A STUDY ON VERMICOMPOSTING OF BANANA LEAF WASTE

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Abstract: *Studies on bioconversion of solid wastes have been performed for controlling pollution due to wastedisposal. Vermicomposting has been identified as an efficient technology for this purpose. The present study aims at the management of banana leaf waste using the eco-biological tool, vermicomposting. Banana leaf waste is one of the major waste in India especially in South India. It is thrown out in huge amount from temples, markets, marriage halls, residential areas etc. In this study Banana leaf waste was collected from Guruvayur Temple and was subjected to vermicomposting using the earthworm, Eisenia fetida. Studies were done with different ratios of cowdung for both raw and dried banana leaf waste. The values of total nitrogen, total phosphorus, total potassium, increased with a decrease in electrical conductivity, total organic carbon and C/N ratio after vermicomposting. Vermicomposting with equal amount of cowdung and leaf waste (replacing one third weight of banana leaf with neem leaves) showed best results in both quality and in vermicompost duration. Finally, the solid wastes were successfully transformed into a nutrient-rich vermicompost.*

Index terms: *Vermicomposting, Solid Waste Management*

1. INTRODUCTION

Solid waste is a major problem in developed and developing countries considering its obnoxious impact on environment. India is severely affected by improper waste collection at source, mismanagement and various cultural and social practices practiced since the time immemorial. Solid waste is defined as the organic and inorganic waste materials produced by different sources and have lost value in the eye of their owner. Municipal Solid Waste (MSW) in India typically contains 51% organic waste, 17% recyclables, 11% hazardous and 21% inert waste. However, about 40% of all MSW is not collected at all and hence lies littered in the city/town and finds its way to nearby drains and water bodies, causing choking as well as pollution of surface water. Unsegregated waste collection and transportation leads to dumping in the open, which generates leachate and gaseous emissions besides causing nuisance in the surrounding environment. Leachate contaminates the groundwater as well as surface water in the vicinity and gaseous emissions contribute to global warming. Solid wastes have the potential to pollute all the vital components of living environment (i.e., air, land and water) at local and at global levels. The problem is more acute in developing nations than in developed nations as the economic growth as well as urbanization is more rapid.

Different types of organic waste are available in India. Urbanization contributes enhanced MSW generation and its unscientific handling damages the environment causing health hazards. With the introduction of Solid Waste Rule, 2016 of the Ministry of Environment, Forest and Climate Change (MEF& CC), the Ministry of Urban Development (MUD) aimed to guide all urban areas in the country towards achieving sustainable municipal solid waste management (MSWM) system adopting the principle of waste minimization at source based on 3R principles, such as reduce, reuse and recycle with proper systems of collection, segregation, processing, transportation, and disposal. Municipal Solid Waste Management system in India is still not following its entire chain with full strength. According to the database of Swachh Bharath Mission (SBM) and State-wise status of implementation of various components under

SBM (up to September 2016) of the MUD, only 21.45 % of the MSW is treated, and the remaining is still going to the landfill (SBM 2016). According to Solid Waste Rule 2016, waste should be segregated by the generator and stored them in three separate streams namely domestic hazardous, bio-degradable, and non-biodegradable wastes in suitable bins. The segregated wastes should be handed over to the authorized waste pickers or waste collectors as per the direction or notification issued by the local authorities from time to time (Solid Waste 117 Rule 2016). Mainly municipalities are responsible for the collection of waste from door-to door. But, segregation component is one of the biggest challenges for Indian Municipal corporations. However, the majority of the urban local bodies (ULBs) do not have the capacity and appropriate action plan along with funds for execution and enactment of the Solid Waste Rule (CPCB, 2013).

Solid waste management systems cover all actions that seek to reduce the negative impacts on health, environment and economy. Developing countries are seriously facing the associated problems in collection, transportation and disposal of communal solid waste. Per capita, solid waste generation in developing countries is increasing annually due to an urbanization trend. Prototype and density of metropolitan areas, the physical composition of waste, density of waste, temperature and precipitation, scavenger's activity for recyclable separation, treatment capacity, insufficiency and limited resources are making tasks very tough for the administration authority in developing countries. Due to diverse life styles in communities, development authorities are not able to offer analogous type of solid waste management system for different communities. Open dumping, open burning and un-engineered sanitary landfills are common practice throughout the country.

