American-Eurasian J. Agric. & Environ. Sci., 10 (6): 983-987, 2011
ISSN 1818-6769

Management of Vegetable Wastes by Vermicomposting Technology

G. Sibi and Manpreet Kaur

Department of Microbiology, Padmashree Institute of Management and Sciences,
Bangalore, 560 060, Karnataka, India

Abstract: In view of the ever increasing population and generation of wastes, attention is now being paid to the recycling of organic wastes as a good source of nutrients. Disposal of vegetable wastes can be done by methods like land filling, incineration, recycling and composting. Vermicomposting is one of the recycling technologies which will improve the quality of the products and have considerable potential as soil amendments. The present study was carried out to assess the potential of earthworms in recycling of vegetable wastes. *Eisenia foetida* were introduced into partially decomposed vegetable wastes under controlled conditions and the physicochemical parameters were recorded at regular intervals. The results revealed that a decrease in pH, electrical conductivity and C/N ratio in the final product and an increased nutrient content at the end of 60 days. Moreover, major nutrients required for plant growth were converted into available forms which facilitate easy uptake by the plants and thus improves crop production. Use of vermicomposting technology could help recycling and reutilization of precious organic wastes rather than being wasted and burned.

Key words: Vermicompost · Vegetable wastes · Earthworms · *Eisenia foetida*

INTRODUCTION

Vegetable waste is an unwanted byproduct of modern civilization. There has been a significant increase in vegetable waste generation in India in the last few decades due to rapid population growth and economic development in the country. Landfills and incineration are the most common means of waste disposal, causing a nuisance because of high biodegradability [1]. This result in loss of potentially valuable materials that can be processed as fertilizer, fuel and fodder [2]. Open dumping of vegetable waste facilitates the breeding for disease vectors such as flies, mosquitoes, cockroaches, rats and other pests.

At present, the management of organic waste is a major concern worldwide, as unscientific disposal of waste can adversely affect the environment by causing offensive odor, ground water contamination and soil pollution [3]. Alternatives of waste management include the use of source reduction and composting. Composting is one of the most promising ways to recycle the waste, as the process reduces the volume and stabilizes the waste. Composting is a widely acceptable alternative for converting waste into a more useful eco-friendly fertilizer to improve soil fertility [4, 5].

Although various physical, chemical and microbiological methods of disposal of organic solid wastes are currently in use, these methods are time consuming and expensive. Therefore, there is a pressing need to find cost-effective alternative method of shorter duration. In this regard, vermicomposting has been reported to be a viable, cost effective and rapid technique for the efficient management of the solid wastes. The environmentally acceptable vermicomposting technology using earthworms can very well be adopted for converting waste into wealth.

Aristotle called earthworms as ‘intestines of the earth’ and are also called as ‘Ecosystem engineers’ as they increase the numbers and types of microbes in the soil by creating conditions under which these creatures can thrive and multiply. Hand *et al*., [6] defined vermicomposting as a low cost technology system for the processing or treatment of organic wastes. Earthworms greatly influence soil properties and cast production, which results in the continuous turnover of the soil and mixing of minerals and organic constituents. The potential benefits of vermicomposting of vegetable waste include control of pollution and production of a value added product [7]. Recycling of wastes through vermicomposting reduces the problem of non-utilization

Corresponding Author: G. Sibi, Head, Department of Microbiology, Padmashree Institute of Management and Sciences, Bangalore - 560 060, Karnataka, India. E-mail: gsibii@gmail.com.

of vegetable waste. During vermicomposting, the important plant nutrients such as N, P, K and Ca present in the organic waste are released and converted into forms that are more soluble and available to plants than those in the parent substrate [8].

Vermicompost is considered as an excellent product since it is homogeneous, has desirable esthetics, reduced level of contaminates, plant growth hormones, higher level of soil enzymes and greater microbial population and tends to hold more nutrients over a long period without adversely impacting the environment. Vermicomposting takes nearly half the time of conventional composting and vermicompost do not require any curing which can be used straightway after production [9]. Vermicompost have outstanding chemical and biological properties with plant growth regulators and significantly larger and diverse microbial populations than the conventional thermophilic composts [10-12]. Additionally, vermicompost contain enzymes like amylase, lipase, cellulase and chitinase, which continue to break down organic matter in the soil even after they have been excreted. [13-15].

