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By

Sudhanthiraraj Subbu Lakshmi and Gurusamy Chelladurai

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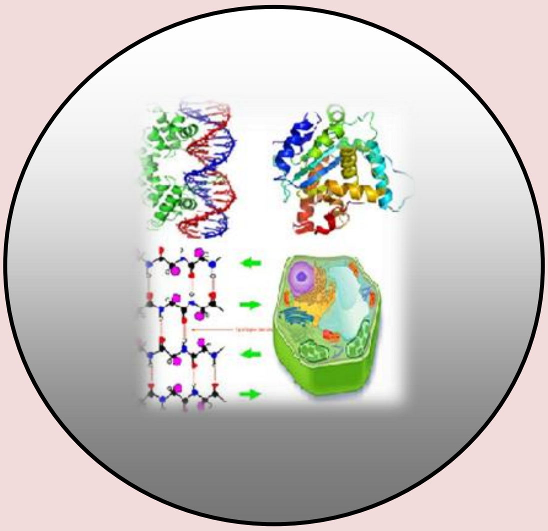

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Dr. S. Subbu Lakshmi
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RESEARCH PAPER

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Nutritional Content of Spent Mushroom Compost (*Ganoderma lucidum, Pleurotus flabellatus)* and Vermicompost

Sudhanthiraraj Subbu Lakshmi and *Gurusamy Chelladurai
Department of microbiology, Kamaraj College, Tuticorin-628003, Tamil Nadu, India
***Department of Zoology, V.O. Chidambaram College, Tuticorin Tamil Nadu, India**

ABSTRACT

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 dry compost materials were used for analyzed of physiochemical parameters. The sodium (Na) concentration of vermicompost and SMC varied significantly with different ratios of substrates used as well as earthworm and different mushrooms cultured. When compared to the raw material as well as all compost material, the level of Na significantly dropped to a greater extent. The growth of mushroom and earthworm enhanced the level of Total Potassium (TK) content. All the compost materials showed the presence of excellent quantity of TK when compared to raw materials. These differences in observation are generally due to the different chemical characteristics of initial feed mixtures. After the cultivation of Ganoderma lucidum and Pleurotus flabellatus using agro-industrial waste with fish waste, significant depletion of Fe was noticed in SMC. More or less, the same trend of reduced level of Fe content was observed in vermicompost materials. The Zn content of SMC and vermicompost materials showed a remarkable depletion. Very high quantity of Mn was present in the raw materials when compared to spent mushroom and vermicompost material. The results indicated that the Mn content gradually decreased after biodegradation of agro-industrial waste and fish wastes when compared to raw materials with various combinations. When agro-industrial waste was treated with earthworm rather than mushroom species, the result was better.
Keywords: Spent Mushroom Compost (SMC), Woodchips, Ganoderma lucidum and Pleurotus flabellatus.

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 (Ramalingam *et al.,* 2004), green wastes from local vegetable market (Logakanthi *et al.,* 2006) 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 (Courtney and Mullen, 2008; Mullen and McMahon, 2001).

Elevated amounts of Nitrogen, Ammonia, Magnesium, Phosphorus and Calcium have been identified in earthworm castings as compared to soil (Umamaheswari, 2005; Reddy and Okhura, 2004; Umamaheswari and Vijayalakshmi, 2003; Singh and Sharma, 2002; Ravichandran *et al.,* 2001).

Pleurotus species are the rich source of protein and minerals like Ca, P, Fe, K and Na and Vitamin like C, B complex like thiamine, riboflavin, folic acid and niacin (Caglarmak, 2007; Patrabamsh and Madan, 1997). They are consumed for their nutritive as well as medicinal values (Agrahar–Murugkar and Subbulakshmi, 2005). Mushroom protein is intermediate between the animals and the vegetables (Mamiro and Royse, 2008; Ndeka, 2002; Mshandete and Cuff, 2007) and is of superior quality because of the presence of all the essential amino acids (Purkayastha and Nayak, 1981).

