondary treatment sludge with sawdust under aerobic conditions. The composting of the waste was carried out for a period of 90 days by mixing pulp and paper industry sludge (PS) with sawdust (SD) in the ratio of 3:1 and inoculating treatment 1 (T_1) with only cow dung whereas inoculating the treatment 2 (T_2) with cow dung and effective microorganisms (EM). The composting process showed satisfactory results with the cow dung and effective microorganism inoculum, i.e., Treatment 2 (T_2). The different chemical parameters like pH, EC, temperature and C:N ratio were analysed during the composting period. The C:N ratio showed a gradual decrease from 36.12 to 21.02 and 38.30 to 17.63 for T_1 and T_2 respectively on the 90th day of composting. The pH varied from 6.5 to 7.3 and from 6.8 to 7.6 in T_1 and T_2 respectively indicating a good compost quality. The EC values decreased gradually from 2.3 µmhos/cm and reached the value 1.2 µmhos/cm in both the treatments. The nutrient values like NPK were almost equal in both the treatments i.e. Though the nutrients levels were equal, the Treatment 2 (T_2) reached the compost stability at the 90th day whereas the Treatment 1 has not reached the stability or maturity at the 90th day, which is indicated by the C:N ratio. Therefore, it can be concluded that the pulp and paper industry sludge (PS) can be successfully converted into value added compost in the period of 90 days by co-composting with sawdust (SD) in the ratio of 3:1 and by mixing with cowdung (CD) + effective microorganisms (EM) as inoculum.

INTRODUCTION

Solid waste management is one of the biggest environmental challenges facing the world today due to increasing population and urbanization. A sustainable approach to handle this will be to treat and reprocess industrial wastes on-site to produce useful products. In India, the pulp and paper making industry is one of the industries with the highest water consumption rate and causing serious pollution problems.

Solid waste is generated in the process of pulping and paper manufacture, and in effluent treatment. Depending on the type of treatment system utilized, different quantities of solids with widely differing compositions are produced (Ali & Sreekrishnan 2001). These solid wastes may be utilized for energy generation (Busbin 1995, Kraft & Orender 1995) or used as a raw material in other processes (Wang et al. 2006) or disposed off beneficially to land (Henry & Cole 1998, Predham & Cline

1998). However, because of generally poor energy yield and cost of handling, these waste materials are most often land filled (Feldkirchner et al. 2003, Magesan & Wang 2003).

In recent years, pulp and paper manufacturing industry has been obliged to substantially reduce wastewater discharge due to the implementation of stringent regulations. Meanwhile, increasing awareness of natural resources conservation and sustainable development have led to increase public concern on the serious polluting industries particularly pulp and paper manufacturing plants.

Co-composting of industrial wastes along with other agro-industrial wastes is gaining momentum in present days. Composting is economical with sustainable option for organic and industrial wastes like sludge from treatment plants as it is easy to operate and can be conducted in contained space, provided it is managed properly to produce a good quality produce. Composting is becoming increasingly popular as an alternative to dispose wastes as a benefiting waste recycling option (Gabrielle et al. 2005, Schenkel 1996). Composting reduces and stabilizes the waste and converts it into hygienic and safe products, which add economic value to the final product.

The aim of the present study is to determine feasibility of recycling of secondary sludge from the pulp and paper industry wastewater treatment plant and saw dust to produce good quality compost and also to assess effectiveness of the two different inoculums added during the composting.

MATERIALS AND METHODS

The pulp and paper industry sludge, used in the present study, was obtained from the secondary clarifier unit from the ETP (Effluent Treatment Plant) of a pulp and paper industry near Karur, Tamil Nadu. The saw dust was obtained from the nearby saw mill in Kavundapalayam, Coimbatore, Tamil Nadu. The cow dung was brought from a dairy farm located in Kavundampalayam. The effective microorganisms used in one of the treatments were obtained from Ramky Environmental Pvt. Ltd., Coimbatore and applied at the rate of 4mL/kg as prescribed by the manufacturer. The effective microorganisms consisted of consortium of microorganism species like *Lactobacillus* sps. *Rhodopsuedomonas* sps., *Bacillus* sps. and *Pseudomonas sps.*

Experimental set-up: Studies were carried out in heap or wind row method of aerobic composting. The heaps of sizes 2m × 2m × 1m was used for composting in aerobic environment. It has been documented that a minimum height of 1.0m and width of 2.0m is enough to retain heat in a composting mass to promote the desirable thermophilic activity (Mathur & Fernham 1985). The process of aerobic composting was carried out in two different treatments as follows:

T1: Paper mill sludge (PS) + saw dust (SD) (ratio 3:1). Cow dung (CD) was added as an inoculum (50g/kg) as a slurry and sprayed.