There is an urgent need globally to find alternative sustainable steps to treat organic wastes originated from mismanagement of farm wastes with increasing disposal cost. Furthermore, a conglomeration of ever-increasing population and consumerist lifestyle is contributing towards the generation of more vegetable waste. In this context, vermicomposting offers excellent potential to promote safe, hygienic and sustainable management of biodegradable vegetable waste. Considering the extensive production of vegetable wastes and keeping the above said problems and ideas in mind, the present study was conducted to assess the potential of earthworms in composting of vegetable waste and various physicochemical parameters of vermicompost.

MATERIALS AND METHODS

Pre-Composting: The shredded vegetable waste was sprayed in a layer of 1-2 feet and exposed to sunlight for 5 days to remove pathogenic microorganisms and noxious gases. The pre-compost yard was constructed to a size of 10' x 5' x 2' and the bottom and side faces were plastered with cement mortar to prevent seepage of water. In order to drain the excess amount of water in the pre-compost yard, drain pipes were provided at the sides of the yard. Then the shredded vegetable waste was dumped in pre-compost yard for preprocessing. In order to maintain better aeration and ventilation, PVC pipes were installed and the heat generated from was let out through the pipes and concurrently atmospheric air was circulated through the pipes. The pre-composting process was completed within 7-10 days and became suitable for vermicompost treatment.

Experimental Design or Vermicomposting: Vermiculture formulations were formed in pits measuring each size of 10' x 5' x 2'. The important parameters i.e., moisture and temperature were controlled by means of spraying water over the beds thereby, the temperature maintained not exceeding 35°C by adorning wet gunny bags over bed and moisture was maintained between 50-60%. At least 2 kg of *Eisenia foetida* was inoculated into each vermibed and the pre-compost was finally covered with a jute mat to protect earthworms from birds. The appearance of black granular crumbly powder on top of vermin beds indicated harvest stage of the compost. Watering was stopped for at least 5 days at this stage and the vermicompost was collected from the top without disturbing the lower layers.

Chemical Analysis: Samples were drawn periodically at 15-days interval from each of the incubated materials and were analyzed for pH, electrical conductivity, total carbon, total nitrogen, total phosphorus, total potassium and micronutrients. Determinations of these parameters were carried out by using the following procedure: Water extracts of vermicompost were obtained by mechanically shaking the samples with distilled water at 1:5 (w/v) for 1 h. The suspensions' glass wool filtrates were used for the determination of pH and electrical conductivity [3]. Moisture content was determined in samples dried at 105°C for 4 h. Total organic carbon was estimated by using the method of Nelson and Sommers [16]. Total Kjeldahl nitrogen was determined by Bremmer and Mulvaney [17] procedure. Colorimetric estimation of total phosphorus and flame photometer determination of total potassium, sodium were done by following the method of Bansal and Kapoor [18]. Calcium and Magnesium were estimated by EDTA titration method [19]. All other micronutrients were analyzed by flame atomic absorption spectrometry (Perkin Elmer Atomic Absorption Spectrophotometer) after filtering the extracts obtained from the digestion of the ashes with 3 N Hcl.

Statistical Analysis: The obtained data were expressed as mean ± SE of 6 replicates. Two way analysis of variance (ANOVA) was applied to determined any significant ($P<0.05$) difference among the parameters observed.

Table 1: Physicochemical parameters of vermicompost

	Percent								ppm						
Days	pH	EC	C	N	P	K	Ca	Mg	Na	Fe	Zn	Mn	Cu	Bo	Al
0	7.08	0.46	9.89	0.61	0.24	0.60	1.24	0.41	100	874	107	375	126	181	950
15	7.01	0.48	9.76	0.84	0.31	0.68	1.48	0.58	100	899	121	389	126	190	957
30	6.91	0.44	8.41	0.95	0.49	0.74	1.81	0.65	100	947	124	387	151	232	955
45	6.84	0.41	7.56	1.07	0.51	0.89	2.12	0.71	100	968	147	392	163	247	958
60	6.78	0.41	7.21	1.24	0.51	0.97	2.44	0.79	100	1045	156	397	164	262	961

*Significant at $P<0.05$

RESULTS AND DISCUSSION

Changes in pH, electrical conductivity, total carbon, total nitrogen, total phosphorous, total potassium, calcium and micronutrients are presented in Table 1. The results suggested that earthworms play a vital role in processing vegetable waste into organic manure by accelerating the process of decomposition and the manure was more homogenous after 60 days.

