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Vermicomposting of textile and dye sludge with carbonaceous materials and its carbon and nitrogen status

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ABSTRACT

Vermicomposting of textile and dye sludge is an economically viable and environmentally safer method of final disposal. The low level of carbon content is considered as a limiting factor for the decomposition of textile and dye sludge, but it contains higher amount of calcium and micronutrients. So, it could potentially be used as an alternate substrate for vermicomposting, if it is mixed with carbonaceous materials and animal wastes. In this study, textile and dye sludge had only four per cent organic carbon content. The C: N ratio is one among the important factors that affects manure quality. To adjust the C: N ratio of the initial materials, the carbonaceous material like sawdust and crop waste were added at different proportions. The saw dust appeared to be an ideal bulking agent for composting because of its ability to absorb moisture, and its structure that provides adequate porosity in the compost heap (Mahimairaja, 1996). The C: N ratio of compost in the present investigation ranged between 15.50: 1 and 20.1:1, which could be readily utilized for crop production as suggested by Gaur (1982). The finished vermicompost obtained by mixing 30 per cent sludge with 20 per cent poultry waste and 50 per cent crop waste contains higher nutrient status (NPK) with narrow C: N ratio (15.5).

Introduction

Industrialized and developing countries spend a handsome amount of their Gross National Product on pollution control measures, but the problem is worsening day by day. Pollution is an indicator of an inefficient process, which must be tackled by proper techniques. Disposal of industrial sludge by environmentally acceptable means poses a very great challenge worldwide. Use of earthworms in the management of sludge has been suggested by Elvira *et al*. (1998). The transformation of industrial sludge into vermicompost helps to convert the sludge into value added product besides it also decontaminates the pollutants that are present in it (Kaushik and Garg, 2004).

Materials and methods

Vermicomposting of textile and dye sludge with carbonaceous materials

To produce value added products from the sludge of textile and dye industry, vermicomposting experiment was carried out by using *Eudrillus euginae* earthworm species at Tamil Nadu Agricultural University, Coimbatore. Sludge was mixed with different carbonaceous materials like crop wastes, sawdust, poultry waste, cow dung slurry and then composted aerobically.

Collection of materials for composting

The textile and dye sludge was collected from Common Effluent Treatment Plant (CETP) at Perundurai, Erode. The organic manures such as poultry wastes, farmyard manure and carbonaceous materials like sawdust and agricultural waste were collected from Department of Veterinary and Animal Husbandry, Tamil Nadu Agricultural University, Coimbatore.

Composting treatments

Sludge was mixed with different carbonaceous materials (the substances that enhance organic carbon content) and organic manures (the substance that enhances the nutrient status of the sludge and accelerates the degradation process) as per the treatment details presented below and earthworms were released at pre-degradation stage.

Treatment details

T_1 - 30% CETP Sludge + 20% Cow dung + 50% Crop waste

T_2- 50% CETP Sludge + 20% Cow dung + 30% Crop waste

T_3- 30% CETP Sludge + 20% Poultry waste + 50% Crop waste

T_4- 50% CETP Sludge+ 20% Poultry waste + 30% Crop waste

T_5- 30% CETP Sludge + 20% Cow dung + 50% Sawdust

T_6- 50% CETP Sludge + 20% Cow dung + 30% Sawdust

T_7- 30% CETP Sludge + 20% Poultry waste + 50% Saw dust

T_8- 50% CETP Sludge + 20% Poultry waste + 30% Sawdust

Replication : Three

Design : CRD

Method of composting

For composting, the sludge was mixed with agricultural wastes and saw dust on weight basis and made up to two kg. 100 g of worms were added to each treatment. Water was sprinkled over the compost heap to maintain the moisture content of 60 per cent level throughout the composting period.

The methods used in the biochemical characterization of waste and carbonaceous materials are listed below (Table 1).

Carbon / Nitrogen ratio (C/N ratio)

Carbon / Nitrogen ratio was calculated from organic carbon and nitrogen contents of the samples analysed..

Results and discussion

Characteristics of textile and dye sludge and amendments used for vermicomposting

The textile and dye sludge, carbonaceous materials and animal wastes used in this study were analysed and the results are presented in Table. The sludge was alkaline in nature with pH of 8.50, very low in organic carbon content (4.86 per cent), nitrogen (0.17 per cent) and phosphorus (0.09 per cent), and high in potassium content (1.37 per cent). Among the amendments, the highest nutrient content was recorded in

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poultry waste. The organic carbon content of crop waste was 42.5 per cent with C/N ratio of 60.7.

