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Microbiology

BIOCHEMICAL ANALYSIS OF SPENT MUSHROOM COMPOST AND VERMICOMPOST

KEY WORDS: spent mushroom, vermi compost, biochemical,

Sudhanthiraraj Subbu lakshmi Department of microbiology, Kamaraj College, Tuticorin, TamilNadu, India

Gurusamy Chelladurai Moorthy * Department of Zoology, V.O.Chidambaram College, Tuticorin TamilNadu, India *Corresponding Author

ABSTRACT

The physiochemical parameters assessed after the 90th day using Spent Mushroom Bed Material (SMBM) and vermicompost. The pH value in the Spent Mushroom Bed Material (SMBM) and vermicompost materials was lower than in the raw materials. The reduction of pH could be attributed to the higher mineralization of nitrogen and phosphorus into nitrites/nitrates and orthophosphate. The electrical conductivity (EC) has significantly decreased in all the compost materials (5.71 to 0.13 ms/cm). This difference may be due to consequent high organic matter loss and release of different mineral salts. Total Organic Carbon (TOC) concentration in both compost materials declined than raw materials after completion of the process. The reduction of TOC showed that the earthworms rapidly multiplied decomposing the organics. The Total Nitrogen (TN) content significantly increased in the 90th day of SMC and vermicompost materials than raw material. Increased in the TN concentration of SMC and vermicompost materials are dependent on the combination of initial feed mixture. The increase of TN showed the good quality of the bio-compost obtained. Total Available Phosphorous (TAP) content was greater than the raw material for all treatments, which may be due to the phosphorus mineralization by the earthworm. The increase in available TAP concentration in organic waste treatments with recommended fertilizer could be due to a high microbial activity induced by the addition of organic residues, and soluble inorganic TAP.

INTRODUCTION

The bioconversion of agriculture and industrial wastes into food has attracted world's attention in recent years. The bioconversion of wastes into useful products has a tremendous potential in that it can help meet the increasing world demand for food and energy. Likewise, many wastes like coir pith and paddy straw [1], green wastes from local vegetable market [2] were decomposed by using mushrooms. Spent mushroom substrate is an excellent one to spend over the top of newly seeded lawns. The material provides cover against birds eating the seeds and will hold the water in the soil while the seeds germinate. The fresh mushroom compost applied to soil has many benefits: it improves soil structure, provides plant nutrients, increases plant nutrient availability, soil microbial populations, soil cation exchange capacity, plant root structures, increases soil aeration, improves soil water status and reduces soil compaction [3].

It improves the quality of compost by increasing high nutrient content. It is an attractive proposition for utilizing spent mushroom compost as soil inorganic fertilizer supplementation. The obtained composts were tested for the presence of various nutrients like C, Total N, S, H, Zn, Mg, Fe, Ni, Cu, Na, K and C/N ratio. Previous studies showed that the spent mushroom bed is an excellent source of phosphorous, potassium and other trace elements [4]. The spent straw contains large quantity of N, P, K and can be used as manure [5].

The end product of vermicomposting is pathogen free, odorless and rich in plant nutrients as compared to conventional compost. Vermicompost is often considered a supplement to fertilizers and it releases the major and minor nutrients slowly with significant reduction in C/N ratio, synchronizing with the requirement of plants [6]. Agricultural utilization of vermicomposting will help in recycling the plant nutrients to soil and also avoid soil degradation [7]. The concentration of macronutrients like N, P and K increased after vermicomposting [8]. Assessment of vermicompost on seedling growth revealed that the seedling growth percentage was more in vermicompost than in compost [9].The worm castings contain higher percentage (nearly twofold) of both macro and micronutrients than the garden compost. From earlier studies also it is evident that vermicompost provides all nutrients in readily available form and also enhances uptake of nutrients by plants [10]. Recent experiments by several authors [11] confirm the earlier reports that vermicompost has more beneficial impact on plants than compost.

MATERIALS AND METHODS

Nutritional analysis

Spent Mushroom Compost (SMC) of Ganoderma lucidum and Pleurotus flabellatus grown on Sugarcane bagasse, woodchips and coir pith along with vermicompost were collected and shade dried. The SMC was obtained after the harvest of G. lucidum and P. flabellatus. Vermicompost was obtained after completion of experiment, i.e. on the 90th day. The analyses were carried out in Greenstar Fertilizers Limited, SPIC Nagar, Tuticorin – 628 005, Tamilnadu. The dry compost materials were used for analyzed of physiochemical parameters. The pH and electrical conductivity (EC) [12] were determined using a double-distilled water suspension of each waste in the ratio 1:10 (w/v) that has been agitated mechanically for 30 minutes and filtered through Whatman No.1 filter paper. Organic Carbon was measured by the Titrimetric method [13]. Total Nitrogen content was determined by Kjeldahl's method [14]. The samples were analyzed in triplicates.

