Asian Journal of Chemistry; Vol. 24, No. 3 (2012), 1051-1054

ASIAN JOURNAL OF CHEMISTRY

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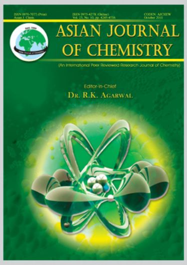

Assessment of Chemical Quality and Manure Value of Vermicompost Prepared from Mushroom Wastes

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(*Received*: 31 January 2011; *Accepted*: 3 November 2011) AJC-10591

Mushroom wastes are surplus materials, which in spite of their benefit and nutritive value aren't usable for agriculture directly due to high salinity. Thus, these materials are always taken away from production sites. Moreover, the disposal of these materials needs space and facilities in addition to expenses. One of the appropriate methods for the disposal of organic residuals is the production of vermicompost from these wastes. This research was carried out to produce vermicompost from mushroom wastes and to investigate the quality of produced vermicompost in a randomly complete block design with three treatments including wastes of three mushroom factories in four replication and greenhouse condition. The chemical features of mushroom wastes including pH, electrical conductivity, organic carbon, N, P, K, Fe, Cu, Zn and Mn were measured before the experiment. After the production process of vermicompost, some of its quality features including the percentage of moisture, pH, electrical conductivity, organic carbon, N, P, K, Fe, Cu, Zn and Mn were measured. Also, the possibility of using the produced vermicompost in growing of plants was considered. The results of chemical analysis of produced vermicompos, in experimental treatments, were tested statistically using MSTATC and SPSS software. Results indicated that the produced vermicompost had pH buffer with low salinity. Also, the amount of electrical conductivity was decreased considerably in comparison with initial materials. The density of nutritious elements such as N, P and Fe was high in the produced vermicompost. This indicates that this type of vermicompost has appropriate properties that improve soil features and its high manure value ensures the availability of nutritient elements for plants. Overall, the comparison of quality and combination of initial materials and produced vermicompost showed that the produced vermicompost features are to a great extent similar to the produced vermicompost from domestic animals' manure and other plants' residuals. These results show the capacity of the produced vermicompost from mushroom wastes for being used in farms as soil improving materials.

Key Words: Spent mushroom compost, Vermicompost, Physicochemical value, Iran.

INTRODUCTION

Mushroom surplus created from mushroom producing industries is a mixture of sustainable organic materials and has different components such as chaff, poultry manure, horse manure, alfalfa grass and gypsum[1]. In mushroom production process, mushroom wastes or spent mushroom compost (SMC) are commonly discarded as wastes and can create different environmental problems. Usually, the density of cations and anions are high in spent mushroom compost and increase the degree of electrical conductivity. These salts are washed and leached away by rainfall or watering. This issue can create problems in the application of mushroom surplus, that is why it is considered in many researches. Polat *et al.*[2] in studying different levels of spent mushroom compost on cations' density and pepper plant's yield found that high levels of spent mushroom compost application, due to the high levels of dissolved salts in them, reduces the plant growth and yield. Uzan, *et al.*[3] compared two old and newly produced spent mushroom compost types. Newly produced spent mushroom compost had much value of Na, Mg and Ca, but these amounts were reduced after spent mushroom compost was left for 8-16 weeks.

To produce 1 kg of mushroom, 5 kg of spent mushroom compost is needed and this high amount of surplus is stacked in mushroom culture factories. This surplus has high salinity, inappropriate organic substances[4], a high percentage of gypsum (Royal Gardening Institute, 2010) that makes it inappropriate for adding to soil and greenhouse culture spaces. A practical solution for this problem is the transformation of these wastes to beneficial and valuable materials, for example vermicompost. In reality, vermicompost includes earthworm waste, degenerated organic matterials, cocoons of earthworm and microorganisms[5]. Vermicomposts have buffer reaction, a porous structure, aeration feature, high water preservation capacity and many populations

