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Composting of Spent Oyster Mushroom Substrate using Biogas Plant Slurry

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Abstract

Spent oyster mushroom substrate was incorporated into biogas plant slurry to prepare quality manure. Among different combinations of spent oyster mushroom substrate and biogas plant slurry, maximum reduction in C/N ratio was observed at 2 : 1 ratio of spent oyster mushroom substrate and slurry after 90 days. The process was further hastened by inoculation with *Trichoderma reesei.* The C/N ratio of final product after 75 days was 20 : 4.

Key words : Composting, Decomposition, Slurry, Spent mushroom substrate, *Trichoderma reesei.*

With increasing need to conserve natural resources and energy, recycling of organic wastes and indigenous materials through bioconversion assume major importance. Mushroom cultivation is an employment and income generating activity for rural masses, farmwomen and unemployed youth. Different mushroom species are grown on spectrum of plant wastes that are mainly lignocellulosic. Among various species of mushrooms, *Agaricus* and *Pleurotus* are common species grown in different parts of India. Associated with mushroom cultivation is the generation of spent mushroom substrate (SMS). For every tone of mushroom harvested, about 1—2 tones of spent substrate is generated. The spent straw left after cultivation of *Agaricus* species is completely decomposed and used for raising different crops while spent oyster mushroom substrate is partially decomposed and is discarded as waste creating environmental nuisance (1). Nowadays, the mushroom growers are facing pressure of environmental legislation giving rise to the need for more suitable solution for disposing SMS. Many investigations are carried out world wide on processes dealing with the utilization of SMS (2). Many of the previous studies on spent-oyster mushroom substrate found on the use as soil amendment but nitrogen is the most limiting macronutrient in this substrate (3). Since SMS is partially decomposed by the fungus it can be further composted for safe disposal. Composting of partially decomposed straw can add more nutrients and the process can be hastened by adding microbial consortium. Our department has developed a 2 m^3 solid state Janta biogas plant for anaerobic digestion of cattle dung for biogas production (4). Effluent of biogas plant (slurry) being rich in ligninolytic microorganisms, can be used for composting of spent oyster mushroom substrate alongwith cellulolytic microorganisms. The study was planned to produce quality manure from spent mushroom substrate using biogas plant slurry and cellulolytic organisms.

Methods

Substrate

Spent oyster mushroom substrate (SMS) was collected from mushroom production technology laboratory, CCS HAU Hisar. Effluent slurry from cattle

Table 1. Chemical composition of spent mushroom substrate (SMS) and biogas plant slurry.

Components	Value (% dry weight basis) SMS	Biogas plant slurry
Total solids	15.7 ± 1.0	9.5 ± 0.5
Volatile solids	87.5 ± 1.0	76.0 ± 0.5
Cellulose	38.0 ± 0.5	16.5 ± 0.5
Lignin	8.0 ± 0.3	8.0 ± 1.0
Hemicellulose	9.6 ± 1.0	4.2 ± 0.5
Nitrogen	0.97 ± 0.50	1.6 ± 0.5
Phosphorus	0.16 ± 0.10	0.60 ± 0.04
Potassium	0.82 ± 0.10	0.93 ± 0.2
C : N	52.32	27.55

Table 2. Experimental setup for composting of spent mushroom substrate (SMS) with biogas plant slurry.

Treatments (SMS:Slurry)	Total solids (%)	Volatile solids (%)	Organic carbon (%)	Nitrogen (%)	C : N ratio
3 : 1	16.6	85.1	49.6	1.07	46.3
2 : 1	16.3	84.5	49.2	1.16	42.4
1 : 1	15.1	83.1	48.2	1.20	40.2
1 : 2	13.5	81.2	47.1	1.21	38.1
CD (0.05%)	0.59	0.43	0.45	0.11	

waste based biogas plant, Department of Microbiology CCS HAU Hisar was used as inoculum for composting of SMS . Culture of *Trichoderma reesei* was obtained from culture collection department of Microbiology CCS HAU Hisar.

Composting of Spent Mushroom Substrate

Composting of spent oyster mushroom substrate was carried out in cemented pits (64 × 64 ×76 cm). SMS was mixed with biogas plant slurry in different ratios viz. 3 : 1, 2 : 1, 1 : 1 and 1 : 2 (wet weight basis), filled in compost pits and covered with polythene sheets. Turning was done at monthly interval.

Analysis

SMS, biogas plant slurry and compost samples at various intervals were analyzed for total solids (TS), volatile solids (VS), total nitrogen, phosphorus and potassium using standard methods (5).

Results and Discussion

Oyster mushroom (*Pleurotus* species) is a wood decomposing fungus belonging to class basidiomycetes. It is cultivated in many parts of the world. Commercial production technologies for this mushroom fungus are well developed and are relatively simple in comparison to other species (6). The spent substrate after the harvest of *Pleurotus* needs suitable management because of high C : N ratio. Szmidt et al. (7) reported that oyster mushroom substrate if applied to the fields leads to disease incidence, nutrient and growth factor depletion. Composting of SMS with biogas plant slurry which is rich in ligninolytic organisms will hasten the decomposition process, stabilize the nutrient loses and improve manurial value of compost.

