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Waste Reduction, Nutrient Recovery from Solid Sludge Waste Materials by Vermicomposting

Sasikala Kannan • Kaliaperumal Rajendran • Eevera Tamilmani • Senthamari Selvi Venugopalan • Kumaran Shanmugam*

Department of Biotechnology, Periyar Maniammai University, Vallam, Thanjavur-613403, Tamil Nadu, India

Corresponding author: * **mskumaran@yahoo.com**

ABSTRACT

New ideas in sludge treatment are necessary for the today's world where land filling and land dumping of solid wastes have not offered an eco-friendly solution to the solid waste management problem. Consumption of organic wastes by earthworms is an ecologically safe and economically viable process to get beneficial products. In this study, a cost effective experimental treatment using cow-dung mix with four different types of solid wastes (textile sludege, biogas sludge, domestic sludge, and fly ash sludge) through vermicomposting process by earthworm (*Eisenia foetida*) was undertaken. Conclusions were drawn from analyses of compost mix for pH, electrical conductivity, total nitrogen, and total organic carbon before and after vermicomposting. Results obtained for various sludge levels (100, 75, 50 & 25%) of mixing (sludge:cowdung) indicated reduction in total organic carbon content and increase in total nitrogen content invariably in all treatments and reduction in electrical conductivity also indicated the quality of the compost obtained.

Keywords: biogas slurry sludge, domestic waste water sludge, fly ash, textile sludge

INTRODUCTION

Vermicompost has been promoted as a viable alternative container media component for agriculture and horticulture (Bachman and Metzger 2008). The organic amendments prepared from different organic wastes through composting and/or vermicomposting, differ in their nutrient levels depending on the kind of composting process (Campitelli and Ceppi 2008). There are problems associated with sludge management in small treatment plants located in rural Indian communities due to costly conventional technology for sludge stabilization. The importance of biological process in the management of sludge has been recognized. Many of these plants have only sludge drying beds. Within the broad range of bioprocesses available, composting and vermicomposting are the most efficient ones for converting sludge into useful products. Vermicomposting is a biodegradation system using suitable earthworm species (for example *Eisenia foetida*) which stabilizes sludge and reduces its pathogenicity. It is now inferred that the digestive tract fluids of worms can render pathogens killed or harmless and can even enrich the good soil bacteria (Edwards 1998). Earthworms with their very high feeding rates metabolize the organic waste substances, stimulate microbial activity greatly and increase rates of mineralization rapidly converting the waste into humus like substances with a finer structure than compost. Composting requires the right temperature, moisture, and feedstock to get right product in the soil. Ideal condition for a compost worm requires neutral pH, 25°C (air temperature), above 70% air humidity and 70-90% substrate moisture level (Fraser-Quick 2002; Panikkar *et al*. 2002). Earthworms are the most important soil dwelling organisms involved in the process of soil formation and organic matter decomposition (Edwards 1998; Kale *et al.* 1982).

In Tirupur of Tamilnadu State (India), textile dyeing industries have disposal and treatment problems associated with huge amount of sludge generated. Fly ash released from boilers of Bharat Heavy Electricals Ltd., Tiruchirapalli, Tamilnadu State (India), a heavy electrical industry is very important in environmental protection point of view to be and the fly ash is to be biodegraded and converted into manure. Other untreated sludges from domestic sludge and biogas plant sludge have disposal problem within our university campus.

The present study aims at evaluating the effectiveness of vermicomposting process with reference to decomposition of four different solid wastes (textile sludge, biogas sludge, domestic sludge, and fly ash sludge) mixed with cow dung procured from nearby villages.

MATERIALS AND METHODS

This study has been carried out in our university vermicompost yard from December 2007 to March 2008. Textile sludge was collected from a textile industry located in Tirupur and fly ash from Bharat Heavy Electricals Limited (BHEL) plant located in Tiruchirapalli. The waste water sludge was collected from Periyar Maniammai University (PMU) hostel and biogas plant slurry sludge from the university's biogas unit. All the four locations were from Tamil Nadu State, India. All the collected samples were separately processed for thorough mixing and kept in plastic lined containers at room temperature.