TABLE-1
MEAN RESULTS OF INITIAL MATERIALS QUALITY AND PRODUCED VERMICOMPOST FROM MUSHROOM WASTES ANALYSIS

Mushroom Factories	Treat-ments	Material	Na (%)	K (%)	Ca (%)	Mg (%)	pH	Ec (dS/m)	NO_3 (%)	N (%)	P (%)	C (%)	Cu (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	Fe (mg/kg)
Sabalan	t1	Mushroom Wastes	1.11	2.36	1.48	5.72	7.39	20.1	10.7	1.92	0.06	14.13	135.06	393.51	898.93	5639.00
		Vermicompost	1.76	5.83	5.28	0.82	7.02	6.20	12.0	1.40	0.27	13.74	185.71	351.47	884.70	5679.66
Arta	t2	Mushroom Wastes	0.71	0.01	2.16	6.28	7.12	15.6	11.6	1.08	0.01	11.60	205.67	333.83	899.34	5680.00
		Vermicompost	2.25	2.12	5.92	0.92	7.55	5.22	8.53	1.37	0.16	10.77	160.87	431.38	901.10	5768.63
Kumiya	t3	Mushroom Wastes	1.06	1.15	1.40	4.04	7.45	17.2	10.5	1.61	0.03	10.06	119.10	348.06	652.59	5515.60
		Vermicompost	1.67	6.67	5.50	0.64	7.25	5.185	9.73	1.40	0.12	13.40	180.77	318.70	921.85	5714.74

of beneficial microorganisms. These features of vermicompost make it an appropriate substitute for peat and other materials used for growing plants in vases[6].

The capability of some earthworms in converting organic residuals such as sewage sludge[7], domesticated animals' wastes, for example pig manure[8,9], cow manure[9], plant residuals[10] and rice residuals and mango leaves[11] and industrial organic wastes, for example pulp wastes and beer yeast[12] are well known. Earthworm wastes usually have nitrogen, phosphorus and potassium about 5-11 times more than soil. In addition, this process increases the amount of Ca, Mg and also microelements[13].

Many evidences show that the earthworms' activities accelerate organic materials mineralization and polysaccharides breakdown, humification materials increase, carbon to nitrogen ratio reduction and reduction in the absorption of heavy metals[6]. In this research, the possiblity of vermicompost production from spent mushroom surplus by *Eisenia foetida* earthworm and chemical characteristics of created vermicompost are investigated.

EXPERIMENTAL

In this research, samples of mushroom wastes from three mushroom producing centers (Kimia, Sabalan and Arta), located in Ardbil city in North West of Iran, were picked up in 2009. Mushroom waste samples were dried at 60 ºC for 48 h, then the samples were screened with a seive containing holes of 0.5 mm in diameter. Chemical features of mushroom wastes, including pH, electrical conductivity, organic carbon, N, P, K, Fe, Cu, Zn and Mn, were measured according to recommended methods by Iran Soil and Water Institute.

A randomized complete block design with three treatments and four replications was carried out. Ten earthworms were added to each vase during a week, after the content of mushroom wastes in vases and the humidity (70 %) and temperature (20-30 ºC) in the environment reached the levels appropriate for earthworms' activity. Adding of earthworms continued for several weeks, until six earthworm were found alive in each vase. This number was the critical level for making sure that the environment is appropriate for earthworms life. At this point, we decided to increase the number of earthworms to 100 in each vase. The next step was to make sure that the environment is good enough to guarantee the continuation of earthworms life. Then the number of earthworms in each vase was increased to 200 each to be considered a treatment. After the production of vermicompost, the quality of the produced vermicompost was investigated by measuring pH, electrical conductivity, organic carbon, N, P, K, Fe, Cu, Zn and Mn parameters in accordance with methods used by Soil and Water Research Institute of Iran and the possibility of using the produced vermicopost in plant production was surveyed.

The results of chemical analysis of produced vermicompost in experimental treatments were tested statistically using MSTATC and SPSS software. One-way ANOVA and comparing means statistical procedures were used to investigate the activity of earthworms and the quality of produced vermicompost.