Table 3. Total solids and total volatile solids content of spent mushroom substrate (SMS) composted with slurry at different time intervals.

Treatments (SMS : Slurry)	Total solids (%) Days after 0	30	60	90	Total volatile solids (% TS) Days after 0	30	60	90
3 : 1	16.6	26.9	28.9	30.2	85.5	79.9	71.8	67.9
2 : 1	16.3	28.4	33.5	35.5	78.4	69.9	69.9	63.9
1 : 1	15.1	28.2	33.1	34.1	79.1	74.9	74.9	69.9
1 : 2	13.5	24.4	28.1	33.1	78.7	73.9	73.9	68.9
CD (0.05%)	0.59	NS	1.91	1.65	0.60	0.49	0.58	0.57

The analysis of spent substrate indicated that it had 38% cellulose, 9.6% hemicellulose and 8.0% lignin indicating that it had sufficient carbon for composting purpose and efficient microflora needs to be inoculated for carrying out composting process (Table 1). Different combinations of SMS and slurry had C/N ratio ranging between 38.1—46.3 (Table 2). Composting of SMS with biogas plant slurry resulted in decrease in total and volatile solids which was faster during first 30 days and comparatively slower subsequently. Maximum 35.5% total solid content was observed at 2 : 1 ratio of SMS and slurry after 90 days of which 63.9% were volatile solids (Table 3). One of the important criteria for assessing compost maturity has been reported as C/N ratio. Total organic carbon decreased and total nitrogen content increased as a result of composting, therefore reduction in C/N ratio was observed (Table 4). Garcia et al. (8) suggested that C/ N ratio below 20 is indicative of acceptable

Table 4. Total nitrogen and C/N ratio of spent mushroom substrate (SMS) composted with slurry at different time intervals.

Treatment (SMS : Slurry)	Nitrogen (%) Days after 0	30	60	90	C/N ratio Days after 0	30	60	90
3 : 1	1.07	1.26	1.34	1.45	46.35	36.82	31.11	27.17
2 : 1	1.16	1.30	1.55	1.60	42.32	35.00	26.19	23.18
1 : 1	1.20	1.25	1.39	1.48	40.16	36.72	31.29	27.43
1 : 2	1.21	1.28	1.45	1.50	38.84	35.70	29.58	26.66
CD (0.05%)	0.11	0.04	0.07	0.05	–	–	–	–

Table 5. Chemical properties of spent mushroom substrate (SMS) composted with slurry (2 : 1) along with *Trichoderma reesei*. * *Trichoderma reesei* was inoculated after 30 days of composting of SMS with slurry.

Parameters	SMS : Slurry (2 : 1) Without inoculation				SMS : Slurry (2 : 1) Inoculation with *Trichoderma reesei*		
(% dry weight basis)	Days after				Days after*		
	0	30	60	75	30	60	75
Total solids	16.3	28.4	33.5	34.5	28.4	34.0	36.0
Total volatile soilds	84.5	80.0	70.0	66.0	80.0	65.0	60.0
Total organic carbon	49.2	45.5	40.6	39.2	46.4	37.7	34.8
Nitrogen	1.16	1.30	1.55	1.57	1.30	1.58	1.70
Phosphorus	0.84	0.86	0.87	0.88	0.86	0.88	0.90
Potassium	0.82	0.83	0.84	0.88	0.83	0.88	0.89
C : N ratio	42.4	37.9	26.2	24.3	37.9	24.9	20.4

compost. The C / N ratio at 2 : 1 ratio of SMS and slurry after 90 days was 23 : 1 which was higher in other combinations.

Inoculation of cellulolytic microorganisms has been reported to enhance rate of decomposition (9). Inoculation of *Trichoderma reesei* culture at 2 : 1 ratio of SMS and slurry resulted in mineralization of more nitrogen than in uninoculated control. As a result, reduction in C : N was also faster than control. The C /N ratio after 75 days in *Trichoderma reesei* inoculated samples was 20 : 4 (Table 4). Garcia et al. (10) included rock dust in SMS to accelerate the composting process due to increased microbial activity and resulted product was valuable for agricultural utilization and soil reclamation.

Total phosphorus and potash content remained stable during composting process suggesting that *Trichoderma reesei* which is rich in lignocelulolytic enzymes, hastened the process of decomposition thereby reducing composting time which ultimately reduced the loss of nutrients through leaching and volatilization (Table 5).

Conclusion

The results of the present study indicate that spent oyster mushroom substrate can be used as quality manure after mixing with biogas plant slurry and inoculation with cellulolytic fungi.

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