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Value addition to livestock excreta and fish waste through vermicomposting

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Abstract

The feasibility of value addition to different livestock excreta and fish waste through native earthworms was assessed in this study. Vermicomposting of livestock excreta with fish waste showed differences. The composting of goat pellet was completed in 45 days and it was 35 days for that of cow, horse and buffalo dung. Productivity ranged between 89.56% and 92.96%. Assessment of physico-chemical parameters indicated maximum levels of all the parameters estimated in the compost produced from cow–fish combination. The maximum C:N ratio recorded was 10:8 in the compost produced by goat- fish combination and that of cow – fish combination was estimated to be a minimum of 9:9.

Key words: *Horse dung, cow dung, goat dung, fish waste, vermicomposting*

Earthworms play an important role in the modification of the physico chemical environment of the soil and for other organisms (Blanchart *et al.,*1999; Brown *et al.,* 2000). Vermicompost is one of nature's best mulching and soil amendment material used as organic fertilizer to improve soil structure, texture, aeration, and water holding capacity (Martin and Gershuny, 1993). Earthworms voraciously feed on organic wastes and while utilizing only a small portion for their body synthesis, they excrete a large part of these consumed waste materials in a half digested form. The intestine of earthworms is reported to harbor wide range of microbes, enzymes and hormones which aid in the rapid decomposition of the half-digested materials into vermicompost (Edwards, 1998). The composting process kills the pathogens due to the heat generated during the thermophilic phase, and the organic waste is converted into stabilized humic substances through mineralization and humification with a significant reduction in volume. Literature survey revealed that in India, most of the laboratory research and field work are being carried out using exotic species of earthworms and research work on the use of local varieties is scanty. Researchers suggest that native (or) local species of earthworms are well adapted to local conditions; hence using such native species would help in achieving ecological security (Kaviraj and Sharma, 2003).

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Vermicomposting has been widely used for stabilization of different types of wastes and for municipal solid waste management strategies as well (Epsein, 1997). Viability of using earthworms for the treatment and as management technique for numerous organic waste has been investigated by a number of workers (Hand *et al.,* 1988). Different types of animal excreta are found to be an excellent substrate for vermicomposting (Hemalatha and Meenambal, 2006). Reports suggest an increase in biomass and cocoon production by *Eisenia foetida*, when cattle dung was used. It is suggested to be greater than that produced from goat pellets (Loh *et al.,* 2004). The potential of *Perionyx excavates* to vermicompost different wastes *viz*., sheep pellets, cow dung, biogas sludge, poultry manure and sand as control has also been well established. These worms were reported to readily accept cow dung and horse excreta (Kale, 1982). Sheep pellets were consumed in 3 or 4 days after it was added. Fish wastes have been used as an organic fertilizer and nutrient for both agricultural purpose and for rehabilitation of degraded areas. Fish sludge contains macro and micro nutrients, especially high levels of nitrogen and phosphorus. This research work aimed at value addition to combinations of livestock excreta and fish waste through vermicomposting using native earthworms.

Materials and methods

Sampling of earthworm

Adult clitellate native earthworm species were collected by hand sorting (Julka, 1988) from undisturbed areas at Allithurai, near Vayalur in Tiruchirappalli district in plastic troughs containing predigested substrate and brought to the laboratory in Holy Cross College, Tiruchirappalli for rearing and further investigation.

Substrate for vermicomposting

Four experimental groups comprised of 500g of livestock excreta each, (cow, horse, goat and buffalo excreta- any one per experimental group), and 500g of fish waste. Prior to use of these wastes as substrate, it is mandatory to subject the raw wastes for pre-digestion. The four experimental groups were mixed well and sprinkled with water to maintain moisture regularly during the period of pre-digestion (30 days). To each of these pre-digested (partially decomposed) experimental groups was added and then used as substrate for vermicomposting in this study.

Preparation of Vermibed

Vermicomposting was carried out in plastic troughs (20×35cm). These troughs were layered with stones for 3 cm (allows excess water to flow down), overlaid with 200g of husk and 3 cm of sand (prevents escape of worms) and finally 500g of agricultural soil was added to each of the four pre-digested experimental groups. They were mixed well and labelled (1FG: fish waste + goat pellets; 2FC: fish waste + cow dung; 3FB: - fish waste + buffalo dung; 4FH – fish waste + horse excreta). Twenty worms were released per experimental group, labelled and the time noted as day 0. 100 to 200 ml of water was sprinkled on the surface daily, to maintain moisture which is essential for the worm growth.

Vermicompost recovery

Appearance of dark brown coloured, loose granular mass with uniformly disintegrated structure in the compost troughs indicated the completion of the vermicomposting process (approximately 35-45 days post introduction of worms). Watering was then stopped for about two days. Later, each experimental group were heaped in separate plastic sheets and kept in the shade. The vermicompost was collected separately (leaving the earthworms below) sieved to collect cocoons, dried in shade and packaged for analysis. The earthworms remained together in the form of a bundle on the plastic sheet. These earthworms were collected carefully and replaced back to the native soil.

