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Chemical changes during vermicomposting (*Perionyx excavatus*) of kitchen wastes

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Household kitchen waste is one of the major sources of municipal solid waste. In India, domestic waste is mostly of organic nature and contributes 70% to 80% of urban solid wastes (Kale 1998). Each household of four family members generates 0.5-0.75 kg kitchen wastes per day (Kale 1998). Under the present condition of environmental degradation vermicomposting technology offers recovery of valuable resources like manure from such biodegradable waste. Vermicomposting is a process of production of vermicompost through stabilization of organic waste by earthworm activity. The process of vermistabilization is due to microbial decomposition of organic matter within the gut of earthworms and thus the undigested released excreta of earthworm does not undergo rapid decomposition (Mitchell 1997). Research on vermicomposting of a variety of wastes is gaining momentum throughout the world (Elvira *et al.* 1997; Edwards 1998; Frederickson *et al.* 1997; Kale 1998; Mitchell 1997; Reinecke *et al.* 1992; Singh 1997). However, reports on the chemical changes during breakdown of the organic waste by the activity of the earthworm are scarce (Albanell *et al.* 1988; Ghosh *et al.* 1999). The aim of the present investigation is to document the stepwise chemical changes during the composting of kitchen waste by an indigenous species of earthworm. Such study is necessary to determine the time of vermistabilization for harvesting of quality compost from a particular type of waste.

Six large earthen bowls (three-control, three-experimental) 60 cm in diameter were used as containers for composting. Four to five minute holes were made at the base of the bowls to avoid water logging. In each earthen bowl bedding of 10 cm thickness was prepared with a layer of sand of 5 cm thick topped with 5 cm of sieved garden soil, to make an initial support medium for earthworms. 200 locally-collected adult earthworms, *Perionyx excavatus*, weighing about 100 g were inoculated into each of three experimental (vermicomposting) sets. The remaining three without earthworms were maintained as controls. The surface of the bed was covered by a plastic net (1 cm^2 hole) in each of the sets (control and experimental) to act as a marker to assist in the recovery of compost. Household kitchen wastes collected from local sources were chopped to reduce the size and volume by about 50-70%. The wastes were then air-dried for 10 days. The following were the chief ingredients of kitchen waste : (i) vegetable skin (potato and onion), leaves of cabbage, parts of cauliflower and carrots; (ii) fruit skin (banana); (iii) egg shells; (iv) drained liquid of boiled rice. Kitchen wastes were mixed properly before loading. After 1d of earthworm inoculation, 3 kg of kitchen wastes were spread uniformly over the bedding material in each of the containers (both control and experimental). The loading of wastes in both the control and experimental sets was done on 27th March '98. Water was sprinkled gently over the substrates to maintain average moisture percentage of 63. The upper layer of organic waste was turned over periodically for better aeration. The composting was continued up to 40th day under laboratory conditions (maximum average temperature 28.4°C).

Samples were collected on every 10th day and dried at 40°C and finely powdered. Moisture content was determined by drying at 105°C (Gravimetric method), total N by the Kjeldahl method and organic C by the rapid titration method of Walkley & Black (1934). The pH was measured by ELICO pH-meter (Digital) using suspensions of the material in water, in the ratio 1:5 (w:v). Chemical analysis of total and available P, K, Ca and Mg were carried out following standard methods (Jackson 1973). Significant differences ($P<0.05$) between control and experimental sets were determined by student's t-test.

Table 1 shows changes in the chemical properties of kitchen waste during its 40 days of composting with and without earthworms. Absence of earthworms in the kitchen waste during the first 10 days of experimentation was probably due to high pH (>9) and unpalatable aromatic substances produced both by plant material and microorganisms at early stages of decomposition (Lee 1985). With the progress of composting pH decreased slowly with a lower trend in the experimental set (>7.5) in comparison to control (>8.0) up to 40 days. CO_2 and organic acids produced during microbial metabolism probably decrease the pH during composting (Hartenstein & Hartenstein 1981). It is likely that the comparatively lower pH (towards neutral) during the vermicomposting process is due to the additional contribution made by the earthworms.