Pleurotus sp. contains high potassium to sodium ratio, which makes mushroom an ideal food for patients suffering from hypertension and heart disease. *Ganoderma lucidum* possesses potential Anti-HIV activity (Chang and Mshigeni, 2001). The practice of mushroom cultivation not only produces a nutritious food but also improves the degradability of straw. This takes place by reducing cellulose, hemi-cellulose, tannin and crude fiber contents of straw, making it an ideal animal feed (Ortega *et al*., 1992). The utilization of various mineral elements present in the SMC may be directly linked to good growth and fruit development in the vegetables (Jonathan *et al.,* 2011).

MATERIALS AND METHOD

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 90^{th} day (Table 1). 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. Zinc, iron, copper and manganese in samples were determined using Atomic Absorption Spectrophotometry (Model: Elico SL-73 AAS). Sodium and potassium were determined with Flame Photometer (Model: Elico CL 361). The samples were analyzed in triplicates.

Statistical analysis

The values were expressed as Mean ± SD and graphs were constructed using Microsoft Excel (Ghehsareh *et al*., 2012).

RESULTS

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

Total Potassium (TK)

The total potassium content estimated in the raw materials was 0.1% in SRM, 0.06% in WRM and 0.6% in CRM respectively. In *G.lucidum* based materials, the high quantity of TK was recorded in GSC_3 (0.40%) followed by GWC_3 (0.10%) and GCC_2 (1.51%) respectively. The low quantity of TK was recorded in GSC_1 (0.31%) followed by GWC_2 (0.08%) and GCC_1 (0.83%) respectively. In *P. flabellatus* based materials, the high quantity of TK was recorded in PSC_3 (0.76%) followed by PWC_3 (0.23%) and PCC_3 (1.41%) respectively. The low quantity of TK was recorded in PSC_1 (0.47%) followed by PWC_1 (0.21%) and PCC_1 (1.21%) respectively. In vermicompost based materials, the high quantity of TK was recorded in SV_3 (0.52%), followed by WV_3 (0.26%) and CV_3 (1.30%) respectively. The low quantity of TK was recorded in SV_1 (0.28%) followed by WV_1 (0.18%) and CV_1 (0.94%) respectively (Fig 1).

Table 1. 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

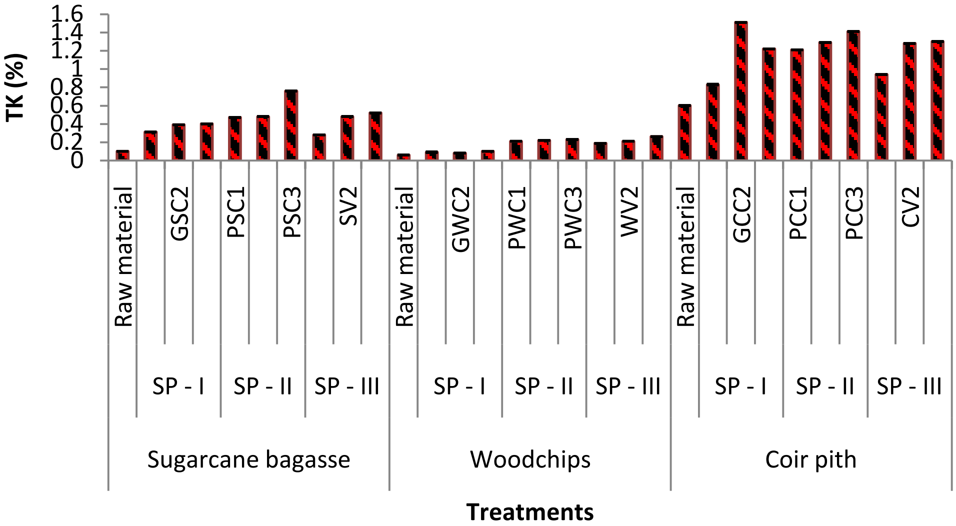

Figure 1. Comparision of TK (%) in different treatment mixtures of spent mushroom compost (*Ganoderma lucidum* and *Pleurotus flabellatus*) and Vermicompost Sodium (Na).

