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Quantification of Physico-Chemical Composition of Spent Mushroom Substrate

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Abstract The physico-chemical analysis of spent mushroom substrate (SMS) showed that average EC and pH of SMS samples collected from three different depths of pit i.e. 0-30 cm, 30-60 cm and 60-90 cm was 1.27 mmhos cm^{-1} and 7.52 respectively. The organic carbon content was 2.56, 2.13 and 1.89% respectively and the amount of available nitrogen, phosphorus and potassium had not differed significantly with different depths. The ratio of NPK in the SMS sample was 2 : 1.2 : 1 with maximum amount in uppermost layer (2.42% N, 1.16% P and 1.08% K). Among different micro-nutrients the average iron (Fe) content was found to be 0.26% followed by manganese (Mn) (0.01%), while the zinc (Zn) and copper (Cu) content was less than 0.01%.

Keywords Spent mushroom substrate, Physico-chemical properties, Micro-nutrients.

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Introduction

Growing of mushrooms on large scale have been providing employment for several people in the developed and developing countries of the world [1]. It has been widely reported that commercial mushroom cultivation use substrates like wheat straw, poultry manure, gypsum, horse manure [2]. Correspondingly, for every kilogram of mushroom cultivated, 3-5 kg of SMS is generated [3]. Singh et al. [4].stated that average farm discards about 24 tones of SMS per month. Uncontrolled disposal of SMS may pose a problem to the environment; therefore, there is a need to convert this waste into harmless substances (waste to wealth) which will be useful for agricultural use or to products that will be environmentally friendly.

Spent mushroom substrate (SMS) is produced in very large quantity from the mushroom farms. Although it is known as spent but it can be reused as an organic manure in agricultural fields. Being rich in macro and micro nutrients, it can act as a supplier of nutrients to the plants. Spent mushroom substrate (SMS) or spent mushroom compost (SMC) is a by-product of mushroom production. It results from the production growing media that is removed from the mushroom farm after the completion of harvest. In India, approximately 1,64,000 mi tones of SMS is produced [5] . In Ireland, approximately 2,54, 000 tones of SMS is generated each year [6] and in Netherlands, more than 8,00,000 tones of SMS is produced per year [7]. In some countries, waste management of SMS is a major problem faced by farmers. Apparently, the obvious solution is to increase the demand for SMS through exploration of new applications for utilization. It would be more economical and favorable if SMS is to be recycled and reused. Often SMS is regarded as an agricultural waste product with little inherent value; yet there is still value in the substrate as it is rich in nutrients and organic matter and can provide benefits to other agricultural or non-agricultural sectors. It has been reported of containing nutrients which could be used for the growth of useful photosynthetic plants [8].

It serves as supplier of both, organic matter that improves soil structure and as source of macro and micro elements for plant nutrition[9]. SMS released after mushroom crop harvesting may cause various environmental problems because the large dumped piles of this subtrate become anaerobic and give off offensive odor causing ground water contamination and nuisance. Mushroom industry needs to dispose off more than 50 mi tones of used mushroom compost each year. The SMS has been found to be a good nutrient source for agriculture because of its rich nutrient status and slow mineralization rate which retain its quality as an organic matter. SMS possesses the quality of good organic manure for raising healthy crops of cereals, fruits , vegetables and ornamental plants. In addition to its ability of reclaiming the contaminated soil, SMS is utilized for nutritionally poor soil, neutralizing acidic soil and in other cases for improving polluted sites [10].

The spent mushroom substrate (SMS)released after button mushroom cultivation contains all the essential nutrients needed for raising a healthy field crop in addition to harbor fungal biomass and large population of heterotrophic microbes. The application of SMS plays vital role in disease management in crops, top dressing and soil amendments promotes a population of antagonistic microorganisms (crop friendly microorganisms), which interfere with the activities of pathogenic fungi. Aged compost, on recolonization with mesophilic bacteria, heterotrophic fungi or actinomycetes, mitigates plant diseases as well. This also stimulates a natural disease defense system in plants.

The thousand tons of waste obtained from mushroom cultivation known as SMS, is being dumped on the road-side and awareness about its proper utilization is not much available . In Haryana, being the leading state in cultivation of button mushroom, SMS in excess of 50,000 tones is generated per year which is not properly utilized. So, keeping this in view, the present studies were undertaken for quantification of physico-chemical composition of SMS.

Materials and Methods

Spent Mushroom Substrate was taken from Mushroom Production Unit of CCS Haryana Agricultural University and analyzed for different properties i.e. pH, electrical conductivity, organic carbon, available nitrogen, available phosphorus, available potassium and available iron, manganese, zinc and copper.

SMS sampling

After the harvesting of white button mushroom (*Agaricus bisporus*) SMS was transferred to SMS pit of 5 meter quadrate and left for 6 months (April to September) for natural weathering. After 6 months, SMS samples were taken from different depths of SMS pit i. e. 0-30, 30-60 and 60-90 cm using hand auger. These samples were then transported in transported in sealed aluminum foil to the laboratory of Department of Soil Sciences, where stones and other materials were removed and the SMS is homogenized through a 2 mm sieve. The SMS samples were stored in the dark bottles till further analysis of its physico-chemical properties.