Healthy earthworms (*Eisenia foetida*) of approximately the same size were collected from our university vermicompost yard and fresh cow dung was also obtained from the university cattle yard. All the experiments were performed in the university vermicompost yard using burnt earthen pots (~ 5L capacity). Four sludge-cowdung compositions were prepared, these combinations being: sludge alone, sludge 75% + cow dung 25%, sludge 50% + cow dung 50% and sludge 25% + cow dung 75%. All combinations were prepared on weight basis with a total weight of one kg material in each pot and each of the combination replicated thrice in a completely randomized design (each pot being incubated with 10 *E. foetida* worms).

The materials under each treatment were incubated under moist conditions for 60 days at a temperature range of 28.0 to 33.7°C. Throughout the decomposition period, moisture content of the waste is maintained at 40 to 50% present. At the end of the 60 days of decomposition period from all the combinations, samples

Received: 24 November, 2008. Accepted: 3 December, 2009.

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were collected and analyzed for pH, Electrical Conductivity (EC), Total Organic Carbon (TOC) and Total Nitrogen (TN). Determination of these parameters were carried out by using the following procedure: pH and EC were measured using aqueous extract of air dried sample by Systronics (India) Digital pH meter 335 and Systronics (India) Conductivity meter 304 respectively. Parameters like TOC and TN were estimated by Walkley and Black titration method and Kjeldhal method, respectively.

RESULTS AND DISCUSSION

Earthworms did not survive completely in 100% of fly ash as reported by (Venkatesh and Eevera 2008). Composting changes the sludge colour to brown from green in all the three compositions (75, 50 and 25%) except in 100% raw waste. During vermicomposting process, the increased pH value of substrate (due to mixing of inoculants) was generally to be significantly decreasing (**Tables 1-7**). For example, in the 25% textile sludge (**Table 1**), there is a drastic change in pH. Before composting the pH was 8.8, but after 60 days of composting it was reduced to 7.3 (**Table 2**). A similar trend was observed in fly ash, hostel wastewater sludge and biogas sludge also (**Tables 4, 6, 7**). Vermicompost manure has always acidic pH, which may be due to the accumulation of organic acids from microbial metabolism or from the production of fulvic and humic acids during decomposition (Albanell *et al.* 1988; Chan and Griffiths 1998). It shows that the alkalinity of the bio-compost is slowly reducing during the composting process. A decreasing trend in pH was observed due to rapid action of worms. The worms preferred to feed on materials having neutral pH to the acidic side, which is evidenced from pH of their castings. When the pH of the substrate had alkaline pH, the worms tend to migrate to the other side (acidic pH) where the substrate was added. However they can return to work on new materials when they feel right conditions for their movement (Panikkar *et al.* 2002).

Table 1 Chemical parameters of the textile sludge-based mixture before vermicomposting.

Ratio of textile sludge and cow dung	pH	EC (Dsm^{-1})	Total nitrogen (%)	Total organic carbon (%)	C:N ratio
100:0	8.72	3.6	0.58	11.62	20:1
75:25	8.73	4.1	0.57	11.54	20:1
50:50	8.63	5.3	0.56	11.36	20:1
25:75	8.80	3.4	0.53	11.27	21:1

Table 2 Chemical parameters of the textile sludge-based composted material.

Ratio of textile sludge and cow dung	pH	EC (Dsm^{-1})	Total nitrogen (%)	Total organic carbon (%)	C:N ratio
100:0	8.1	3.0	0.72	9.50	13:1
75:25	8.2	1.4	0.80	9.00	11:1
50:50	7.4	0.9	1.30	8.87	7:1
25:75	7.3	1.0	1.28	8.0	6:1

Table 3 Chemical parameters of the fly ash-based mix before composting.