C level showed a declining trend during the composting and vermicomposting process (Table 1). The lowering of C during the first 10 days was particularly due to bacterial decomposition, as the difference in C level between control and experimental sets was not statistically significant (t-test, $P>0.05$). Strikingly there was about 60% decrease in the C content in the sets with earthworm (from 25.6 ± 1.15 to 10.4 ± 0.32) compared to 36% decrease in those without earthworms (from 22.81 ± 0.84 to 15.23 ± 0.95) during the last 20 days of decomposition. This indicated that earthworms accelerated the decomposition of the organic matter.

N content reduced significantly (t-test, $P<0.05$) during the vermicomposting process (Table 1). This is probably due to NH_3 volatilization, incorporation into earthworm tissue and leaching into the bedding material. The relatively high level of N

Table 1. Physicochemical analysis of composted kitchen waste with and without earthworms at different time intervals; values are mean ±S.E. (n=3).

Parameters	Initial (0 day)	Without worms (Control) days				With worms (Experimental) days			
		10	20	30	40	10	20	30	40
pH	10.0	9.85	9.24	8.67	8.27	9.54	8.97	8.55	7.59
	0.003	0.03	0.02	0.05	0.03	0.03	0.03	0.05	0.15
Organic C (%)	36.8	31.1	22.8	18.7	15.2	31.50	25.66	18.74	10.48
	0.71	0.47	0.84	0.02	0.95	0.57	1.15	0.33	0.32
Total N (%)	3.49	3.14	2.33	2.00	1.78	3.02	2.57	2.28	1.67
	0.06	0.06	0.04	0.07	0.07	0.05	0.01	0.06	0.13
C:N	10.55	9.94	9.78	9.39	8.53	10.43	9.98	8.23	6.41
	0.16	0.29	0.20	0.34	0.17	0.22	0.40	0.19	0.64
Total P (%)	0.89	1.07	1.10	1.07	1.38	1.12	0.99	1.46	1.09
	0.02	0.04	0.03	0.02	0.05	0.06	0.01	0.22	0.02
Total K (%)	2.18	2.27	1.85	1.52	1.22	2.02	1.46	1.16	0.85
	0.02	0.15	0.04	0.02	0.02	0.09	0.05	0.04	0.02
Total Ca (%)	4.73	5.57	5.06	4.52	4.30	5.41	4.97	4.65	2.83
	0.26	0.21	0.35	0.21	0.20	0.40	0.24	0.13	0.16
Total Mg (%)	0.54	0.68	0.59	0.59	0.61	0.60	0.52	0.50	0.40
	0.01	0.07	0.005	0.005	0.016	0.01	0.02	0.01	0.01

during the last 20 days of vermicomposting compared to composting (Table 1) is probably contributed by earthworms through excretion of NH^{+}_{4} and secretion of mucus. The remainder of nutrients followed more or less similar trend, i.e., P content increased at a fluctuating level while K and Ca decreased and the Mg level remained almost static during composting with and without earthworm. Ghosh *et al.* (1999) reported higher level of transformation of phosphorus from organic to inorganic state, and thereby into available forms during vermicomposting compared to ordinary composting. Rise in the level of P content during vermicomposting is probably due to mineralization and mobilization of P due to bacterial and faecal phosphatase activity of earthworms (Krisnamoorthy 1990).

The level of macronutrients in the vermicompost is less than that of the compost following 40 days of composting (Table 1). Interestingly the macronutrients increased to a greater degree in the bed soil with earthworm after 40 days (Table 2). This indicates that soluble nutrients had leached from the worm-worked material so that their levels in the worm-worked beds were higher than the controls (Table 1 and Table 2). Lowering of nutrients during vermicomposting confirmed the previous observation of Hartenstein & Hartenstein (1981) and Mitchell (1997). Such lowering is possibly due to incorporation into earthworm tissue as well as leaching of nutrients into the bedding material (Mitchell 1997).

Table 2. Physicochemical analysis of soil bed (initially and after 40 days) with and without earthworms during kitchen-waste composting; each datum represents the mean of two replications.