T2: Paper mill sludge (PS) + saw dust (SD) (ratio 3:1). Cowdung (CD) with effective microorganisms (50g/kg) as a slurry and mixed with EM (4mL/kg) and sprayed.

The wind rows were aerated by natural convection as hot air rises through the top of the pile, creating a partial vacuum that draws cooler air from the sides, thus, circulating air providing enough oxygen and access for the microbes to nutrients. Pre-sampling of paper mill sludge, saw dust and the cow dung for analysis of chemical properties was done, and the results are given in Table 1. The wind rows were turned for every 15 days. The samples were drawn at intervals of 15 days, dried and ground to pass through 1mm sieve and used for chemical analysis. Carbon content was determined by Walkley and Black wet digestion method as described by Jackson (1973). Total nitrogen was estimated by microKjehldal method. Total phosphorus and total potassium were extracted by diges-

Table 1: Chemical characteristics of the wastes used in composting.

Characteristics	Pulp & Paper sludge	Saw dust	Cow dung
pH	6.8	5.3	7.23
EC dS/m	3.5	0.4	0.80
Organic carbon%	22.38	54.4	26.53
TKN%	0.95	0.75	0.89
C/N ratio	23.56	72.5	29.80
Potassium%	0.75	0.32	0.38
Phosphorous%	0.24	0.52	0.48

tion with di-acid, and estimated colorimetrically and by flame photometer respectively (Jackson 1973). pH and EC was determined in 1:50 wastewater extract after 30 minutes stirring by using digital pH and EC meters.

RESULTS AND DISCUSSION

Compost temperature is either a consequence or determinant of microbial activity (Vallini et al. 2002). The heaps T_1 and T_2 showed variation in temperature patterns, i.e., initially the temperature was in the range of 28-30°C followed by an increase to about 55°C at 12th day in treatment T_1 and to 60°C at 10th day in the treatment T_2 indicating that the process was at faster rate in the treatment T_2. The temperature gradually decreased to mesophilic range by the end of composting period as indicated in Fig. 1. The heat generated in this process also helps in destruction of pathogens (Golueke 1977).

The pH values showed variation from 6.5 to 7.3 in treatment T_1 and from 6.8 to 7.6 in the treatment T_2. The pH of the final compost was found to be near neutral, which is optimum according to Beulah Gnana Ananthi & Partheeban (2001) (Fig. 2). Apparently, pH increase is due to degradation of short-chained fatty acids and ammonification of organic N (Michel & Reddy 1998).

The decreasing profile of EC (electrical conductivity) indicates that the compost is ideal for land application (Fig. 3). Final EC of the compost mixture was within the recommended value as soil amendment (Rynk 1992). The decreasing pattern was observed in both the treatments, i.e., T_1 and T_2.

C:N ratio is an index of maturity of the compost. The C:N ratio for the compost at the end of 90th day was found to be 21.02 and 17.63 for T_1 and T_2 treatments respectively as represented in Table 2 and Fig. 4. This indicates that the compost formed with the inoculum (effective microorganisms, EM), i.e., T_2 reached maturity at an earlier stage than the treatment T_1, which can be explained due to the increased activity of microorganisms. The C:N ratio 17.63 for the treatment T_2 at the 90th day is complying with the standards put forward by The Central Public Health and Environmental Engineering Organization (CPHEEO 2000) India. The C:N ratio showed a decreasing trend with the time in the composting process indicating a decrease in the available carbon. C:N ratio below 20 is indicative of an acceptable maturity in the final product, a ratio of 15 or even less being preferable (Inbar et

Table 2: C:N ratios of the two treatments at 0, 45th and 90th days of composting.

Treatments/C:N ratio	0th	45th	90th
T_1	36.12	30.52	21.02
T_2	38.30	26.35	17.63

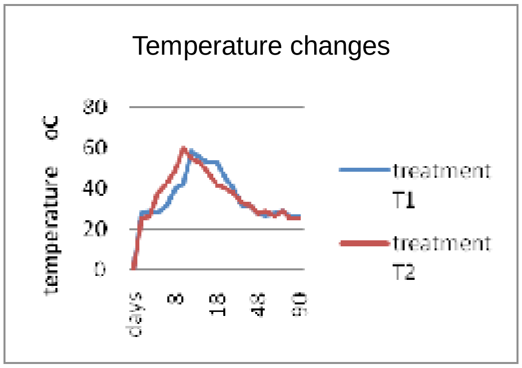

Fig. 1: Temperature patterns during composting period.