Effect of pH

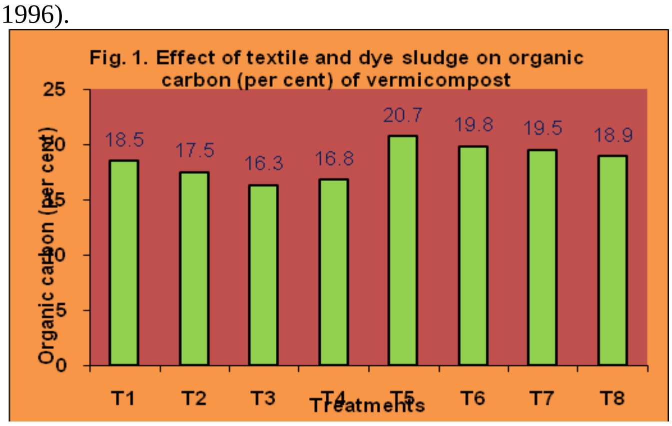
The pH increased during the process of composting. It ranged from 7.28 to 7.65 at initial stage and 7.62 to 7.94 at final stage. At final stage, the highest pH value of 7.94 was recorded in T_3 (30 % CETP sludge + 20 % poultry waste - PW + 50 % crop waste-CW) followed by 7.82 in T_1 (30 % CETP sludge + 20 % cow dung - CD + 50 % CW) and T_8 (50 % CETP sludge + 20 % PW + 30 % saw dust - SD), which were on par with each other. The pH showed an increasing trend and a good indicator of composting process. The pH was in the range of 7.60 to 7.90 at end of composting process. This is in confirmation with findings of Moorthy *et al.* (1996). The neutral pH recorded in the final product might be due to the production of CO_2 and organic acids by microbial activity during the process of bioconversion of different substrates in the feed mixtures (Elvira *et al.*, 1998).

Electrical conductivity

The EC increased during the process of composting. It ranged from 2.75 to 2.92 dS m^{-1} at initial stage and 2.91 to 3.10 dS m^{-1} at final stage. At final stage, the highest EC value was observed in T_5 (3.10 dS m^{-1}) followed by T_6 (3.08 dS m^{-1}), which were on par with each other. Addition of carbonaceous materials *viz.,* crop wastes and sawdust altered the EC of the final compost. The increase in EC could be attributed to the release of soluble salts during the decomposition of organic materials. Kiruba (1996) and Mini (1998) have also reported an increase in EC during the decomposition of industrial solid waste materials.

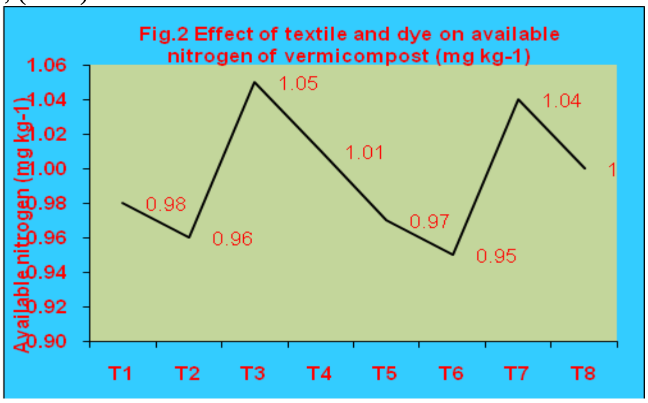
Organic carbon

The changes that occurred during the process of composting in OC content due to mixing of different materials with CETP sludge are present in Figure 1. In general, there was significant reduction in organic carbon content from 39.70 per cent to 18.50 per cent due to vermicomposting process. The highest reduction of organic carbon content was achieved in T_3 (30 % CETP sludge + 20 % PW + 50 per cent CW) followed by T_4 (50 % CETP sludge + 20 % PW + 30 % CW). In general, mixing of poultry waste along with crop waste (T_3, T_4) had a profound influence in reducing the organic carbon content compared to sawdust (T_5 to T_8). The reduction in organic carbon was due to the utilization of carbon as an energy source and to build up protoplasm (Gaur, 1982). Borkar *et al.* (1991) reported that reduction in organic carbon was due to the release of CO_2 through the break down of carbon by microorganisms during the composting process. An enhanced organic matter decomposition in the presence of earth worms, which results in lowering of C: N ratio was observed by Talashilkar *et al.* (1999). A large fraction of organic carbon was lost as CO_2 and by the end of vermicomposting period. It was supported by Elvira *et al.* (1996).