With the progress of vermicomposting, pH tended towards neutral and the decrease may be due to the accumulation of organic wastes during microbial metabolism which was in accordance with Chudhary *et al.*, [20]; Joshi and Chauhan, [21] and Chauhan *et al.*, [22].

The EC was reduced in the range of 10.8% and may be due to loss of weight of organic matter and release of different mineral salts in available forms.

The organic carbon was declined (9.89 to 7.21) during the study period and the reduction in organic carbon could be due to the respiration activity of earthworms and microorganisms [23]. Earthworms modify the substrate condition which consequently promotes the carbon losses from the substrate through microbial respiration in form of CO_2 and even through mineralization of organic matter, where as N increases as a result of carbon loss [18].

Total nitrogen content was 0.71 per cent at initial day and was 1.62 per cent at the end of 60 days showing 56% increase. Losses of organic carbon might be responsible for nitrogen addition in the form of mucus nitrogenous excretory substances, growth stimulatory hormones and enzymes from the gut of earthworms. A decrease in pH may also be an important factor in nitrogen retention as it lost as volatile ammonia at higher pH values. Increase in nitrogen content in vermicompost of sugarcane trash and cow dung substrate as compared to controls was reported by Ramalingam and Thilagar [24]. Atiyeh *et al.*, [25] reported that by enhancing nitrogen mineralization, earthworms have a great impact on nitrogen transformation in manure, so that nitrogen retained in the nitrate form.

Total phosphorus was greater at the end of vermicomposting (0.51 percent) than the initial day (0.24 percent) with an increase of 52.9%. Increase in the amount of phosphorus in the vermicompost with the progress of time was reported by Tripathi and Bhardwaj [26] and release of phosphorous in available form is partly by earthworm gut phosphatases [27].

The values of potassium in different intervals revealed a 41% increase at the end of 60 days, which may be due to the metabolic activity of microorganisms present in earthworms' gut. Solubilization of inorganic potassium in organic wastes by microorganisms through acid production was claimed by Premuzic *et al.* [28]. Suthar [29] suggested that earthworm processed waste material contains high concentration of exchangeable K, due to enhanced microbial activity during the vermicomposting process, which consequently enhanced the rate of mineralization.

The increase in nitrogen, phosphorus and potassium in the vermicompost confirms the enhanced mineralization of these elements due to enhanced microbial and enzyme activity in the guts of worms [30].

Calcium content was increased with days of vermicomposting and recorded 2.44 percent after 60 days. It is suggested that gut process associated with calcium metabolism are primarily responsible for enhanced content of inorganic calcium content worm cast. However, the similar pattern of calcium enhancement is well documented in available literature [3]. However sodium per cent was constant throughout the study. Micronutrient contents were significantly increased at the end of 60 days when compared to the initial day.

There is an urgent need globally to find alternative sustainable steps to treat vegetable wastes originated from mismanagement with increasing disposal cost. Furthermore, a conglomeration of ever-increasing population and consumerist lifestyle is contributing towards the generation of more vegetable wastes. It has been demonstrated that, through vermicomposting, solid wastes such as household and kitchen wastes, vegetable wastes, paper wastes and others could be sustainably transformed into organic fertilizer or vermicompost that provides great benefits to agricultural soil and plants.

Vermicomposting is an eco-biotechnological process that transforms energy rich and complex organic substances in to a stabilized vermicomposts which aids in the disposal by improving the physical quantities of waste [31, 32]. Vermicomposting is stabilization of organic material involving in the joint action of earthworms and micro organisms. Although microbes are responsible for the biochemical degradation of organic matter, earthworms are the important derivers of the process, conditioning the substrate and altering the biological activity. The role of earthworms in the process of vermicomposting of waste is a physical and biochemical process. The physical process includes substrate aeration, mixing as well as actual grinding while the biochemical process is influenced by microbial decomposition of substrate in the intestine of earthworms. Various studies have shown that vermicomposting of organic waste accelerates organic matter stabilization [33] and gives chelating and phytohormonal elements which have a high content of microbial matter [34] and stabilized humic substances.