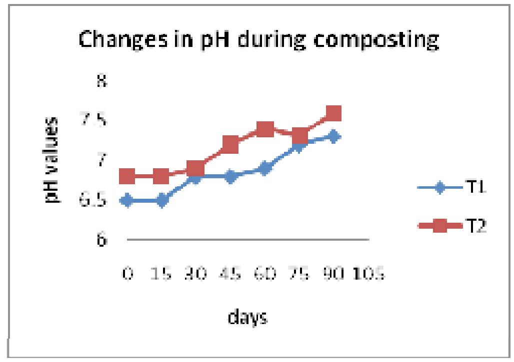

Fig. 2: pH profile during composting.

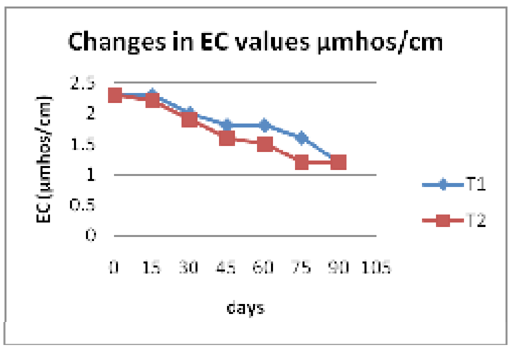

Fig. 3: EC profile during composting.

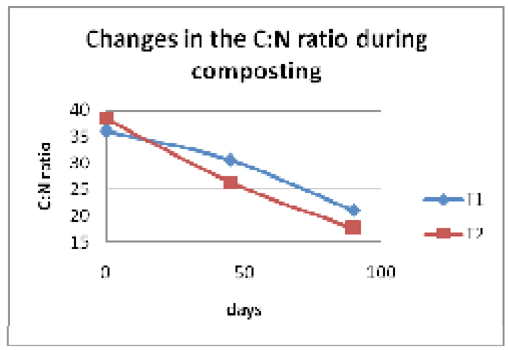

Fig. 4: Changes in the C:N ratio during composting.

al. 1990). The C:N ratio was on the higher side on the first day, but it decreased subsequently with time. This can be explained due to the loss of organic carbon in the form of CO_2 due to decomposition of organic matter into CO_2 and H_2O.

The concentrations of N, P, K were determined at the 90th day, which showed that there is significant increase in minerals (Table 3). These findings were consistent with other researchers (Zucconi & De Bertoldi 1987).

Microorganisms play an important role in aerobic composting process. Mesophilic microorganisms utilize soluble and readily degradable carbohydrates during the early stages of composting. Resistant organic compounds such as cellulose, hemicelluloses and lignin are degraded when most of the readily degrading compounds are depleted. During thermophilic stage microorganisms rapidly attack proteins, lipids and complex organic compounds. Most of the decomposition occurs during this stage of composting (Poincelot 1975). The addition of effective microorganisms in the treatment T_2 showed significant difference from the treatment T_1 during the composting process. The T_2 reached thermophilic phase earlier than T_1 thereby speeding up the process of composting, which is indicated by Fig. 1 and Fig. 4 where the C:N ratio reached below 20 in treatment T_2. The nutrient levels in the T_1 and T_2 varied; T_2 showed high percentage of mineralization when compared to T_1, (NPK values). This is due to the increased activity of microorganisms present in the effective microorganisms added to the treatment T_2.

Table 3: Nutrients values on the 90th day of composting in the two treatments.

Nutrients(%)	Treatment T_1	Treatment T_2
Nitrogen	1.03	1.25
Phosphorous	0.31	0.39
Potassium	0.90	0.98

CONCLUSION

The present study indicates that the pulp and paper industry sludge, rich in nitrogenous material, can be successfully recycled with saw dust by mixing in the ratio of 3:1 with the suitable inoculum (cow dung and effective microorganisms (EM)) in a period of 90 days. The composting time decreased and the nutritive value increased considerably in the Treatment T_2 due to the activity of microorganisms. Therefore, the addition effective microorganisms play a vital role in the recycling and bioconversion of the wastes into value added compost suitable for land application.

The success of this study indicates the possibility of converting the industrial sludge with saw dust into a value added compost. Co-composting these waste materials is an example of how different waste streams may be treated in an integrated way to achieve a sustainable technology for waste management.

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