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Changes in physical properties during composting

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Abstract
An experiment was conducted during the year 2021 and 2022 at Vermicompost Production Unit, RPCAU, Pusa with an objective to find out the effect of four different food materials i.e., temple waste, food waste, household waste and agricultural waste in combinations with cow dung (65:35) and cow dung alone as fifth one in presence and absence of the epigeic earthworm *Eisenia fetida* on the changes in physical properties of compost during various stages of composting. The experiment was conducted in Completely Randomized design (factorial) replicated thrice. Results indicated that physical properties improved over the course of the composting process for all the treatment combination, and the vermicompost consistently recorded better properties than regular compost irrespective of the substrates used.

Keywords: Compost, vermicompost, waste, *Eisenia fetida*, micronutrients

Introduction

India produces around 3 billion tonnes of organic wastes annually (Bhardwaj, 2010) [2] and the unscientific disposal causes an adverse impact on human health and environment like water pollution, methane emission and soil degradation which leads to loss of vegetation and decline in agricultural productivity (Bundela *et al.*, 2010) [3]. For hygienic disposal of organic wastes it should be managed effectively which can be achieved by composting and vermicomposting of farm, urban and agro-industrial waste. Composting is the aerobic microbial transformation of organic matter (Baca *et al.*, 1992) [1], and has been designated as the most adequate method of managing organic wastes or organic fraction of urban solid waste (Tognetti *et al.*, 2005) [9]. Among various methods of composting, one of the best options for treating domestic household waste is vermicomposting (Dalal, 2012) [4]. Analysis conducted by National Environmental Engineering Research Institute (2005) reveals that on an average domestic waste in India consists Nitrogen (0.64 ± 0.8)%, Phosphorus (0.67 ± 0.15)%, Potassium (0.68 ± 0.15)% with C:N ratio (26 ± 5)%. As organic portions of various wastes which are commonly discarded are quite rich in nutrients so, these processes provided new ways of recycling such untapped potential source of nutrients giving a valuable manure in a short period of time while under normal conditions it takes a long time for decomposition.

Keeping these in view, the present studies were carried out to understand the effect of various food materials both in presence and absence of earthworms on the changes in physical properties of compost with time progression.

Material and Method

An experiment was conducted from 2021 to 2022 at Vermicompost Production Unit, RPCAU, Pusa in which compost was prepared from different substrates in combination with cow dung in the ratio of 65:35 and observations related to micronutrient dynamics were recorded at different stages of decomposition during the composting process.

Experimental details

Experimental site- Vermicompost Unit, RPCAU, Pusa
Experimental design- Completely Randomized Design (Factorial)
Replication- 3
Factor- 2
Earthworm species used for vermicomposting- *Eisenia fetida*
Types of food substrates- Floral offerings/temple waste**,** Food waste**,** Household waste**,** Agricultural waste**,** Cow dung

Factor I – 4 Stages of observation (S) during composting

S_1	Initial or 0 day after initiation (0 DAI)
S_2	30 days after initiation (30 DAI)
S_3	60 days after initiation (60 DAI)
S_4	90 days after initiation (90 DAI)

Factor II – 10 combinations of various food materials and cow dung (V) for compost preparation

V_1	Temple waste + cow dung (65:35) with earthworms
V_2	Food waste + cow dung (65:35) with earthworms
V_3	Household waste + cow dung (65:35) with earthworms
V_4	Agricultural waste + cow dung (65:35) with earthworms
V_5	Cow dung with earthworms
V_6	Temple waste + cow dung (65:35) without earthworms
V_7	Food waste + cow dung (65:35) without earthworms
V_8	Household waste + cow dung (65:35) without earthworms
V_9	Agricultural waste + cow dung (65:35) without earthworms
V_{10}	Cow dung without earthworms

Physical parameters

Moisture content- The moisture content of the compost was recorded at various time intervals (at 30, 60 and 90 days after initiation) from all the treatments separately as moisture percent by weight as described by FCO (1985) [5].

Maximum water holding capacity- The maximum water holding capacity was recorded at various time intervals (at 0, 30, 60 and 90 DAI) from all the composting pits. It was determined by Keen Raozkowski box method described by Piper (1966) [8].

Odour- Odour of the compost was observed by smelling test as described by FCO (1985) [5].

Bulk density- Bulk density determination of the compost from all composting pit was done at different time intervals by tapping method as described by FCO (1985) [5].