Estimation of the physicochemical parameters

The physical characteristics namely pH (Piper, 1944) and Electrical conductivity (EC) (Chandrabose *et al.,* 1988), macronutrients namely- total calcium (TCa) (JAOAC, 1967), total potassium (TK) (Hald, 1947), nitrogen

(Kjeldahl, 1883), total phosphorous (TP) (APHA,1998), total organic carbon (TOC) and total organic matter (Walkley and Black, 1934), as well as the levels of micronutrients-Mg (JAOAC, 1967), Fe and Zn (AOAC, 2000) were analyzed in the vermicompost that was harvested.

Statistical Analysis

The data on the physicochemical parameters was subjected to one way analysis of variance to find out the influence of different excreta on them. The significant data of these parameters were further subjected to Duncan's Post Hoc multiple comparison test to find out the occurrence of homogeneity in the composting potential among the different groups. The statistical tool was selected with the notion that their result would ultimately throw light on the resemblances and disparities in the excreta of the four animals used for vermicomposting.

Results and discussion

Maximum duration of 45 days was required to compost the (1FG) fish waste and goat pellets whereas combinations of fish waste with cow, buffalo and horse excreta (2FC, 3FB, 4FH) took only 35 days. Literature review, revealed a period of 45 to a few months (Diaz *et al*. 2002). The productivity of the composting process was found to be a maximum with 92.96% in fish waste + goat pellet combination, followed by 91.72% and 90.78% in horse + fish waste and buffalo + fish waste respectively. Minimum productivity of 89.56% was observed for fish waste + cow excreta (Table -1). Feed material having C-N ratio less than 40 could be used successfully for vermicomposting. Vermicompost prepared out of the mixture of crop residues supplemented with cow-dung in the ratio of 1:1 also exhibited higher nutrient content. Cow-dung has widely been accepted as the best substrate provided its pH is below 9.5 (Barik *et al.,* 2010).

Table 1. Time taken for completion of vermicomposting and % productivity in the four experimental groups

Experimental Group	Duration for Vermicomposting (days)	Productivity (%)
1FG	45	92.96
2FC	35	89.56
3FB	35	90.78
4FH	35	91.72

Note: All values are mean of triplicates
FG- Fish excreta +goat pellets
FC- Fish excreta + Cow excreta
FB- Fish excreta +Buffalo excreta
FH- Fish excreta + Horse excreta

Table 2. Physicochemical parameters of the vermicompost harvested from the four experimental groups

Parameter \ Experimental group	1FG	1FC	1FB	1FH
pH	7.2±0.1	7.7±0.1	7.1±0.1	6.9±0.1
Electrical Conductivity (EC in Mmhos/cm)	4.14±0.1	4.65±0.005	4.23±0.01	3.74±0.02
Pottasium(%)	0.65±0.01	0.79±0.01	0.73±0.02	0.59±0.02
Magnesium (%)	0.97±0.01	1.14±0.01	1.12±0.02	0.90±0.01
Zinc ppm	310.0±0.5	353.3±0.1	312.7±0.15	315.7±0.1
Iron (%)	0.7±0.02	0.9±0.02	0.7±0.01	0.9±0.02
Phosphorous (%)	0.17±0.01	1.28±0.02	1.01±0.04	1.22±0.01
Calcium (%)	4.52±0.03	4.78±0.02	3.99±0.01	4.13±0.02
Total Nitrogen (%)	1.48±0.02	1.62±0.03	1.57±0.01	1.53±0.02
Total Carbon (%)	16.0±0.15	16.0±0.1	15.95±0.02	16.0±0.06
Organic Matter (%)	29.5±0.21	30.1±0.15	29.7±0.20	29.5±0.10
C:N Ratio	10:8	9:9	10:1	10:5
Note: All values are mean of triplicates ± SD				

Table 3. One way analysis of variance between the experimental groups and the biochemical parameters studied