Banana is an important food crop of India. We Indians use banana leaf for having food and it is a part of our culture. Besides, banana leaf waste is thrown out in huge amount from temples, markets, marriage halls, residential areas etc. It can be inferred from journals that high lignin content of banana leaf makes it little difficult for it to decompose (Alejangro et al., 2017). So it is important to give special attention towards the management of banana leaf waste. Guruvayur temple in Kerala, has been known to be an auspicious site for conducting marriages leaving behind about 20 MT (2008 estimate) of municipal solid waste. In general, of the municipal solid waste generated in India, about 40% consist of vegetables and leaves. But, here, out of the biodegradable portion of waste, the main constituent is banana leaves, which is used for serving lunch during marriages.(Govind et al., 2015). It is produced largely from hotels especially vegetarian hotels which are more in India. This project is thus intended to recycle banana leaf waste through vermicomposting.

India is slowly drowning in its own garbage. It is estimated that by 2030, the country will need a landfill almost as big as the city of Bengaluru to dump its waste. Urban areas alone generate around 62 million tonnes of garbage every single year, making India the third largest garbage generator in the world. However, the real issue is not waste generation but the fact that more than 45 million tonnes of waste in India remain untreated. There has been technological advancement for processing, treatment and disposal of solid waste. Energy-from-waste is a crucial element of solid waste management because it reduces the volume of waste from disposal and also helps in converting the waste into renewable energy and organic manure. Ideally, it falls in the flow chart after segregation, collection, recycling and before getting to the land fill. But many waste to energy plants in India are not operating to their full potential.

The biodegradable component of India's solid waste is currently estimated at a little over 50 per cent. It is believed that if we segregate biodegradable waste from the rest, it could reduce the challenges by half. Around 100 cities are set to be developed as smart cities. Civic bodies have to redraw long term vision in solid waste management and rework their strategies as per changing lifestyles. They should reinvent garbage management in cities so that we can process waste and not landfill it (with adequate provisioning in processing and recycling).To do this, households and institutions must segregate their waste at source so that it could be managed as a resource. Compost/ vermicompost pits should be constructed in every locality to process organic waste.

Banana leaf waste is a waste which creates so much nuisance, due to its improper collection and management. It can be seen littered on road sides, water bodies etc. and it takes more time for its proper degradation. The study is thus intended to findout the effect of vermicomposting on banana leaf waste which is a very common waste in India, especially in south India. The study incorporated the comparison of vermicomposting of both raw and dried banana leaf waste by varying the quantity of cowdung.

2 MATERIALS AND METHODS

2.1 Materials

2.1.1 Banana leaf waste

Banana leaf waste was taken from Guruvayoor Temple. Organic waste was removed and the leaf was then cleaned. Then it was cut into small pieces for vermicomposting

Earthworm

Inorder to achieve the objective, vermicomposting was done with exotic earthworm species, Eisenia Fetida which was collected from vermicomposting unit of Kerala Agricultural University, Mannuthy.

Dry Banana leaf waste

Dry Banana leaf waste was collected from banana plantation near Government Engineering College Thrissur.

2.2. Preparation of worm box

Wormbox is basically home for worms, and the place where they digest organic material. In this project,20 liter capacity plastic buckets was used as the feeding place for earthworms. Vermibeds were prepared with banana leaf waste with varying quantity of cowdung. Filtering unit was placed at the bottom of the wormbox for the collection of vermiwash.

2.3 Inoculation of Eartworms

100 numbers of young non-clitellate earthworms Eisenia fetida were introduced in the vermibeds. The moisture level of the containers was maintained around 35-40% throughout the study by sprinkling water. All containers were incubated in a humid and dark place at room temperature and were kept undisturbed and allowed to produce vermicast. They were covered by a net to avoid the escape of worms and to safeguard from pests. Turmeric powder was poured around the wormbox to avoid the disturbance of ants. Eisenia Fetida (commonly called as compost worm or red worm) is an epigeic worm and hence produces the castings on the surface the vermibed.

2.3 Experimental Procedure

2.3.1Experimental setup

Six feed mixtures having different ratios of banana leaf waste and cowdung, including banana waste alone was established. Total of 800 gram waste was put in each circular plastic container (volume 20 liter, diameter 30 cm, depth 40 cm). The composition of raw banana leaf (RBL) waste, dry banana leaf (DBL) waste and cowdung(CD) of first set of experiment in different treatments is given in Table.