RESULTS

The physiochemical parameters were assessed in the Spent Mushroom Compost (Ganoderma lucidum and Pleurotus flabellatus) and Vermicompost (Table 1).

Hydrogen ion concentration (pH)

The pH values in various raw materials of SRM, WRM and CRM were 8.2, 8.5 and 8.1 respectively. In G. lucidum based materials, the maximum reduction in pH occurred in GCC$_1$ (6.1). The minimum reduction occurred in GCC$_3$ (6.6). In P. flabellatus based materials, the maximum reduction in pH occurred in PCC$_1$ (6.2) followed by PSC$_1$ (6.2) and. PWC$_1$ (6.3). The minimum reduction in pH occurred in PWC$_3$ (6.7) followed by PSC$_3$ (6.5) and PCC$_3$ (6.5). In vermicompost based materials, the maximum reduction in pH occurred in SV$_1$ (6.1). The minimum reduction occurred in CV$_2$ and CV$_3$ (6.5) (Fig.1).

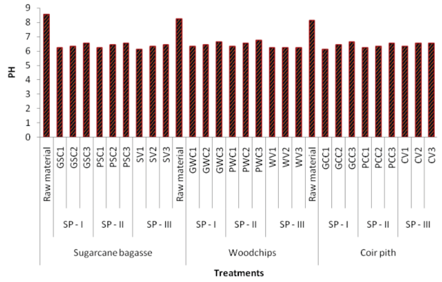

Fig. 1. Comparison of pH in different treatment mixtures of Spent Mushroom Compost (*Ganoderma lucidum* and *Pleurotus flabellatus*) and Vermicompost

Electrical Conductivity (EC)

The EC in various raw materials of SRM, WRM and CRM were 2.1, 1.9 and 6.2 respectively. In G.lucidum based materials, the maximum EC was recorded in GCC$_1$(5.71) followed by GSC$_1$ (1.62) and GWC$_1$ (0.63). Minimum EC was recorded in GWC$_3$ (0.21) followed by GSC$_3$ (1.18) and GCC$_3$ (3.6). In P. flabellatus based materials, the maximum EC was recorded in PCC$_1$ (5.22) and minimum EC was recorded in PWC$_3$(0.44). In vermicompost based materials, the maximum EC was recorded in CV$_1$ (4.36) and minimum EC was recorded in WV$_2$(0.52) (Fig.2).

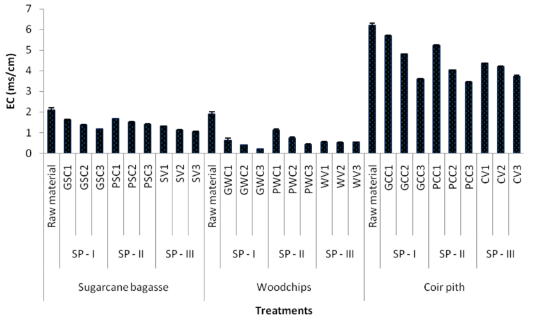

Fig. 2. Comparision of EC in different treatment mixtures of Spent Mushroom Compost (*Ganoderma lucidum* and *Pleurotus flabellatus*) and Vermicompost

Total Organic Carbon (TOC)

The concentrations of TOC in raw materials were 45.2% in SRM, 42.5% in WRM and 43.1% in CRM respectively. In G.lucidum based materials, the highest reduction of TOC was in GSC$_3$ (26.25%), GWC$_3$ (22.93 %) and GCC$_3$ (29.11 %). The lowest reduction of TOC was noticed in GSC$_1$(33.31%), GWC$_1$(28.90%) and GCC$_1$(35.96%). In P. flabellatus based materials, the highest reduction of TOC was in PSC$_3$(23.34%), PWC$_3$(26.02%) and PCC$_3$ (26.20%) while the lowest reduction was in PCC$_1$(30.51%), PSC$_1$ (30.13%) and PWC$_1$ (28.4%) respectively. The concentration of TOC was very low in vermicompost when compared to spent mushroom compost materials. In vermicompost materials, the highest reduction of TOC was in CV$_3$(13.55%) followed by SV$_2$ (13.68%) and WV$_3$(15.3%) while the lowest reduction of TOC was in WV$_1$ (24.17%) followed by SV$_1$ (16.63%) and CV$_1$ (15.86%) respectively (Fig.3).