Ratio of fly ash and cow dung	pH	EC (Dsm^{-1})	Total nitrogen (%)	Total organic carbon (%)	C:N ratio
100:0	7.70	1.32	0.20	12.29	61:1
75:25	8.09	1.09	0.19	12.15	64:1
50:50	8.21	1.12	0.19	11.49	60:1
25:75	7.94	1.14	0.30	11.36	38:1

Table 4 Chemical parameters of the fly ash-based composted material.

Ratio of fly ash and cow dung	pH	EC (Dsm^{-1})	Total nitrogen (%)	Total organic carbon (%)	C: N ratio
100:0	11.7	1.20	0.20	11.84	59:1
75:25	10.4	0.98	0.63	10.64	17:1
50:50	7.91	0.88	0.78	9.58	12:1
25:75	7.51	0.72	1.01	10.46	10:1

Table 5 Chemical parameters of the hostel waste water sludge based mixture (before compositing).

Ratio of hostel waste water sludge and cow dung	pH	EC (Dsm^{-1})	Total nitrogen (%)	Total organic carbon (%)	C: N ratio
100	7.30	2.0	0.46	12.84	28:1
75:25	7.82	1.80	0.48	12.64	26:1
50:50	8.23	1.20	0.46	12.58	27:1
25:75	8.43	1.11	0.49	12.46	25:1

Table 6 Chemical parameters of the hostel waste water sludge-based compost (after composting).

Ratio of hostel waste water sludge and cow dung	pH	EC (Dsm^{-1})	Total nitrogen (%)	Total organic carbon (%)	C: N ratio
100:0	7.07	1.8	0.69	10.38	15:1
75:25	7.00	1.4	0.82	10.06	12:1
50:50	7.18	1.0	0.97	9.28	10:1
25:75	7.61	0.8	0.87	9.26	11:1

Table 7 Chemical parameters of biogas plant slurry (before and after composting).

Slurry (%)	pH	EC (Dsm^{-1})	Total nitrogen (%)	Total organic carbon (%)	C: N ratio
Before 100	8.74	2.0	0.43	6.49	15:1
After 100	8.36	1.06	1.54	4.21	3:1

Mixing with cow dung makes the sludge substrates palatable to the worms and accelerates the breakdown of the available organic matter. This reduces TOC and an increase in TN contents in the order 100% < 75% < 50% < 25% thus resulting in a C: N ratio (**Tables 2, 4, 6, 7**). As a typical example for 50% composition, during vermicomposting the C: N ratio changes from 20: 1 to 7: 1 (**Tables 1, 2**) in the case of textile sludge, 60: 1 to 12: 1 (**Tables 3, 4**) in the case of fly ash, 27: 1 to 10: 1 (**Tables 5, 6**) in the case of hostel waste water sludge, and for 100% composition of biogas slurry it changes from 15: 1 to 3: 1 (**Table 7**). In all the organic carbon content decreases and nitrogen content increases, organic carbon being lost as carbon dioxide (Crawford 1983).

An increasing in nitrogen content was related to the recycling of nitrogen as reported in the vermicomposting of market waste containing high organic material (Karthikeyan *et al.* 2007). In the microbial decomposition of organic matter, carbon is used as a source of energy and nitrogen for building cell structure. Increase in the nitrogen value is a result of carbon loss, and probably because of mineralization of organic matter (Kaushik and Greg 2003). Decrease in the C: N ratio due to the loss of organic carbon and increase in the nitrogen value has been reported already (Palmisano *et al.* 1993; Edwards 1998). The results of the present study are in agreement with those reported earlier for different combinations of fly ash and cow dung incubated with *E. fetida* and *Eutrillus eugenia* for 50 days to achieve mass reduction and recovery of nutrients (Bhattacharya *et al.* 2004; Venkatesh and Eevera 2008).