Result and Discussion

Moisture content (%)

The moisture content of the vermicompost and compost was significantly influenced by different food materials during the composting process which is presented in Table 1. From the data it was observed that the moisture content decreased from the initial setting up of windrows towards the end of composting. At day zero highest moisture content was found in the treatment V_5 and V_{10} having cow dung as food material (72.15%) while treatment having agricultural waste and cow dung as substrate recorded lowest moisture content (65.18%). At 30 DAI, moisture content for the treatments with earthworm inoculation ranged from 41.20 to 48.69% whereas, for treatment without earthworm inoculation, it varied between 39.5 to 63.25%. In the same way at 60 DAI, moisture content for vermicomposting ranged from 32.30 to 36.53% whereas, for composting, it varied between 34.02 to 44.40%. Then at 90 DAI, moisture content continuously declined and for vermicompost it ranged from 16.45 to 21.21% while, for compost it varied between 16.55 to 34.59%. In the final product lowest value for moisture content was found in the treatment V_3: Household waste + cow dung with earthworms (16.45%) which was at par with V_4: Agricultural waste + cow dung with earthworms (18.99%) whereas, V_{10}: Cow dung without earthworms recorded highest moisture content (34.59%). As described by FCO (1985) [5], the moisture content range for vermicompost and compost is between 15 to 25% and so for final product in vermicomposting it was within the range but same cannot be said for all substrate combinations in case of compost.

Table 1: Changes in moisture content

Moisture content (%)					
Treatments	Stages of observation				
	0 DAI	30 DAI	60 DAI	90 DAI	Mean
V_1 Temple waste + cow dung (65:35) with earthworms	67.25	41.20	32.89	20.57	40.48
V_2 Food waste + cow dung (65:35) with earthworms	69.50	48.69	33.17	21.21	43.14
V_3 Household waste + cow dung (65:35) with earthworms	65.18	45.22	32.81	16.45	39.92
V_4 Agricultural waste + cow dung (65:35) with earthworms	65.45	42.87	32.30	18.99	39.90
V_5 Cow dung with earthworms	72.15	52.36	36.53	19.83	45.22
V_6 Temple waste + cow dung (65:35) without earthworms	67.25	39.56	34.02	16.55	39.34
V_7 Food waste + cow dung (65:35) without earthworms	69.50	54.05	44.40	23.11	47.76
V_8 Household waste + cow dung (65:35) without earthworms	65.18	40.87	40.03	26.46	43.13
V_9 Agricultural waste + cow dung (65:35) without earthworms	65.45	60.47	40.29	24.28	47.62
V_{10} Cow dung without earthworms	72.15	63.25	41.84	34.59	52.96
Mean	67.91	48.85	36.83	22.20	
	C.D (0.5%)		S.Em(±)		
Stages (S)	1.35		0.48		
Vermicompost (V)	2.14		0.76		
S X V	4.28		1.52		

Maximum water holding capacity (%)

Data pertaining to maximum water holding capacity of compost at different days after initiation (DAI) of process (i.e., 0, 30, 60 and 90 days) as influenced by different substrates (cow dung alone, temple waste, food waste, household waste and agricultural waste) in presence and absence of earth worms has been presented in Table 2.

A scrutiny of data indicated that there was a declining trend in maximum water holding capacity during the decomposition process and it varied from 38.38 to 53.45% at day 0, 30.09 to 48.95% at 30 DAI, 23.53 to 34.83% at 60 DAI and 16.39 to 25.70% at 90 DAI.

At day zero highest maximum water holding capacity was found in the treatment having agricultural waste and cow dung (53.45%) while treatment having food waste and cow dung as substrate combination recorded lowest value (38.38%). At day 30, maximum water holding capacity for the treatments with earthworm inoculation ranged from 36.90 to

48.95% whereas, for treatment without earthworm inoculation, it varied between 30.09 to 47.76%. Likewise, at the end of vermicomposting process i.e. day 90, maximum water holding capacity for vermicompost ranged from 18.78 to 25.70% while, for compost it varied between 16.39 to 23.76%. The treatment V_5: Cow dung with earthworms was found to have highest value for maximum water holding capacity (25.70%) and lowest was recorded for V_6: Temple waste + cow dung without earthworms (16.39%). The finding was in tunes with the findings of Kusum (2019) [6].