RESULTS AND DISCUSSION

Physico-chemical characteristics of mushroom wastes of Kimia, Sabalan and Arta factories (in Ardabil) that were used as bed material are presented in Table-1. Results show that these samples have pH buffer, but high electrical conductivity, which is an indication of the necessity for the produced materials to be washed and desalinized. Appropriate pH for many earthworms ranges from 6.5-7, but some of earthworm species[13] are resistant to acidic pH. Some of bed materials have high levels of salts (for example animal manure). Thus, to desalinize, using water is essential for washing the spent mushroom compost in order to make the environment appropriate for the life and reproduction of earthworms. To reduce the pH of bed material, it is possible to use natural wastes such as moss peat, old saw dust, pine and alfalfa leaves and growing tree leaves in acidic soil[13]. Mitchel *et al.*[9] also points out the need for washing the initial material before the vermicompost production process begins. Carbon percentage and carbon to nitrogen ratio in our samples are low, which show a degree of initial ripening of materials. This situation shows that adding materials rich in nitrogen to accelerate the process of vermicompost production is not necessary[9].

Results of ANOVA for chemical characteristics of produced vermicompost in different treatments are displayed in Table-2. These results show that K and pH parameters had significant differences at *p*-level of 0.05 and EC at *p*-level of 0.01 (Table-2). Differences in these parameters in different treatments (mushroom wastes of every three factories) show a quality difference in wastes of studied factories, taking these variables into consideration. As the results of comparing means (Table-2) for significant parameters show, the amount of potassium in produced vermicompost is highest in vermicompost produced in Kimia factory and Sabalan and Arta factories stand in second and third places respectively. The level of EC was the highest in Sabalan and then Arta and Kimia factories, respectively. The maximum amount of phosphor resulting from vermicompost production belonged to Arta factory and the wastes of Kimia mushroom and Sabalan stood in second and third ranks respectively.

TABLE-2
MEAN OF SQUARES RESULTING FROM ANOVA IN ASSESSING PARAMETERS OF VERMICOMPOST PRODUCED FROM WASTES IN MUSHROOM PRODUCTION FACTORIES (SABALAN, ARTA AND KIMIA IN ARDABIL CITY)

S.O.V.	df	Na (%)	K (%)	Ca (%)	Mg (%)	pH	Ec (dS/m)	NO_3 (%)	N (%)	P (%)	C (%)	Cu (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	Fe (mg/kg)
T	2	0.39^{ns}	23.53*	0.42^{ns}	0.08^{ns}	0.29*	1.32**	12.42	0.00^{ns}	0.01**	10.58^{ns}	691.53^{ns}	13435.57^{ns}	1386.42^{ns}	8034.85^{ns}
R	4	0.35^{ns}	22.98*	0.38^{ns}	0.01^{ns}	0.04	0.17	3.54	0.00*	0.01**	4.25^{ns}	2144.48^{ns}	13635.92^{ns}	2120.93^{ns}	22838.99^{ns}
E	6	0.12	3.30	0.75	0.26	0.07	0.12	4.66	0.00	0.001	5.92	13826.29	12160.75	7545.62	13826.85

**Different is significant at the 0.01 level. *Different is significant at the 0.05 level. ^{ns}Non significant.

As presented in Table-1, the produced vermicompost had pH buffer and low electrical conductivity. But, the amount of nutritious elements such as N, P and Fe were high in produced vermicompost. This indicates the suitability of this vermicompost for ensuring the existence of nutritious elements in the soil which improve its qualitative characteristics and high manure value. Parvaresh *et al.*[14] have also pointed to the appropriate chemical quality and high manure value of vermicompost.

The pH ranges in produced vermicompost differed compared to initial material (Table-1). But, electrical conductivity value was reduced considerably showing better quality of produced vermicompost in comparison to initial material. Majd *et al.*[15] reported the amounts of pH and electrical conductivity variation during vermicompost production process. Almost, total nitrogen ratio was reduced during the process, which probably is related to sublimation, washing and also penetration of nitrogen to earthworms' body. Mitchel *et al.*[9] observed that 18 % of bed material N is penetrated to earthworm's body. P and K and other nutritious elements increased in vermicomposts the reason being the carbon emission during the process[16] as CO_2. The calcium percentage of produced vermicompost was more than that of initial material (Fig. 1). In an experiment by Da Silva *et al.*[17] the Ca and Mg density increased in vermicompost. The increase in calcium amount was consistent with the findings of this research, but Mg values were different from the findings of present study. The comparison of the quality and composition of the initial materials and produced vermicompost characteristics are represented in Table-1. The features of produced vermicompost from spent mushroom compost are almost similar to vermicompost characteristics produced from animal manure and other plant residuals[15] that indicate the capacity of the this kind of vermicopost in improving the quality of soil in farmlands.