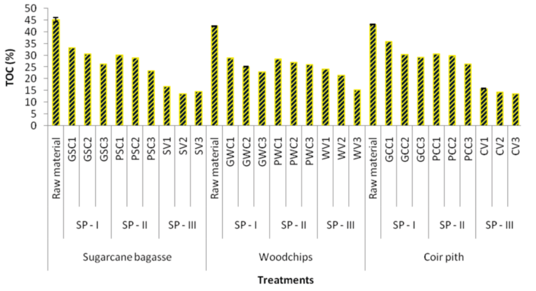

Fig.3. Comparision of TOC (%) in different treatment mixtures of Spent mushroom compost (*Ganoderma lucidum* and *Pleurotus flabellatus*) and Vermicompost

Total Nitrogen (TN)

The total nitrogen content estimated in the raw materials was 0.7% in SRM, 0.65% in WRM and 1.05% in CRM respectively. In G.lucidum based materials, the maximum total nitrogen content was in GSC$_3$ (1.86%) followed by GWC$_3$ (1.40%) and GCC$_3$ (1.35%). The minimum total nitrogen content was in GSC$_1$ (1.29%), GWC$_1$ (0.96%) and GCC$_1$ (1.24%) respectively. In P. flabellatus based materials, the highest total nitrogen content was observed in PWC$_3$(1.85%) and the lowest content was observed in PSC$_1$ (1.53%). In vermicompost, the maximum total nitrogen content was observed in CV$_3$(2.33%) while the minimum in WV$_1$ (1.22%) (Fig.4).

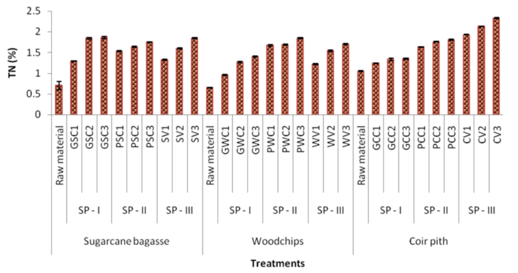

Fig. 4. Comparision of TN(%) in different treatment mixtures of Spent mushroom compost (*Ganoderma lucidum* and *Pleurotus flabellatus*) and Vermicompost

Total Available Phosphorous (TAP)

The TAP content in the raw materials was 0.007% in SRM, 0.009% in WRM and 0.008% in CRM respectively. In G.lucidum based materials, the TAP content was maximum in GSC$_3$ (0.03%) followed by GWC$_3$ (0.02%) and GCC$_1$, GCC$_2$ and GCC$_3$ (0.01% each). The TAP content was minimum in (GSC$_1$- 0.01%) followed by (GWC$_1$- 0.01%) and (GCC$_1$, GCC$_2$ and GCC$_3$ - 0.01%). In P. flabellatus based materials, the TAP content was maximum in PCC$_3$ (0.17%) followed by PWC$_3$ (0.13%) and PSC$_3$ (0.10%). The TAP content was minimum in PWC$_1$ (0.01%) followed by PSC$_1$and PSC$_2$ (0.04%) and PCC$_1$(0.07%). In vermicompost, the TAP content was maximum in VC$_3$ (0.51%) followed by VS$_3$ (0.26%) and VW$_3$ (0.13%). The TAP content was minimum in VW$_1$(0.03%) followed by VC$_3$(0.04%) and VS$_1$ (0.16%) (Fig.5).

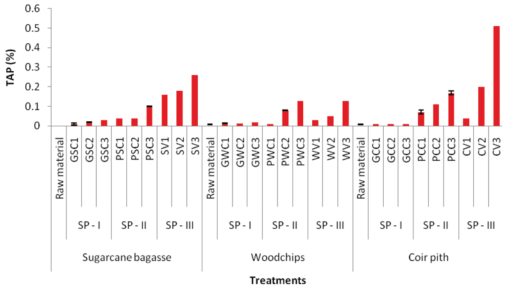

Fig. 5. Comparision of TAP (%) in different treatment mixtures of Spent mushroom compost (*Ganoderma lucidum* and *Pleurotus flabellatus*) and Vermicompost