CONCLUSION

Among various sources of organic matter, vermicomposts have been recognized as having considerable potential as soil amendments and has been adopted widely for organic farming. Bioconservation of natural resources like vegetable wastes could be done by recycling and reutilization of precious organic waste rather than being wasted and burned. The use of effective technology such as vermicomposting results in reduced time period of composting with minimum resources which would lead to zero waste generating regions.

REFERENCES

1. Bouallagui, H., M. Torrijos, J.J. Godon, R. Moletta, R.B. Cheikh, Y. Touhami, J.P. Delgenes and M. Hamdi, 2004. Two-phases anaerobic digestion of fruit and vegetable wastes: bioreactors performance. Biochem. Eng. J., 21: 193-197.
2. Baffi, C., M.T. Dell Abate, S. Silva, A. Beneditti, A. Nassisi, P.L. Genevini and F. Adani, 2005. A comparison of chemical, thermal and biological approach to evaluate compost stability. By Geophysical Research Abstracts. 7: 09116. European Geosciences Union.
3. Garg, V.K., Y.K. Yadav, A. Sheoran, S. Chand and P. Kaushik, 2006. Live stocks excreta management through vermicomposting using an epigeic earthworm *Eisenia foetida.* Environmentalist, 26: 269-276.
4. Fang, M., J.W.C. Wong, K.K. Ma and M.H. Wong, 1999. Co-composting of sewage sludge and coal fly ash: nutrient transformations. Biores. Technol., 67: 19-24.
5. Maleena, I., 1998. Composting piggery waste: a review. Biores. Technol., 63: 197-203.
6. Hand, P., W.A. Hayes, J.C. Frankland and J.E. Satchell, 1988. The Vermicomposting of cow slurry. Pedobiologia, 31: 199-209.
7. Payal, G., G. Asha and S. Satya, 2006. Vermicomposting of difference types of waster using *Eisenia foetida* - a comparative study. Biores. Technol., 97: 391-395.
8. Ndegwa, P.M. and S.A. Thompson, 2001. Integrating composting and vermicomposting in the treatment of bioconversion of biosolids. Biores. Technol., 76: 107-112.
9. Dominguez, J., C.A. Edwards and S. Subler, 1997. A comparison of vermicomposting and composting, BioCycle, 28: 57-59.
10. Edwards, C.A. and I. Burrows, 1988. The Potential of Earthworms Composts as Plant Growth Media. In Edward, C.A. and E.F. Neuhauser (Eds.). Earthworms in Waste and Environmental Management. SPB Academic Publishing, The Hague, The Netherlands; ISBN 90-5103-017-7, pp: 21-32.
11. Edwards, C.A., 1998. The Use of Earthworms in the Breakdown and Management of Organic Wastes. In Edwards, C.A. (Ed.). Earthworm Ecology; CRC Press, Boca Raton, FL, USA, pp: 327-354.
12. Tomati, V. and E. Galli, 1995. Earthworms, Soil Fertility and Plant Productivity. Acta Zoologica Fennica, 196: 11-14.
13. Chaoui, H.I., L.M. Zibilske and T. Ohno, 2003. Effects of earthworms casts and compost on soil microbial activity and plant nutrient availability. Soil Biol. Biochem., 35(2): 295-302.
14. Lunt, H.A. and H.G. Jacobson, 1994. The chemical composition of earthworm casts. Soil Sci., 58: 367-75.
15. Tiwari, S.C., B.K. Tiwari and R.R. Mishra, 1989. Microbial populations, enzyme activities and nitrogenphosphorus- potassium enrichment in earthworm casts and in surrounding soil of a pineapple plantation. J. Biol. Fert. Soils, 8: 178-182.