Na content in raw materials was 2876 ppm in SRM, 1650 ppm in WRM and 5730 ppm in CRM respectively. In *G.lucidum* based materials, the maximum Na content was observed in GCC_1 (5175 ppm) followed by GSC_1 (2874 ppm) and GWC_1 (1014 ppm), while the minimum Na content was observed in GWC_3 (564 ppm) followed by GSC_3 (2553.66 ppm) and GCC_3 (4218 ppm). In *P. flabellatus* based materials, the maximum Na content was observed in PCC_1 (4842.33 ppm) followed by PSC_1 (1913.66 ppm) and PWC_1 (1626.33 ppm), while the minimum Na content was observed in PSC_3 (1318.33 ppm) followed by PWC_3 (1381.66 ppm) and PCC_3 (3925.33 ppm). In vermicompost based materials, the maximum Na content was observed in VC_2 (5789 ppm) followed by VS_2 (2787.33 ppm) and VW_3 (1019.66 ppm), while the minimum Na content was observed in of VW_2 (935 ppm) followed by VS_1 (1241 ppm) and VC_3 (5121 ppm) (Figure 2).

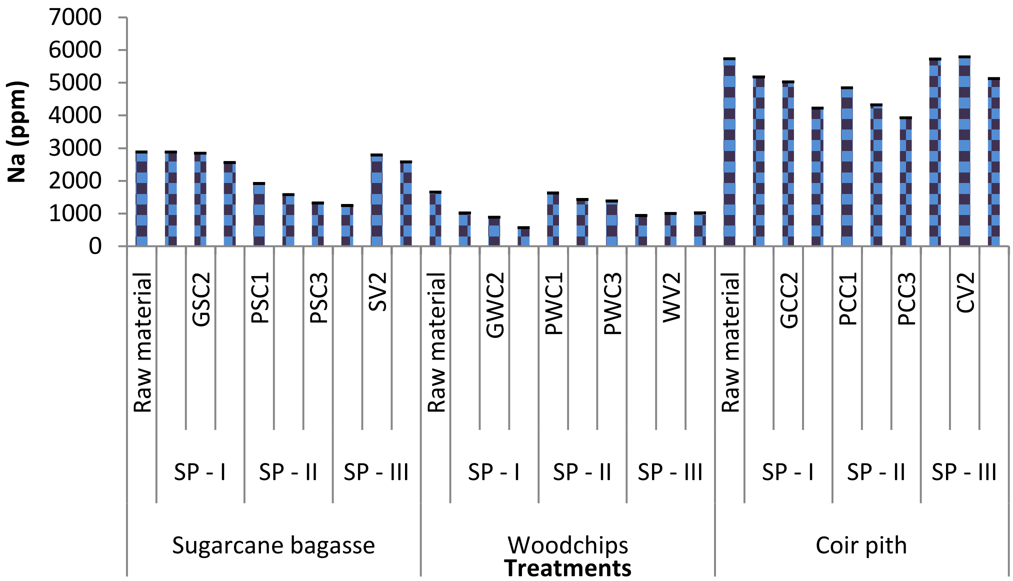

Figure 2. Comparision of Na (ppm) in different treatment mixtures of spent mushroom compost (*Ganoderma lucidum* and *Pleurotus flabellatus*) and Vermicompost.

Copper (Cu)

The level of Cu observed in raw materials was 29 ppm in SRM, 18 ppm in WRM and 13 ppm in CRM. In *G.lucidum* based materials, the Cu was not detectable in GSC_1 GSC_2, GSC_3, GWC_1 GWC_2, GWC_3, GCC_1, GCC_2 and GCC_3. In *P. flabellatus* based materials, the highest reduction of Cu was noted in PCC_3 (6 ppm) and PSC3 (13 ppm). The lowest reduction of Cu was noted in PSC_1 (15.8 ppm) and PCC_1 (12.66 ppm). It was absent in PWC_1, PWC_2 and PWC_3. In vermicompost based materials, the highest reduction of Cu was noted in VW_3 (9 ppm) and VS_3 (18 ppm). The lowest reduction of Cu was noted in VS_1 (25 ppm) and VW_1 (16 ppm). It was absent in VC_1, VC_2 and VC_3 (Fig. 3).