Total nitrogen

The total N content of initial samples varied from 0.35 to 0.46 per cent, while it ranged from 0.95 to 1.05 per cent in final vermicompost. In general, the total N content invariably increased in vermicompost irrespective of different material mixed with CETP sludge. Among the treatments, T_3 (30 % CETP sludge + 20 % PW + 50 % CW) recorded the highest N content of 1.05 per cent followed by T_7 (50 % CETP sludge + 20% PW + 30% CW) and the lowest value was recorded in T_6 (50% CETPS + 20% CD + 30% SD). Earthworms also have a great impact on nitrogen transformations in manure by enhancing nitrogen mineralization, so that mineral nitrogen was retained in the nitrate form (Atiyeh *et al.,*2000). The final N content of vermicompost is dependent on the initial N present in the waste and the extent of decomposition (Gaur and Singh, 1995). The finished vermicompost had higher concentration of NPK and micronutrients in the present investigation. This is in accordance with the findings of Jambhekar(1992) and Delgado *et al.*(1995). On the other hand, the nutrient contents of the vermicompost and the ordinary manure have been found to be similar as reported by Shinde *et al.*, (1992) and Talashilkar *et al.*, (1999).



Carbon / Nitrogen ratio

The C: N ratio of the vermicompost varied between 81.7 and 107.0 at initial stage and between 15.5 and 21.30 at final stages of composting process. Addition of poultry waste and cow dung (T_3, T_4) had the lowest initial and final C: N ratio compared to rest of the treatments. However, higher C: N ratio of 21.30 and 20.80 were recorded in T_7 (30 % CETP sludge + 20 % PW + 50 % SD) and T_8 (50 % CETP sludge + 20% PW + 30% SD) respectively. In general, addition of poultry waste and cow dung with CETP sludge (T_3, T_4) reduced the final C: N ratio compared to rest of treatments. Therefore considerable amounts of NH_3 as volatile forms of nitrogen will be lost. The C: N ratio is often used to describe the maturity of composts and should reach values of about 15-25 (Mathur *et al.*, 1993). The C: N values should not be too high, as the application of such compost can result in immobilization of available nitrogen, causing an N-deficiency in plants (Kostov *et al.*, 1995).

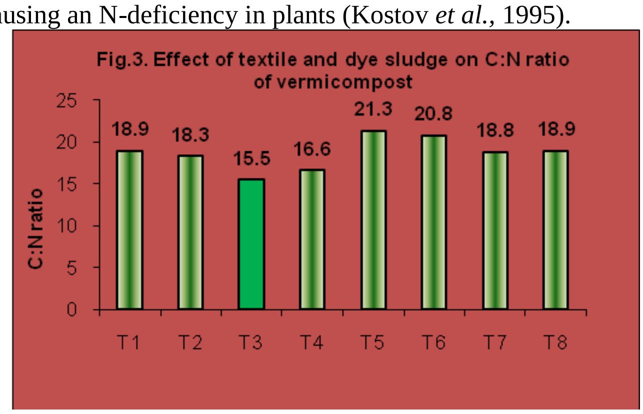


Table 1. Biochemical properties analytical methods

Parameters	Methods followed	References
pH	Sample and distilled water @ 1:10 and measured in pH meter	Falcon *et al.* (1987)
Electrical conductivity	Sample and distilled water @ 1:10 and measured in conductivity meter	Falcon *et al.* (1987)
Preparation of triacid extract	Nitric acid : sulphuric acid: perchloric acid @ 9:2:1 ratio	Biswas *et al.* (1977)
Preparation of diacid extract	Sulphuric acid and perchloric acid @ 5:2 ratio	Biswas *et al.* (1977)
Total nitrogen	Diacid extract - semiautomatic Kjeldahl apparatus	Bremner (1965)
Total phosphorus	Triacid extract - vanadomolybdate yellow colour method	Jackson (1973)
Total potassium	Triacid extract - flame photometer	Jackson (1973)
Organic carbon	Chromic acid wet digestion	Walkley and Black (1934)

The C: N ratio of the compost is one of the important indicators of compost maturity. A lower C: N ratio of 15 to 20:1 is said to be optimum for good quality matured manure (Fig.4). In the present study, the C: N ratio was much wider at the beginning which narrowed down at the end of the composting process. The C: N ratio of compost in the present investigation ranged between 15.50: 1 and 20.1:1, which could be readily utilized for crop production as suggested by Gaur (1982). Enhanced organic matter decomposition in the presence of earthworms and subsequent reduction in lowering of C: N ratio has been reported by Kale *et al*. (1982) and Talashilkar *et al*. (1999). According to Senesi (1989) a decline of C: N ratio to less than 20 indicates an advanced degree of organic matter stabilization and reflects a satisfactory degree of maturity of organic waste

Conclusion

The pH and EC of the vermicompost increased during the process of composting and the rate of decomposition was found to be faster when 20 per cent poultry waste and 50 per cent crop waste were mixed with 30 per cent sludge. The finished vermicompost obtained by mixing 30 per cent sludge with 20 per cent poultry waste and 50 per cent crop waste contains higher nutrient status (NPK) with narrow C: N ratio (15.5).

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