16. Nelson, D.W. and L.E. Sommers, 1982. Total carbon and organic carbon and organic matter. In: A.L. Page, R.H. Miller and D.R. Keeney (Eds.). Methods of Soil Analysis. American Society of agronomy, Medison, pp: 539-579.
17. Bremmer, J.M. and R.G. Mulvaney, 1982. Nitrogen Total In: A.L. page R.H. Millar and D.R. Keeney, (eds.), Method of Soil Analysis, American Society of agronomy, Madison, pp: 575-624.
18. Bansal, S. and K.K. Kapoor, 2000. Vermicomposting of crop residues and cattle dung with *Eisenia foetida*. Biores. Technol., 73: 95-98.
19. Piper, C.S., 1966. *Soil and Plant Analysis*. Hans publications, Bombay, India.
20. Chudhary, P.S., T.K. Pal, G. Bhattacharjee and S.K. Dev, 2000. Chemical characterization of kitchen waste vermicompost processed by *Perionyx excavatus*. Environ. Ecol., 18(4): 902-904.
21. Joshi, P.C. and A. Chauhan, 2006. Composting of some organic materials using *Eisenia foetida* and Conventional microbial methods: A comparative study. Uttar Pradesh J. Zool., 26(1): 123-125.
22. Chauhan, A., S. Kumar, P.S. Amit and G. Mohit, 2010. Vermicomposting of vegetable wastes with cow dung using three earthworm species *Eisenia foetida*, *Eudrilus eugeniae* and *Perionyx excavatus*. Nature and Sci., 8(1): 33-43.
23. Curry, J.P., D. Byrne and K.E. Boyle, 1995. The earthworm of winter cereal field and its effects on soil and nitrogen turnover. Biol. Fertil. Soil., 19: 166-172.
24. Ramalingam, R. and M. Thilagar, 2000. Bioconversion of agro-waste sugarcane trash using an Indian epigeic earthworm, *Perionyx excavatus* (Perrier). Ind. J. Environ. Ecoplan., 3: 447-452.
25. Atiyeh, R.M., J. Dominguez, S. Subler and C.A. Edwards, 2000. Change in the biochemical properties of cow manure during processing by earthworm *Eisenia andrei* (bouch) and the effect of seeding growth. Pedobiologia, 44: 709-724.
26. Tripathi, G. and P. Bhardwaj, 2004. Comparative studies on biomass production, life cycles and composting efficiency of *Eisenia foetida* (Savigny) and *Lampito mauritii* (Kinberg). Biores. Technol., 94: 275-283.
27. Lee, K.E., 1992. Some trends opportunities earthworm research or Darwin children. The future of our discipline. Soil Biol. Biochem., 24: 1765-1771.
28. Premuzic, Z., M. Bargiela, A. Garcia, A. Rendina and A. Iorio, 1998. Calcium, iron potassium, phosphorous and vitamin C content of organic and hydroponic tomatoes. Hort. Sci., 33: 255-257.
29. Suthar, S., 2007. Nutrients changes and biodynamic of epigeic earthworms *Perionyx excavatus* during recycling of some agricultural wastes. Biores. Technol., in press, doi.:10.1016/j.biortech.2006.o6.001
30. Parthasarathi, K. and L.S. Ranganathan, 2000. Chemical characteristics of mono and polycultured soil worms casts by tropical earthworms. Environ. Ecol., 18: 742-746.
31. Zularisam, A.W., Z. Siti Zahirah, I. Zakaria, M.M. Syukri, A. Anwar and M. Sakinah, 2010. Production of biofertilizer from vermicomposting process of municipal sewage sludge. J. Applied Sci., 10(7): 580-584.
32. Yadav, K.D., V. Tare and M.M. Ahammed, 2010. Vermicomposting of source separated human faeces for nutrient recycling. Waste Manage., 30: 50-56.
33. Frederickson, J., K.R. Butt, R.M. Morris and C. Daniel, 1997. Combining vermiculture with traditional green waste composting systems. Soil Biol. Biochem., 29: 725-730.
34. Arancon, N.M., C.A. Edwards, P. Bierman, J.D. Metzger and C. Lucht, 2005. Effects of vermicomposts produced from cattle manure, food waste and paper waste on growth yield of peppers in the field. Pedobiologia, 49: 297-306.