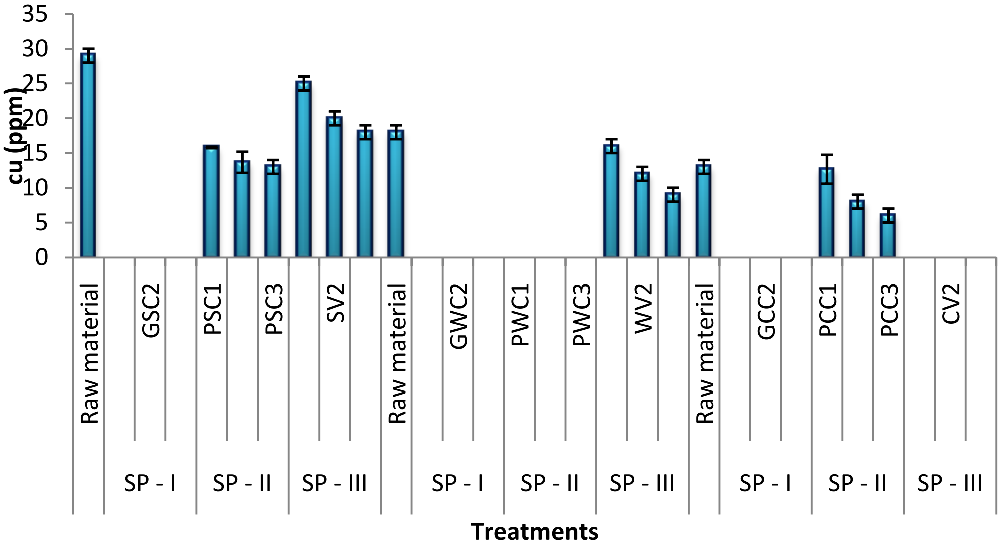

Figure 3. Comparision of Cu (ppm) in different treatment mixtures of spent mushroom compost (*Ganoderma lucidum* and *Pleurotus flabellatus*) and Vermicompost.

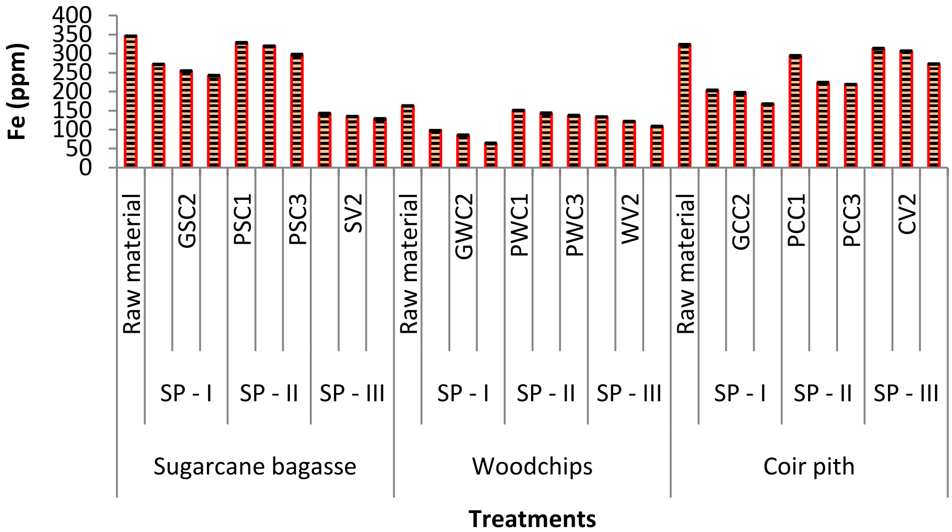

Figure 4. Comparision of Fe (ppm) in different treatment mixtures.