Electrical conductivity (EC) and ph

Five g of SMS was taken from each composite sample and mixed with 50 ml of distilled water in a 100 ml beaker to make a suspension of 1 : 5 . The aliquots were allowed to rest for 2 h for settling down the sediments. EC and pH were determined by using Elico EC meter and Elico pH analyser respectively.

Organic carbon

Dry combustion method [11] was used in the present study for calculating organic carbon in SMS samples.

The dry combustion method is based on oxidation of carbon and thermal decomposition of carbonate materials in a medium-temperature resistance furnace.

Available nitrogen

In the present study, Colorimetric (Nessler's reagent) method [12] was used to determine available nitrogen in SMS samples. The samples were digested in diacid mixture of H_2SO_4 and $HClO_4$ in the ratio of 9 : 1 and then Nessler's reagent, potassium tetraiodomercuriate (I_4HgK_2) was added, from which an orange color complex of oxidimercurammonium iodide, $HgOHg(NH_2)I$ was obtained.Intensity of colored complex was measured on a spectrophotometer at 440 nm wavelength by using blue filter and nitrogen content was calculated using the standard curve against the measured transmittance.

Available phosphorus

Vanadomolybdophosphoric (VMP) yellow color method [13] was used to determine available phosphorus in SMS samples. The SMS samples were digested in diacid mixture of HNO_3 and $HClO_4$ in a ratio of 4 : 1 and then Vanadate-molybdate reagent was used to develop vanadomolybdophosphoric acid yellow color. The intensity of yellow color was measured on spectrophotometer by using blue filter at 440 nm wvelength and phosphorus content was calculated using the standard curve against the measured transmitance.

Available potassium

Potassium in the SMs samples was determined by using flame photometer. It is based on the principle that atoms of some specific element absorb energy from flame and get excited to the higher orbit. Such atoms release energy of a characteristic wavelength, which is specific for that element and is proportional to the concentation of atoms of that element in a sample. The samples were digested in diacid mixture of HNO_3 and $HClO_4$ in a ratio of 4 : 1 and the intensity of filterate was measured with a spectrophotometer at 660 nm wave-length by using a red filter. Potassium content in samples was then calculated using the standard curve against the measured transmitance.

Zinc, iron, Manganese and copper

Atomic Absorption Spectrophotometer (AAS) was used in the present study to determine content of micronutrients in SMS samples.The AAS is based on the principle that atoms of metallic elements (Zn, Mn, Fe, Cu), which normally remain in ground state, under flame conditions, absorb energy when subjected to radiation of specific wavelength. The absorption of radiation is proportional to the concentration of atoms of that element. The SMS samples were digested in diacid mixture of HNO_3 and $HClO_4$ in a ratio of 4 : 1 and the reading of Zn/Mn/Fe/Cu in sample was measured from AAS and concentration was calculated from standard curve against the sample reading.

Results and Discussion

The results presented in Table 1 show that except EC all the parameters decresased with the increase in depth of SMS pit (Fig. 1.) The range of all the parameters is as under :
Electrical conductivity of SMS increased with the increase in depth of SMS pit. It was observed that

Table 1. Properties of naturally weathered spent mushroom substate (SMS) * . * After 6 months.

SMS pit depth	EC (mm hos cm^{-1})	pH	OC (%)	N (%)	P (%)	K (%)	Fe (%)	Mn (%)	Zn (%)	Cu (%)
0-30 cm	1.01	7.66	2.56	2.42	1.16	1.08	0.34	0.02	0.01	0.01
30-60 cm	1.07	7.51	2.13	1.91	1.15	0.96	0.28	0.01	<0.01	<0.01
60-90 cm	1.74	7.40	1.89	1.60	1.08	0.93	0.18	0.01	<0.01	<0.01
CD (p=0.05)	0.11	0.09	0.34	N/A	N/A	N/A	0.1	N/A	N/A	N/A
Overall mean	1.27	7.52	2.19	1.98	1.13	0.99	0.26	0.01	<0.01	<0.01

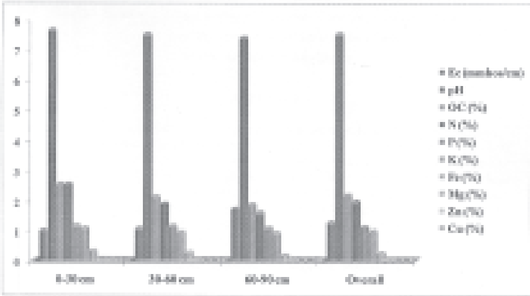

Fig. 1. Properties of 6 months old naturally weathered spent mushroom substrate.