Parameters	Initial	After 40 days	
		Without worms	With worms
pH	5.4	8.1	7.6
Organic C[1]	1.69	3.21	3.37
Total N[1]	0.14	0.28	0.31
Av. P[2]	1.83	36.7	58.6
Av. K[2]	6.0	102.0	89.0
Av. Ca[2]	167.7	236.6	297.5
Av. Mg[2]	22.5	38.8	42.0
C:N	12.0	11.4	10.8

Expressed as 1%, 2 mg 100 g^{-1} soil

The C to N ratio, which is one of the most widely used indices for compost maturation, decreased from 20 days with a lower trend in the experimental compared to control sets (Table 1). The drop in C:N ratio was significant (t-test, $P<0.05$) from 30 days. Interestingly, the experimental set in comparison to control showed significantly (t-tests $P<0.05$) low C:N ratio both in 30 days (control - 9.3, experimental - 8.2) and 40 days (control - 8.5, experimental - 6.4) of composting. Moreover, the soil beds with earthworms also showed C:N ratio lower than beds without earthworms. Thus it can be inferred that microbial decomposition contributes to the over all composting process and presence of earthworm speeds up the decomposition process. The lowering of C:N ratio was probably achieved by the combustion of carbon substances during respiration and the incorporation of plant derived organic material and transit of organic matter through the gut of earthworms.

From the data on C:N ratio and nutrient status after different days of vermicomposting it appears that an ideal C:N ratio of 8.2 with a suitable pool of nutrients is attained after 30 days (Table 1). A C:N ratio of 8.2 is suitable for field application of compost for the release of nutrients and to enhance microbial activity. Further increasing of time (i.e. exceeding 30 days, especially in the case of vermicomposting of kitchen waste) is not an ideal situation for the stimulation of biological activity in the soil.

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References

Albanell, E., J. Plaxiats & T. Cabrero. 1988. Chemical changes during vermicomposting (*Eisenia fetida*) of sheep manure mixed with cotton industrial waste. *Biology and Fertility of Soils* **6**: 266-269.

Edwards, C.A. 1998. The use of earthworms in the breakdown and management of organic wastes. pp. 327-354. *In* : C.A. Edwards (ed.) *Earthworm Ecology*. CRC Press LLC, Florida.

Elvira, C., J. Sampedro, J. Dominguez & S. Mato. 1997. Vermicomposting of waste water sludge from paper pulp industry with nitrogen rich materials. *Soil Biology & Biochemistry* **29**: 759-762.

Frederickson, J., K.R. Butt, R.M. Morris & C. Daniel. 1997. Combined vermiculture with traditional green waste composting systems. *Soil Biology & Biochemistry* **29**: 725-730.

Ghosh, M., G.N. Chattopadhyay & K. Baral. 1999. Transformation of phosphorus during vermicomposting. *Bioresource Technology* **69**: 149-154.

Hartenstein, R. & F. Hartenstein. 1981. Physicochemical changes effected in activated sludge by earthworms *Eisenia foetida. Journal of Environmental Quality* **10**: 377-382.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall Pvt. Ltd., New Delhi.

Kale, R.D. 1998. Earthworms : Nature's gift for utilisation of organic wastes. pp. 355-376. *In*: C.A. Edwards (ed.) *Earthworm Ecology*. CRC Press LLC, Florida.

Krisnamoorthy, R.V. 1990. Mineralization of phosphorus by faecal phosphatases of some earthworms of Indian tropics. *Proceedings of Indian Academy of Sciences (Animal Sciences)* **99**: 509-518.

Lee, K.E. 1985. *Earthworms. Their Ecology and Relationships with Soils and Land Use*. Academic Press, Sydney.

Mitchell A. 1997. Production of *Eisenia fetida* and vermicompost from feed-lot cattle manure. *Soil Biology & Biochemistry* **29**: 763-766.

Reinecke, A.J., S.A. Viljoen & R.J. Saayman. 1992. The suitability of *Eudrilus euginiae, Perionyx excavatus* and *Eisenia fetida* (Oligochaeta) for vermicomposting in Southern Africa in terms of their temperature requirements. *Soil Biology & Biochemistry* **24**: 1295-1307.

Singh, J. 1997. Habitat preferences of selected Indian earthworm species and their efficiency in reduction of organic materials. *Soil Biology & Biochemistry* **29**: 585-588.

Walkley, A. & I.A. Black. 1934. Determination of organic carbon in soil. *Soil Science* **37**: 29-38.