Iron

Fe level was 345 ppm in SRM, 162 ppm in WRM and 323 ppm in CRM. In *G.lucidum* based materials, the maximum level of Fe content was in GSC_1 (271 ppm) followed by GCC_1 (202.66 ppm) and GWC_1 (97 ppm). The minimum level of Fe content was in GWC_3 (63.33 ppm) followed by GCC_3 (167 ppm) GSC_3 (241.33 ppm).

In *P. flabellatus* based materials, the maximum level of Fe content was noticed in PSC_1 (327.66 ppm) followed by PCC_1 (293.33 ppm) and PWC_1 (150 ppm). The minimum level of Fe content was in PWC_3 (136.33 ppm) followed by PCC_3 (218 ppm) and PSC_3 (296.66 ppm). In vermicompost based materials, the maximum level of Fe content was observed in VC_1 (312.33 ppm) followed by VS_1 (141.66 ppm) and VW_1 (133 ppm). The minimum level was in VW_3 (107.66 ppm) followed by VS_3 (127.66 ppm) and VC_3 (272 ppm) (Figure 4).

Zinc (Zn)
Zinc in the raw materials was 29 ppm in SRM, 175.2 ppm in WRM and 58.2 ppm in CRM. In *G.lucidum* based materials, the highest reduction of Zn content was in GSC_3 (17.33 ppm) followed by GWC_3 (153.33 ppm) and GCC_3 (23.33 ppm). The lowest reduction of Zn content was in GSC_1 (26.33 ppm) followed by GWC_1 (169 ppm), GCC_1 (43.33 ppm). In *P. flabellatus* based materials, the highest reduction of Zn content was in PSC_1 (15 ppm) followed by PWC_1 (106 ppm) and PCC_1 (10 ppm). The lowest reduction of Zn content was in PSC_3 (24 ppm) followed by PWC_3 (140.66 ppm) and PCC_3 (40 ppm). In vermicompost based materials, the highest reduction of Zn content was in VW_1 (101.66 ppm) and VC_3 (40 ppm). The lowest reduction of Zn content was in VW_3 (134 ppm) and VC_1 (53 ppm). The Zn content has increased in VS_1 (56 ppm) and VS_3 (34 ppm) (Figure 5).

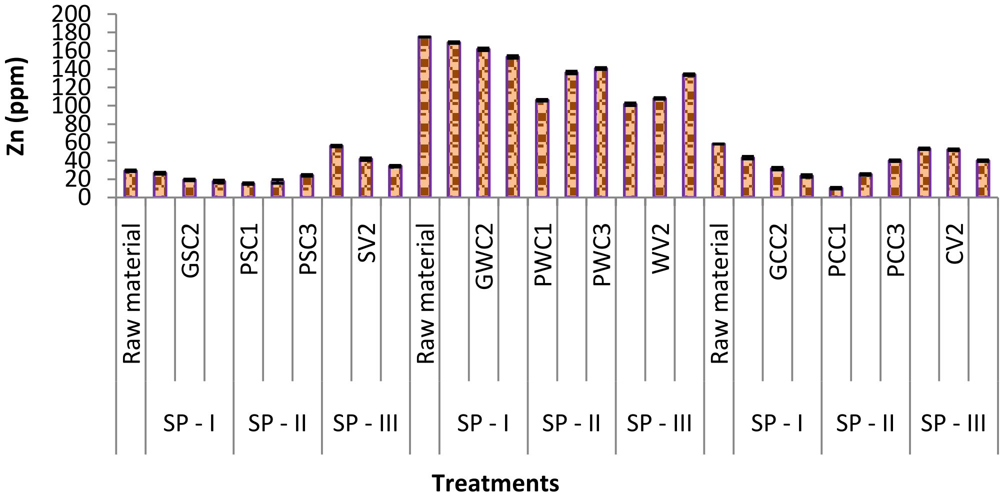

Figure 5. Comparision of Zn (ppm) in different treatment mixtures of vermicompost.