Electrical conductivity is also considerably decreasing during the vermicomposting process revealing a reduction of salinity which is the essential character of a good biocompost (Karthikeyan *et al.* 2007). Volatilization of ammonia and precipitation of neutral salts is the reason for the reduction in EC values (Wong *et al.* 1995).

CONCLUSION

The present study indicates that *E. foetida* is capable of converting the organic waste into manure. It has been proved that through vermicomposting wealth from solid wastes like textile sludge, fly ash, waste water sludge, etc can be generated. Based on the chemical analysis, vermicompost obtained in this experiment is useful as a soil conditioner and also as a healthy organic fertilizer.

ACKNOWLEDGEMENTS

We sincerely acknowledge Periyar Maniammai University's vermicompost unit for providing space and earthworms to carry out this research. Sasikala Kannan acknowledges BHEL, Tiruchirapalli and Common Effluent Treatment Plant at Triupur for providing us fly ash and sludge respectively. Kumaran Shanmugam acknowledges the financial assistance from Department of Biotechnology, Government of India, New Delhi (Sanction # BT/ PR10018/NNT/28/95/2007). Authors are thankful to Professor V. Sethuraman, Department of Chemistry, PMU for technical discussion.

REFERENCES

Albanell E, Plaixas J, Cabreo T (1988) Chemical changes during vermicomposting of sheep manure mixed with cotton industrial wastes. *Biology and Fertility of Soils* **6**, 266-269

Bachman GR, Metzger JD (2008) Growth of bedding plants in commercial potting substrate amended with vermicompost. *Bioresource Technology* **8**, 3155-3161

Bhattacharya SS, Chattopadhyay GN (2004) Transformation of nitrogen during vermicomposting of fly ash. *Waste Management Resource* **22**, 488-491

Campitelli P, Ceppi S (2008) Chemical, physical and biological compost and vermicompost characterization: A chemometric study. *Chemometrics and Intelligent Laboratory Systems* **1**, 64-71

Chan PLS, Griffiths DA (1998) Transformation of nitrogen during vermicomposting of fly ash. *Waste Management Resource* **22**, 488-491

Crawford JH (1983) Review of composting. *Process Biochemistry* **18**, 14-15

Edwards CA (1998) The use of earthworms in the breakdown and management of organic wastes. In: Edwards CA (Ed) *Earthworm Ecology*, CRC Press, Boca Raton, pp 327-354

Fraser-Quick G (2002) Vermiculture – A sustainable total waste management solution; *Waste Management* **4**, 13-16

Kale RD, Bano K, Krishnamoorthy RV (1982) Potential of *Periyonyx excavatus* for utilizing organic wastes. *Pedbiologia* **23**, 419-425

Karthikeyan V, Sathyamoorthy GI, Murugesan R (2007) Vermi composting of market waste in Salem, Tamilnadu, India, *Proceedings of the International Conference on Sustainable Solid Waste Management*, 5-7 September 2007, Chennai, India, pp 276-281

Kaushik P, Greg VK (2003) Vermicomposting of mixed solid textile mill sludge and cow dung with epigenic earthworms *Eisenia foetida*. *Bioresource Technology* **90**, 311-316

Palmisano AC, Maruscik DA, Ritchie CJ, Schwab BS, Harper SS, Rapaport RA (1993) A novel bioreactor simulating composting of municipal solid waste. *Journal of Microbiological Methods* **18**, 99-112

Panikkar A, Hackney P, Riley S Onsite residential waste treatment via composting of blackwater and biowaste, Proceedings EERE (2002). Environmental Engineering Research Event Blackheath, NSW, 3-6th December 2002

Venkatesh RM, Eevera T (2008) Mass reduction and recovery of nutrients through vermicomposting of fly ash. *Applied Ecology and Environmental Research* **1**, 77-84

Wong JWC, Li S WY, Wong MH (1995) Coal fly ash as a composting material for sewage sludge: Effects on microbial activity. *Environmental Technology* **16**, 527-537