Electrical conductivity of initial residual materials in current study reduced from 17.63 to 5.54 ds/cm^2, which shows the desalinization process during the production. In this experiment the values of elements such as Cu, Fe, Zn and Mn increased from 153.38, 5611.53, 816.95 and 358.47 to 175.78, 5721.01, 902.55 and 367.18, respectively compared to initial material. The increase in the amount of Zn was more than the other elements (Fig. 2). One advantage of *Eisenia foetida* earthworm is the biological accumulation of microelements in produced vermicompost[18], which is in accordance with the findings of current research. Also, in an experiment by Omrani and Asgharnia[19], which was carried out to investigate the production of vermicompost from municipal solid waste, Fe and Mn densities in produced vermicompost were 287.66, 1794.16 mg/L respectively, which were more than their density in the initial materials.

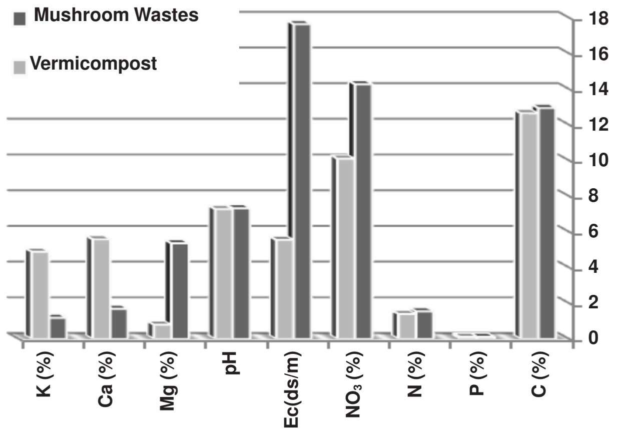

Fig. 1. Changes in some physicochemical characteristics in raw materials and produced vermicompost

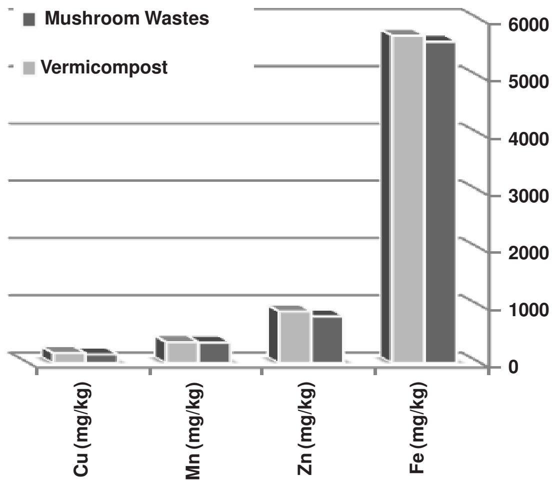

Fig. 2. Comparison of the micro element values in raw materials and produced vermicompost

Conclusion

Overall, considering the obtained results, it can be concluded that mushroom wastes cannot be considered a good food for *Eisenia foetida* earthworm and for the production of vermicompost because of their high electrical conductivity and the probability of Ammoniac presence. But, earthworms are capable of using these wastes after the wastes are being washed. The chemical characteristics of vermicompost produced in this way are better than the chemical characteristics of initial residuals significantly and are useful for soil improvement and ensuring the existence of needed elements for plants in the soil. It is suggested that, in the future researches, mushroom wastes combined with other bed materials such as saw dust be used to make the growth of earthworms possible and also accelerate the production of vermicompost from spent mushroom compost.

ACKNOWLEDGEMENTS

Thanks to Islamic Azad University, Ardabil Branch for financial assistance and E. Akbari Jedi and F. Zakeri for technical advice.

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