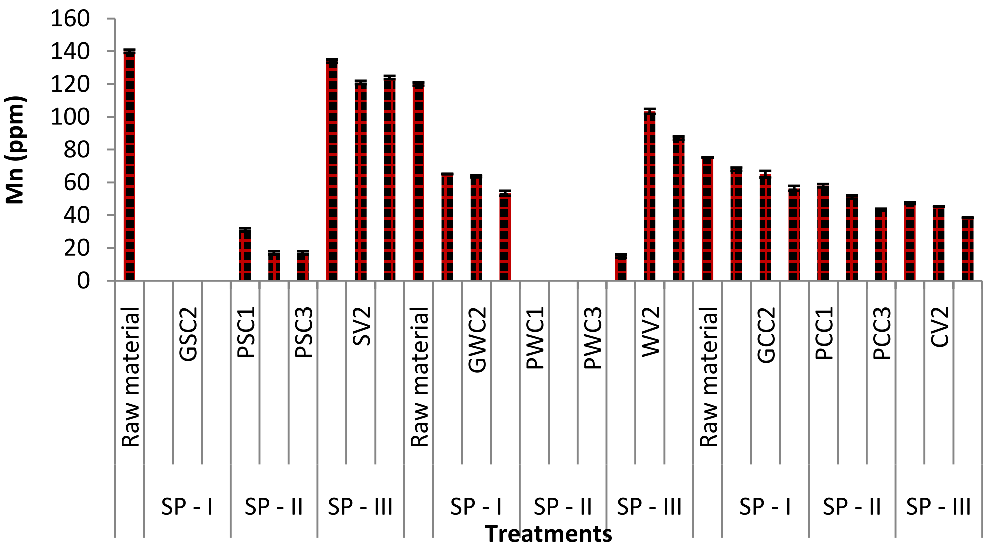

Figure 6. Comparision of Mn (ppm) in different treatment mixtures of vermicompost.

Manganese (Mn)

The Mn content in the raw material was 140 ppm in SRM, 120 ppm in WRM and 75.2 ppm in CRM. In *G.lucidum* based materials, the highest reduction of Mn content was in GWC_3 (53.33 ppm) and GCC_3 (56.33 ppm). The lowest reduction of Mn content was in GWC_3 (65.1 ppm) and GCC_1 (68 ppm). The Mn content was absent in GSC_1, GSC_2 and GSC_3. In *P. flabellatus* based materials, the highest reduction of Mn content was in PSC_2 and PSC_3 (17 ppm) followed by PCC_3 (43.33 ppm). The lowest reduction of Mn content was in PSC_1 (31 ppm) and PCC_1 (58 ppm). The Mn content was absent in PWC_1, PWC_2 and PWC_3. In vermicompost based materials, the highest reduction of Mn content was in VS_2 (121 ppm) followed by VW_1 (15 ppm) VC_3 (38.36 ppm). The lowest reduction of Mn content was in VS_1 (31 ppm) followed VW_2 (103.33 ppm) and VC_1 (134 ppm) (Figure 6).

DISCUSSION

The sodium concentration of vermicompost and spent mushroom compost material varied with different ratios of substrates used as well as earthworm and different mushrooms cultured. When compared to the raw material, the level of sodium in the final compost material significantly dropped to a greater extent. Sodium is a vital nutrient for all organisms to carry out their routine life and metabolic activity. The earthworms consumed various treated materials and absorbed reasonable quantity of sodium for their own use, resulting in the depletion of sodium in the end product (Lee *et al*., 2009; Danny *et al*., 2004). The reduction in sodium in the end product could also be attributed to the solubility of sodium as some quantum of Na may be solubilized in the excess water sprayed over the bed during the process of vermicomposting and leached out of the bed (Khwairakpam and Bhargava, 2007; Elvira *et al*., 1998).