DISCUSSION

In the experiment, the pH value in the SMC and vermicompost materials was lower than in the raw materials. This indicates that the reduction of pH values at the end of the process was due to the bioconversion of organic material into various intermediate types of organic acids. [15] reported that the reduction of pH during vermicomposting is due to the higher mineralization of nitrogen and phosphorus into nitrites/nitrates and orthophosphate that causes the lowering of pH value. Furthermore, it occurs due to the production of CO$_2$ and organic acids by microbial metabolism during decomposition of different substrates in the feed mixtures. The reduction of pH in vermicompost has also been reported by [16]. [17] reported that earthworms absorb water and breathe through their skin. They are sensitive to pH variations of the substrate. pH value is one of the most important factors affecting the survival of worms. Different pH values affect the activity of worms. There is a certain range of pH value for earthworms to survive. The decrease in pH after cumulative sludge may probably be attributed to nitrification of $N\text{-}NH^+_4$ or release of H^+ ions during mineralization from the sludge [18]. [19] also reported a decrease in soil pH with application of wheat or rice straw.

EC significantly declined (28.69% or 28% to 46%) in the final vermicompost during the management of bio-sludge of the beverage industry [20]. In the present study, after 90th day the electrical conductivity has decreased in all the compost materials.

The EC of SMC and vermicomposted materials ranged from 5.71 to 0.13 ms/cm. This difference may be due to high organic matter loss consequently and release of different mineral salts [21].

In this study, TOC concentration in both compost materials declined than raw materials after completion of the process. The final reduction in TOC values in all types of compost materials was possibly due to the rapid respiration rate that leads to the loss of TOC in terms of CO_2 and the organic carbon utilized by the worms and resulting in TOC reduction [22]. The reduction of organic carbon may be due to the growth of mushrooms, which resulted in the decomposition of waste [23]. The reduction of TOC showed that the earthworms rapidly multiplied decomposing the organics. Similar type of results was observed by several authors in various studies [24-26] in which various types of wastes were decomposed by earthworms. The organic carbon content declined drastically from the substrate upto 90 days [27] The TOC reduction of 24% to 60% during vermicomposting was also observed in different combinations of vermibed in an earlier research [28].

The Total Nitrogen (TN) content has increased after the 90th day in SMC and vermicompost materials. This result indicates that TN concentration of SMC and vermicompost materials are dependent on the combination of initial feed mixture [21]. [27] reported that TN has increased in all vermibeds after 150 days. The increase in TN values in the final SMC and vermicompost materials may be due to the initial physicochemical properties in the substrates, microbial mineralization of nitrogen and enzyme activity in the gut of the worms [26,22]. The increase of TN during composting process might be caused by the weight loss of the compost piles during composting process [29].

A similar trend has been observed by [30] who had reported a TN increase of 2.0 to 3.2 times in textile mill sludge vermicompost. It was suggested that earthworms could increase nitrogen levels in vermicompost by the addition of their excretory products, mucus, etc. In general, different nitrogen pattern and mineralization activities depend on the total amount of nitrogen in the initial waste and on the earthworm activity in the waste decomposition [31]. [32] reported that the nitrogen content accumulated in the earthworm cast after the digestion of wastes by the earthworm.

The increase of total nitrogen showed the good quality of the bio-compost obtained [24,25,33]. The present study and the earlier reports indicated that the earthworms use the carbon content in the spent material as a source of energy. Simultaneously, the nitrogen present in them was recycled. During this process, the casting of earthworms in turn enriched the macronutrients such as N, P and K resulting in the conversion of the spent materials into a good organic fertilizer. All these activities stabilized the level of carbon and nitrogen in the compost.

TAP content of different agro-industrial wastes increased in final compost materials. The phosphorus content was greater than the raw material for all treatments [34] which may be due to the phosphorus mineralization by the earthworm. This result was supported by [35] who suggested that unavailable phosphorus was converted in the earthworm intestine to an available form and also by solublization by the microorganism in their casts. [36] reported an increase in concentration of phosphorous during vermicomposting. The enhanced phosphorous level in vermicompost is probably through mineralization and mobilization of phosphorus by bacterial and faecal phosphatase activity of earthworms [37].

The incorporation of crop residues may increase the availability of TAP either directly by the process of decomposition and release of TAP from the biomass or indirectly by increase in the amount of soluble organic matter which are mainly organic acids that increase the rate of desorption of phosphate and improve the available TAP content in the soil [38]. The increase in available TAP concentration in organic waste treatments with recommended fertilizer could be due to a high microbial activity induced by the addition of organic residues and soluble inorganic TAP, which speeds up TAP cycling [39].