maximum EC was recorded in the sample taken from 60-90 cm depth (1.74 mm hos cm^{-1}) followed by sample taken from 30-60 cm depth (1.07 mm hos cm^{-1}) with minimum in the sample taken from 0-30 cm depth (1.01 mm hos cm^{-1}). The overall EC of SMS was found to be 1.27 mm hos cm^{-1} . SMS sample taken from 0-30 cm depth have the maximum pH (7.66) followed by sample taken from 30-60 cm depth (7.51) with minimum in the sample taken from 60-90 cm depth (7.40). The overall pH of SMS was 7.52. In the present study, the analysis of 6 months old SMS from three different depths of the SMS pit showed that up to 60 cm depth, EC was 1.07 mm hos cm^{-1} while it increased after 60 cm to 1.74 mm hos cm^{-1}. All the three samples collected from three different depths have alkaline pH, which differed significantly. The uppermost layer (0-30 cm) has the maximum pH of 7.66 which is significantly higher than other two samples (30-60 cm and 60-90 cm). SMS samples taken from different depths have average electrical conductivity of 1.27 mm hos cm^{-1} and pH of 7.52. Calculated the physico-chemical properties of SMS and found that the EC of 6 and 9 months old SMS was 6.22 mmhos cm^{-1} and 0.95 mmhos cm^{-1} while the pH was 7.3 and 6.7, respectively [14].

Mean OC content of the samples taken from different depths was 2.19% . The OC content of different depths i.e. 0-30 cm, 30-60 cm and 60-90 cm was found to be 2.56, 2.13 and 1.89% respectively . Organic carbon content was found to be maximum, 2.56%, in upper layer of 0-30 cm which gradually decreased as depth increased to 90 cm. The overall content of OC in SMS samples was recorded 2.19%, OC content decreased gradually upon aging as reported by Gupta et al. [14]. They found that OC of 6 and 9 months old SMS was 2.51 and 1.46% respectively.

The results showed that the nitrogen content of SMS decreased with the increase in depth of the SMS pit. The maximum nitrogen content was present in the sample taken from 0-30 cm depth (2.42%) followed by the sample taken from 30-60 cm depth (1.91%) sample from 60-90 cm depth (1.60%). The overall nitrogen content in SMS sample was 1.98%. The maximum phosphorus content was found to be in the sample taken from 0-30 cm depth (1.16%) followed by the samples taken from 30-60 cm depth (1.15%) and 60-90 cm depth (1.08%) with overall percentage of 1.13%. Potassium content of SMS samles from different depths decreased with the increase in pit depth. The maximum P content was in the sample taken from 0-30 cm depth (1.08%) followed by depth of 30-60 cm (0.96%) and 60-90 cm (0.93%). The overall content of potassium in SMS samples was 0.99%.

Table 1 showed that all the micronutrients are present in very trace amount. Iron content was in the range of 0.18% (0-30 cm depth) to 0.34% (60-90 cm) with a value of 0.28% in the sample taken from 30-60 cm depth. The overall iron content in SMS samples was 0.26%. The maximum amount of manganese, zinc and copper was found in samples taken from 0-30 cm depth having percentage of 0.02, 0.01 and 0.01% respectively. The samles taken from 30-60 cm and 60-90 cm depth have very low content of manganese (0.01%), zinc (<0.01%) and copper (0.01%).

The macronutrients i.e. nitrogen, phosphorus and potassium in SMS are present in appreciable amount. The NPK content was 1.98, 1.13 and 0.98% giving ratio of approximately 2 : 1 : 1. Although the maximum NPK was recorded in the samples of 0-30 cm but there was no significant difference among all the the three samples taken from three different depths. The percentage of micro-nutrients was in traces and was very low in all the SMS samples. The analysis showed that in the upper layer of 0-30 cm depth, iron has a maximum percentage of 0.34 which was followed by manganese (0.02%), zinc (0.01%) and copper (0.01%). The mean values of different parameters such as EC,pH, OC, N, P,K, Fe, Mn, Zn and Cu was recorded 1.27 mm hos cm^{-1} , 7.52, 2.19%, 1.98%, 1.13%, 0.99%, 0.26%, 0.01%, <0.01% and <0.01% respectively. Similarly, Gupta et al. [14] found that the content of nitrogen, phossphorus and potassium in 6 and 9 months old was 2.73, 0.31, 0.32% and 1.96, 0.200% respectively. On the other hand Fidanza et al. [15] reported that the percentage of nitrogen, phosphorus and potassium in SMS was 1.1, 0.29 and 1.04 respectively.

Conclusion

The physico-chemical analysis of SMS showed that the average EC and pH of SMS samples collected from three different depths was 1.27 mm hos cm^{-1} and 7.52 respectively. The organic carbon content of SMS collected from three different depths of SMs pit i.e. 0-30 cm. 30-60 cm and 60-90 was 2.56, 2.13 and 1.89% respectively. The amount of available nitrogen, phosphorus and potassium had not differed significantly with different depths. The ratio of NPK in the SMS sample was 2 : 1.2 : 1 with maximum amount in uppermost layer (2.42% N, 1.16% P and 1.08% K). The presence of micro-nutrients in SMS samples was in traces. Among different micronutrients the average iron (Fe) content was found to be 0.26% followed by manganese (Mn) (0.01%) while the zine (Zn) and copper (Cu) content was less than 0.01%.

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