When the raw material was treated with the mushrooms and earthworm, the level of Cu decreased in sugarcane bagasse from 29 to 13 ppm, in woodchips from 18 to 9 ppm and in coir pith 13 to 6 ppm. When different agro-industrial and fish wastes were treated with mushrooms and earthworm, it resulted in decrease of Cu in all the treatments. Some treatments had no Cu content in final compost materials. It was reported that during digestion, decomposition and mineralization of the raw material and the spent materials, the excess quantity of copper present in them was absorbed by the tissues of the earthworm and thus the toxic potential of the raw materials was reduced (Leonard and Dolfing, 2001; Jain and Singh, 2004; Jain *et al*., 2004; Shahmansouri *et al*., 2005). This action further manifested the action of the microbes that are present in the digestive tract of earthworms in many fold (Selladurai and Anbu Saravanan, 2009; Mehalingam *et al*., 2008; Karthikeyan *et al*., 2007).

Potassium is commonly found in all cultivated and wild mushrooms (Mattila *et al*., 2001; La Guardia *et al*., 2005). In the present study, all types of compost materials showed the presence of excellent quantity of potassium (TK) compared to raw materials. These differences in observation are generally due to the different chemical characteristics of initial feed mixtures (Rupani *et al.,* 2013) and production of carbonic, nitric and sulfuric acids by microorganisms present in the gut of earthworms (Kaviraj and Sharma, 2003). The growth of mushrooms and earthworms enhanced the level of TK in the all compost materials (Lee *et al*., 2009; Ersin Polat *et al*., 2009). Reports show inconsistent results regarding TK in the final vermicompost of different industrial wastes. Higher potassium content has been observed in sewage sludge compost (Delgado *et al*., 1995); whereas Orozco *et al*. (1996) reported lower TK in coffee pulp waste after vermicomposting. Kaur and Benipal (2006) found that incorporation of rice residue and farmyard manure increased available TK status and water-soluble and fixed TK. The cultivation of *Ganoderma lucidum* and *Pleurotus flabellatus* using agro-industrial wastes with fish waste resulted in the depletion of Fe. More or less, the same trend was noticed in vermicompost materials. The composition of spent mushroom bed materials (*G. lucidum* and *P. flabellatus*) and vermicompost varied from raw materials (Maniruzzaman Sikder *et al*., 2010; Lee *et al*., 2009; Ersin Polat *et al*., 2009). This study showed that the earthworm had effectively reduced the heavy metal level that was present in higher concentration in the raw material as substantiated by the observation of Selladurai and Anbu Saravanan (2000), Suthar (2008) and Dominguez (2004).

With reference to the heavy metal Zn, the spent mushroom compost of woodchips and coir pith, obtained after the harvest of mushroom, and the vermicompost materials showed reduced Zn content.

It was also low in sugarcane bagasse spent materials, but not in sugarcane bagasse vermicompost materials. The results indicated that the Zn content of SMC materials showed a remarkable depletion. A comparison of metal contents of SMC with that of untreated soil showed that the metals Zn, Ni, Pb and Cd were not present in SMC in greater concentrations than in the soil. The heavy metal concentrations of SMC are below the levels indicated by the EU (CEC, 1986) for the agricultural use of waste organic material (sewage sludge). Very high concentration of Mn was observed in the raw materials compared to spent mushroom and vermicompost material. The results indicated that the Mn content gradually decreased after biodegradation of agro-industrial and fish wastes compared to raw materials with various combinations. A reduction in Mn content was observed in composted materials, which confirmed the effective action of microbial agents (Reghuvaran and Ravindranath, 2010).

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 earthworm. 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 quantities of macro were 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 earthworm 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.

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Corresponding author: Dr. Sudhanthiraraj Subbu Lakshmi, Department of microbiology, Kamaraj College, Tuticorin-628003, Tamil Nadu, India
Email: gcd.zoology@gmail.com , resbio@scholarlyjournals.org