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Vermistabilisation of textile and dye sludge with organic wastes and its phophorus and potassium value

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ABSTRACT

Vermicomposting of textile and dye sludge is an economically viable and environmentally safer method of final disposal. Use of earthworms in the industrial sludge management has been termed as vermistabilization (Neuhauser *et al.,*1988). The worms and microorganisms enhance the biodegradation of organic matter. During this process, important plant nutrients such as nitrogen, potassium, phosphorus, calcium etc. present in the waste are converted through microbial action into forms that are much more soluble and available to plants than those in the parent substrate (Ndegwa and Thompson, 2001).. 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. At maturity phase, the highest P content was observed in the treatment that received sludge, poultry waste and saw dust (T_7, T_8). Kaushik and Garg (2003) reported that textile mill sludge could be potentially useful as raw substrate in vermicomposting if mixed up to 30 per cent with cow dung. *E. foetida* is an epigeic earthworm species which lives in organic wastes and requires high moisture content, adequate amounts of suitable organic material and dark conditions for proper growth and development (Gunadi *et al.*, 2002). The enhancement of P in vermicompost was due to mineralization of the organic matter accompanied by a reduction in the total volume of the waste under ideal conditions. 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

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 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. 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.

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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.

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)

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 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).

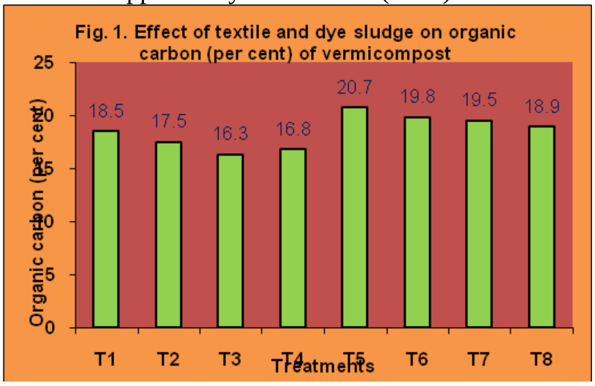
Electrical conductivity

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

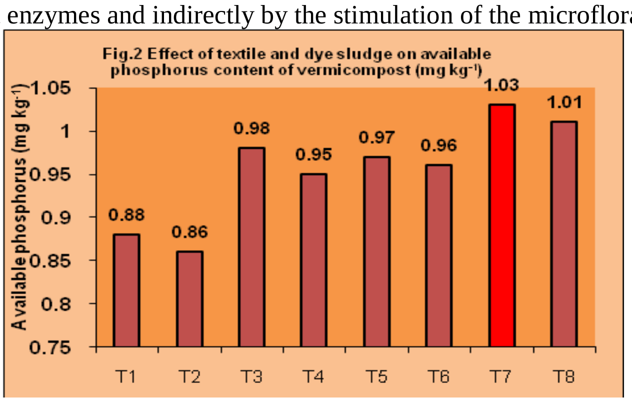
The changes that occurred during the process of composting in OC content due to mixing of different materials with CETP sludge are present in Figure 1. In general, there was significant reduction in organic carbon content from 39.70 per cent to 18.50 per cent due to vermicomposting process. The highest 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).



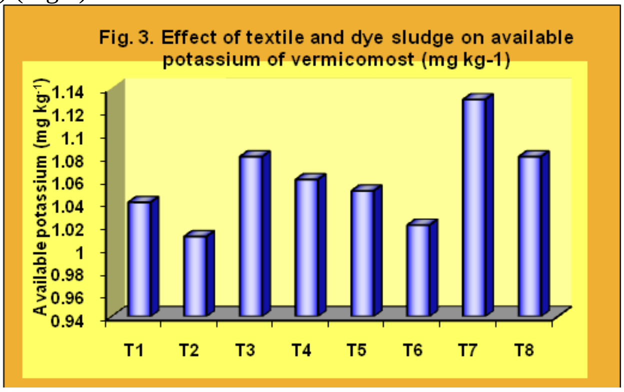
Total phosphorus

The total P ranged from 0.76 to 1.03 per cent during the vermicomposting process. The initial total P was higher in T_7 (0.83 per cent), which was followed by T_8 and T_3 (0.82 per cent). The highest final value of 1.03 per cent was observed in T_7 (30 % CETP sludge + 20 % PW + 50 % SD) followed by 1.01 per cent in T_8 (50 % CETP sludge + 20 % PW + 30 % SD). The total P also increased in all treatments irrespective of mixing different materials with CETP sludge. (Fig. 2).In general, the total P content increased during the composting process due to volume reduction, but the rate of increase was very low when compared to nitrogen. At maturity phase, the highest P content was observed in the treatment that received sludge, poultry waste and saw dust (T_7, T_8). The enhancement of P in vermicompost was due to mineralization of the organic matter accompanied by a reduction in the total volume of the waste under ideal conditions. The increase in total phosphorus in finished vermicompost may be due to the direct action of worm gut enzymes and indirectly by the stimulation of the microflora .



Total potassium

Addition of different materials significantly enhanced the total K content both at the beginning and at the end of composting period. The total K during vermicomposting ranged from 0.87 to 1.13 per cent during the vermicomposting process. Among the treatments, poultry waste added treatments (T_7, T_8, T_3, and T_4) had higher total K content both at initial and final stages compared to cow dung addition. At the end of composting, the highest value of 1.13 per cent recorded in T_7 (30 % CETP sludge + 20 % PW + 50 % SD) followed by T_8 and T_3 (1.08 per cent). The lowest value of 0.87 per cent was recorded in T_2 (50 % CETP sludge + 20 % CD + 30 % SD).(Fig.3).



The total potassium content of the vermicompost increased as in the case of nitrogen and phosphorus. Among the treatments, the highest level of potassium was observed in T_7 (30 % ETP sludge + 20 % poultry waste + 50 % saw dust). This might be due to the presence of initial high potassium content in sludge, poultry waste and saw dust which appeared to be an ideal bulking agent for manuring because they provide adequate porosity to absorb moisture.

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). 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 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.

The decrease in C: N ratio is associated with an increase in total potassium and nitrogen of final worm-worked product (Kaushik and Garg, 2004). Delgado *et al*. (1995) have also reported higher concentration of total potassium in the sewage sludge vermicompost.

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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