		Sum of Squares	df	Mean Square	F	Sig.
pH	Between Groups	1.043	3	.348	34.750	.000*
	Within Groups	.080	8	.010		
	Total	1.123	11			
Electrical Conductivity	Between Groups	1.235	3	.412	3293.244	.000*
	Within Groups	.001	8	.000		
	Total	1.236	11			
Potassium	Between Groups	.072	3	.024	170.510	.000*
	Within Groups	.001	8	.000		
	Total	.074	11			
Magnesium	Between Groups	.118	3	.039	337.595	.000*
	Within Groups	.001	8	.000		
	Total	.119	11			
Zinc	Between Groups	3718.890	3	1239.630	16904.045	.000*
	Within Groups	.587	8	.073		
	Total	3719.477	11			
Iron	Between Groups	.120	3	.040	218.424	.000*
	Within Groups	.001	8	.000		
	Total	.122	11			
Phosphorous	Between Groups	2.376	3	.792	1485.125	.000*
	Within Groups	.004	8	.001		
	Total	2.380	11			
Calcium	Between Groups	1.198	3	.399	1169.130	.000*
	Within Groups	.003	8	.000		
	Total	1.201	11			
Total Nitrogen	Between Groups	.033	3	.011	33.735	.000*
	Within Groups	.003	8	.000		
	Total	.035	11			
Total Carbon	Between Groups	.012	3	.004	.442	.729
	Within Groups	.075	8	.009		
	Total	.087	11			
Organic matter	Between Groups	.897	3	.299	10.248	.004*
	Within Groups	.233	8	.029		
	Total	1.130	11			

The results of the physicochemical parameters of the vermicompost produced from the four experimental groups are presented in Table-2. Slightly alkaline pH of 7.7±0.1 was recorded in fish waste + cow excreta group (2FC). The pH of the other three experimental groups were in the near neutral range of 6.9±0.14 (FH - fish + horse), 7.1±0.1 (3FB -Fish + Buffalo) and 7.2 ± 0.1 (1FG - Fish + Goat). Similarly the electrical conductivity was maximum in fish waste + cow dung group (2FC) with 4.65±0.01Mmhos/cm, minimum of 3.74±0.02Mmhos/cm in (4FH) fish waste + horse excreta, **w**hereas that of the other two experimental groups were, 4.23±0.01 Mmhos/cm, (3FB -Fish + Buffalo) and 4.14±0.1 Mmhos/cm, (1FG - Fish + Goat). Garg *et al.* (2006) suggested that electrical conductivity was due to a loss of weight by organic matter and release of different mineral salts. The vermicompost produced by 2FC (fish + cow) combination contained maximum levels of potassium, magnesium, zinc, iron, total nitrogen, total carbon, calcium and organic matter. The C:N ratio was highest in the 1 FG (fish + goat) combination. Variations in nutrients levels of the vermicompost could be due to varied activity of enzymes produced by the

microbial flora in the gut of earthworm during vermicomposting process (Bano *et al*.,1987; Scheu,1987; Mulongy and Bedoret,1989; Parthasarathi and Ranganathan,1999, Kalam *et al*., 2004 and Parthasarathi *et al.,* 2008). According to Ramesh and Thilagaraj (1996) and Kitturmath *et al*. (2007), the organic matter ingested by earthworm underwent physical, chemical and biological changes thus forming nutrient enriched casts. The pH of vermicompost recorded in this study was in conformity with the report of many authors, who reported it to be in a range of 6-8 (Brady, 1988; Sullivan and Miller, 2001; Saebo and Ferrini, 2006 and Ali, 2011).

Results of one way analysis of variance (Table 3) revealed the significance ($P<0.05$) in all the physicochemical parameters studied among the four experimental groups except total carbon ($p>0.05$). Further Duncan's Post Hoc multiple comparison test revealed all the four experimental groups to produce unique clusters. However, homogenous subsets for the vermicompost produced by the four experimental groups were formed with only 5 of the 10 parameters studied namely, pH (1FB &1FG); magnesium (1FB &1FC); iron (1FC &1FH); total nitrogen (1FG &1FH). The statistical analysis thus clearly revealed presence of variance in the vermicomposting potentials of the four experimental groups. The results of the experiments and statistical analysis suggest that the quality of vermicompost produced using animal excreta can be enhanced by amendment of the process with fish waste as well. Loh *et al*., (2004), have also suggested that cattle manure are more nutritious and form an amicable food for earthworms than goat manure. Amendments of the vermicomposting process, like with fish waste in the present study has also been reported to enhance the quality of vermicompost (Vukovic et al. 2021).

Conclusion

An attempt to use fish waste as a substrate for vermicomposting in combination with excreta of cow, goat, buffalo and horse was made in this study using native earthworms. Analysis of the physico-chemical parameters showed cow dung and fish waste combination to be rich in potassium (0.79%), magnesium (1.14%), zinc (353.3 ppm), phosphorus (0.9%), total nitrogen (1.28%), total carbon (1.62%), calcium (16.0%) and organic matter (4.78%). Vermicompost produced with horse excreta + fish waste combination contained minimum quantities of potassium, magnesium and organic matter. This study has successfully established that livestock excreta and fish waste could be successfully used in combination to produce high quality organic fertilizer. Fish waste could thus be used as an efficient substrate for vermicomposting. Cow buffalo and horse excreta were found to be better than the goat pellets in the present study.

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Conflict of interest - The authors declare that they have no conflict of interest.

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