Table 2.1 Various treatment units used in vermicomposting process

Treatment Units	Weights (g)	Ratio
Treatment 1 (T1)	800g RBL	1:0
Treatment 2 (T2)	600g RBL + 200g CD	3:1
Treatment 3 (T3)	400g RBL + 400g CD	1:1
Treatment 4 (T4)	800g DBL	1:0
Treatment 5 (T5)	600g DBL + 200g CD	3:1
Treatment 6 (T6)	400g DBL + 400g CD	1:1

Two controls were also prepared which contains only banana leaf waste i.e. without cowdung and earthworm. One contained 800 gram of raw banana leaf waste and other with 800 gram of dried banana leaf waste. Physico chemical analysis of control such as pH, Electrical Conductivity, Total Nitrogen, Total Phosphorous, Total Potassium and Total Organic Carbon were done inorder to compare the results with vermicompost.

RESULTS AND DISCUSSIONS.

3.1. Analysis of control Two controls were also prepared which contains only banana leaf waste i.e. without cowdung and earthworm. One contained 800 gram of raw banana leaf waste and other with 800 gram of dried banana leaf waste. Physico chemical analysis of control such as pH, Electrical Conductivity, Total Nitrogen, Total Phosphorous, Total Potassium and Total Organic Carbon were done inorder to compare the results with vermicompost.

Table 3.1: Analysis of control

Control	Total Weight Reduction	pH	Electrical Conductivity (dsm^{-1})	Total Nitrogen (%)
Raw banana leaves	11%	8.1	4.5	0.27
Dry banana leaves	6.1%	8.2	4.6	0.261
Control	Total Phosphorous (%)	Total Potassium (%)	Total Organic Carbon (%)	C:N Ratio
Raw banana leaves	0.14	0.128	23.2	85.92
Dry banana leaves	0.145	0.116	24.01	91.99

Analysis of parameters of vermicompost
Effect on duration

The duration of vermicomposting process varied with raw and dried banana leaf waste. The quantity of cowdung in vermicomposting also has a significant effect on duration.

Table 3.2 Effect on Duration

Treatment Units	Duration of vermicomposting (Days)
Raw banana leaf waste (RBL)	
T1(1:0)	50
T2(3:1)	47
T3(1:1)	42
Dry banana leaf waste (DBL)	
T4(1:0)	60
T5(3:1)	55
T6(1:1)	49

It is clear from the table that raw banana leaf waste vermicomposted much faster than raw banana leaf waste. Also, as the quantity of cowdung increased, the duration of vermicomposting decreased. This can be due to the presence of several cellulose and lignin degrading microbes in cowdung, which help in initial degradation of the agro-wastes. When earthworms are added, the worms first start feeding on the residual cow-dung and then go onto feed the agro-waste substrates and quickly convert them vermicompost and thereby decreasing total time for whole process.

Reduction in quantity of waste

Weight reduction is an important criteria in solid waste management. It can be inferred from journals that after vermicomposting about 50% of weight can be reduced. (Allan et al., 2015). In this project, after vermicomposting, final weights of all treatment units were measured and reduction of waste (percentage) was calculated.

Table 3.3 Reduction in weight after Vermicomposting

Treatment Units	Initial weight (leaf waste + CD) (g)	Final Weight (g)	Reduction in weight (g)
Raw banana leaf waste (RBL)			
T1(1:0)	800 + 0	455	43.12%
T2(3:1)	600+200	406	49.25%
T3(1:1)	400+400	360	55%
Dry banana leaf waste (DBL)			
T4(1:0)	800 + 0	472	41%
T5(3:1)	600+200	436	45.5%
T6(1:1)	400+400	380	52.5%

3.1.3. Effect on pH

As per the standard, after vermicomposting the range of pH must be 6.5 – 7.5. When control was analyzed the value of pH was obtained as 8.1 for raw banana leaf and 8.2 for dry banana leaf. All results were within limits after vermicomposting

Table 3.4 pH of different Vermicompost

Treatment Units	pH
Raw banana leaf waste (RBL)	
T1(1:0)	7.1
T2(3:1)	7.2
T3(1:1)	6.9
Dry banana leaf waste (DBL)	
T4(1:0)	7.0
T5(3:1)	7.1
T6(1:1)	7.1

Effect on Electrical conductivity

Table below shows the results on Electrical Conductivity of various treatment units. When comparing the results with control, which has an Electrical Conductivity of 4.5 for raw banana leaf waste and 4.6 for dry banana leaf waste, the conductivity of vermicompost decreased. The reduction in Electrical Conductivity indicates the utilization of soluble salts by microorganisms and earthworms.