Table 2: Changes in maximum water holding capacity

Maximum water holding capacity (%)					
Treatments	Stages of observation				
	0 DAI	30 DAI	60 DAI	90 DAI	Mean
V_1 Temple waste + cow dung (65:35) with earthworms	48.17	41.57	30.47	21.22	35.36
V_2 Food waste + cow dung (65:35) with earthworms	38.38	39.83	24.72	20.25	30.80
V_3 Household waste + cow dung (65:35) with earthworms	42.80	35.64	26.97	18.78	31.05
V_4 Agricultural waste + cow dung (65:35) with earthworms	53.45	48.95	34.83	24.25	40.37
V_5 Cow dung with earthworms	44.17	36.90	30.91	25.70	34.42
V_6 Temple waste + cow dung (65:35) without earthworms	48.17	30.09	23.53	16.39	29.54
V_7 Food waste + cow dung (65:35) without earthworms	38.38	33.86	24.28	16.90	28.35
V_8 Household waste + cow dung (65:35) without earthworms	42.63	34.91	25.91	18.04	30.37
V_9 Agricultural waste + cow dung (65:35) without earthworms	53.45	47.76	34.13	23.76	39.77
V_{10} Cow dung without earthworms	44.17	32.46	27.71	19.29	30.91
Mean	45.38	38.20	28.35	20.46	
	C.D (0.5%)		S.Em(±)		
Stages (S)	0.85		0.30		
Vermicompost (V)	1.34		0.48		
S X V	2.68		0.95		

Bulk density (Mg m^{-3})

During the process of composting the periodical changes in bulk density as influenced by substrates used have been presented in Table 3. A perusal of data indicated that the bulk density in vermicompost and compost ranged between 1.7 to 3.0 Mg m^{-3}, 1.5 to 2.4 Mg m^{-3}, 1.0 to 1.8 Mg m^{-3}, and 0.7 to 1.6 Mg m^{-3} at 0, 30, 60 and 90 days, respectively. The results revealed that regardless of the substrates, bulk density declined as composting went from the beginning to the end, or at 0 to 90 DAI and the reduction was higher with earthworm inoculation. The bulk density in regular compost decreased from 3.0 to 1.6 Mg m^{-3} while in vermicompost its reduced from 3.0 to 0.7 Mg m^{-3}.

Initially at 0 DAI, treatment with food waste and household waste as one of the substrates was found to have greater bulk density (3.0 Mg m^{-3}) while those treatments with only cow dung as the raw material exhibited lower value (3.0 Mg m^{-3}). Then, at 30 DAI a gradual decrease in bulk density was registered for all substrate combinations and the treatment V_5: Cow dung with earthworms recorded significantly lowest bulk density value (1.0 Mg m^{-3}) whereas, V_8: Household waste + cow dung without earthworms registered significantly higher value (2.4 Mg m^{-3}). Likewise, at day 90 again V_5 was found to have significantly lower bulk density (0.7 Mg m^{-3}) which was at par with V_4 (0.8 Mg m^{-3}) whereas, V_6: Temple waste + cow dung without earthworms was significantly higher in bulk density value (1.6 Mg m^{-3}). Throughout the process, a gradual reduction in bulk density was noted and the decline was greater in case of vermicomposting than composting. The results were in accordance with the findings of Kusum (2019) [6].

Table 3: Changes in bulk density

Bulk density (Mg m^{-3})					
Treatments	Stages of observation				
	0 DAI	30 DAI	60 DAI	90 DAI	Mean
V_1 Temple waste + cow dung (65:35) with earthworms	2.7	1.7	1.6	1.0	1.8
V_2 Food waste + cow dung (65:35) with earthworms	3.0	2.0	1.8	1.1	2.0
V_3 Household waste + cow dung (65:35) with earthworms	3.0	2.0	1.6	1.2	1.9
V_4 Agricultural waste + cow dung (65:35) with earthworms	1.8	1.5	1.0	0.8	1.3
V_5 Cow dung with earthworms	1.7	1.0	1.0	0.7	1.1
V_6 Temple waste + cow dung (65:35) without earthworms	2.7	2.0	1.8	1.6	2.0
V_7 Food waste + cow dung (65:35) without earthworms	3.0	2.1	1.8	1.5	2.1
V_8 Household waste + cow dung (65:35) without earthworms	3.0	2.4	1.8	1.4	2.2
V_9 Agricultural waste + cow dung (65:35) without earthworms	1.8	1.5	1.4	1.3	1.5
V_{10} Cow dung without earthworms	1.7	1.5	1.4	1.3	1.5
Mean	2.5	1.8	1.5	1.2	
	C.D (0.5%)		S.Em(±)		
Stages (S)	0.04		0.02		
Vermicompost (V)	0.07		0.02		
S X V	0.13		0.05		

Odour

The final prepared vermicompost and compost from all different combinations of household waste and cow dung was determined using qualitative smelling test and an earthy smell was observed which indicated the maturity of compost. Foul odour was absent in final product.

Conclusion

On the basis of the results recorded, it can be concluded that regardless of the food materials utilised, physical attributes improved throughout the composting process for all treatment combinations and vermicomposting consistently recorded better qualities than ordinary composting.

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