CONCLUSION

The biochemical analysis of spent mushroom materials and vermicompost in the present study indicated that the nutrient qualities of the materials were enhanced to a greater extent in sugarcane bagasse compost compared to coir pith and woodchips compost. The total quantity of certain minerals and nutrients present in the raw material was either reduced or tuned according to the requirement of the plants by the mushroom and earthworms. Compared with different treatment mixture of 1:1, 1:2 and control in all spent mushroom compost and vermicompost, the best performance was in 1:2 treatments. So, the 1:2 ratio of treated agro-industrial waste was considered the best since it showed best performance and also the macro and micro nutrient level present in the vermicompost and mushroom compost materials showed a promising level required for the plants. Better quantity of macro was present in vermicompost when compared to spent mushroom compost. The sugarcane bagasse was the best substrates compared to others like woodchips and coir pith. So, the essential nutrient was good in sugarcane bagasse vermicompost for plant growth. When agro-industrial waste was treated with earthworms rather than mushroom species, the result was better. Hence, it is concluded that the 1:2 ratio of sugarcane bagasse and fish waste would be an ideal combination for the waste disposal to a greater extent.

ACKNOWLEDGMENTS

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Table 1. Spent mushroom compost (Ganoderma lucidum and Pleurotus flabellatus) and vermicompost prepared with different concentrations of fish waste for analysis of physiochemical characters

Treatments	Ratio of substrates	Composition of bed materials used
SRM	Raw materials	Sugarcane bagasse
WRM		Woodchips
CRM		Coir pith
GSC_1	Control	Remains of G. lucidum after harvest + 500g sugarcane bagasse
GSC_2	1:1	Remains of G. lucidum after harvest + 500g sugarcane bagasse + 500g fish wastes
GSC_3	1:2	Remains of G. lucidum after harvest + 500g sugarcane bagasse + 1 kg fish wastes
GWC_1	Control	Remains of G. lucidum after harvest +500g woodchips
GWC_2	1:1	Remains of Ganoderma lucidum after harvest +500g woodchips + 500g Fish wastes
GWC_3	1:2	Remains of G. lucidum after harvest +500g woodchips +1 kg Fish wastes
GCC_1	Control	Remains of G. lucidum after harvest +500g Coir pith
GCC_2	1:1	Remains of G. lucidum after harvest +500g Coir pith +500g Fish wastes
GCC_3	1:2	Remains of G. lucidum after harvest +500g Coir pith + 1 kg Fish wastes
PSC_1	Control	Remains of P. flabellatus after harvest + 500g sugarcane bagasse
PSC_2	1:1	Remains of P. flabellatus after harvest + 500g sugarcane bagasse+ 500g fish wastes

PSC$_3$	1:2	Remains of P. flabellatus after harvest + 500g sugarcane bagasse+ 1 kg fish wastes
PWC$_1$	Control	Remains of P. flabellatus after harvest + 500g woodchips
PWC$_2$	1:1	Remains of P. flabellatus after harvest + 500g woodchips +500g fish wastes
PWC$_3$	1:2	Remains of P. flabellatus after harvest + 500g woodchips + 1kg fish wastes
PCC$_1$	Control	Remains of P. flabellatus after harvest + 500g coir pith
PCC$_2$	1:1	Remains of P. flabellatus after harvest + 500g coir pith+ 500g fish wastes
PCC$_3$	1:2	Remains of P. flabellatus after harvest + 500g coir pith+ 1 kg fish wastes
SV$_1$	Control	500g sugarcane bagasse + 500g cowdung
SV$_2$	1:1	500g sugarcane bagasse + 500g cowdung + 500g fish wastes
SV$_3$	1:2	500g sugarcane bagasse + 500g cowdung + 1kg fish wastes
WV$_1$	Control	500g woodchips + 500g cowdung
WV$_2$	1:1	500g woodchips + 500g cowdung + 500g fish wastes
WV$_3$	1:2	500g woodchips + 500g cowdung + 1 kg fish wastes
CV$_1$	Control	500g coir pith + 500g cowdung
CV$_2$	1:1	500g coir pith + 500g cowdung + 500g fish wastes
CV$_3$	1:2	500g coir pith + 500g cow dung + 1 kg fish wastes

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