Table 3.5. Electrical conductivity of different treatment units

Treatment Units	Electrical Conductivity (dsm^{-1})
Raw banana leaf waste (RBL)	
T1(1:0)	3.5
T2(3:1)	2.6
T3(1:1)	2.2
Dry banana leaf waste (DBL)	
T4(1:0)	3.4
T5(3:1)	3.1
T6(1:1)	2.5

Effect on Total Nitrogen

Total nitrogen in percent by mass were analyzed for vermicomposting units and was found to be within the limits. Also, Total Nitrogen increased after vermicomposting when compared with control.

Table 3.6 Total Nitrogen in percent by mass of total dry mass of different treatment units

Treatment Units	Total Nitrogen (%)
Raw banana leaf waste (RBL)	
T1(1:0)	0.80
T2(3:1)	0.912
T3(1:1)	1.01
Dry banana leaf waste (DBL)	
T4(1:0)	0.85
T5(3:1)	0.914
T6(1:1)	0.95

Effect on Total Phosphorous

Total Phosphorous in percent by mass were analyzed for vermicomposting units and was found to be within the limits. Also, Total Phosphorous increased for all treatment units after vermicomposting when compared with control.

Table 3.7. Total Phosphorous in percent by mass of total dry mass of different treatment units

Treatment Units	Total Phosphorous (%)
Raw banana leaf waste (RBL)	
T1(1:0)	0.36
T2(3:1)	0.42
T3(1:1)	0.495
Dry banana leaf waste (DBL)	
T4(1:0)	0.356
T5(3:1)	0.45
T6(1:1)	0.59

Effect on Total Potassium

Total Potassium in percent by mass were analyzed for vermicomposting units and was found to be within the limits. Also, Total Potassium increased for all treatment units after vermicomposting when compared with control.

Table 3.8 Total Potassium in percent by mass of total dry mass of different treatment units

Treatment Units	Total Potassium (%)
Raw banana leaf waste (RBL)	
T1(1:0)	0.484
T2(3:1)	0.641
T3(1:1)	0.679
Dry banana leaf waste (DBL)	
T4(1:0)	0.596
T5(3:1)	0.64
T6(1:1)	0.68

After vermicomposting, the NPK values of all treatment units were found to be increasing. The maximum value of Total Nitrogen, Total Phosphorous and Total Potassium was obtained in the treatment unit with maximum cowdung.

Total Organic Carbon

Total organic carbon (TOC) is a measure of the total amount of carbon in organic compounds. It has become an important parameter used to monitor overall levels of organic compounds present. TOC of both control and treatment units were measured. It was seen that TOC levels in the treatment unit was much less when compared with TOC of Control. Lower TOC of all the vermicomposts suggested enhanced oxidation of organic carbon, as the results of the increased microbial activity. Table 4.9 shows the TOC levels in different treatment units.

Table 3.9 Total Organic Carbon levels of different vermcompost

Treatment Units	TOC %
Raw banana leaf waste (RBL)	
T1(1:0)	15.1
T2(3:1)	17.51
T3(1:1)	18.14
Dry banana leaf waste (DBL)	
T4(1:0)	16.02
T5(3:1)	17.68
T6(1:1)	18.05

3.1.8 C:N Ratio

The C:N ratio is the mass of carbon to the mass of nitrogen in a particular substance. The C:N ratio is important because due to the fact that it has a direct impact on residue decomposition and also nitrogen cycling in our soils. According to Indian Standards, the maximum value of C:N ratio is limited to 20:1. For the control with raw banana leaf waste the C:N ratio was 85.92 and with dry banana leaf waste the ratio was 91.99. After vermicomposting, the C:N ratio for all treatment units was within the limits. The C/N ratios are far much reduced from its original state and the solid wastes have been recycled into a perfect vermicompost.

Table 3.10. C:N Ratio of different vermicompost

Treatment Units	C:N%
Raw banana leaf waste (RBL)	
T1(1:0)	18.87
T2(3:1)	19.19
T3(1:1)	17.96
Dry banana leaf waste (DBL)	
T4(1:0)	18.84
T5(3:1)	19.77
T6(1:1)	19

4. CONCLUSION

It can be concluded from the study that vermicomposting is a sustainable and economically viable method for treating banana leaf waste. Waste was effectively treated and converted into high quality manure by vermicomposting technology. Gradual increase in NPK values can be observed as the quantity of cowdung increases. It can also be observed that as the quantity of cowdung increased, the duration for vermicomposting process decreased. This can be due to the presence of several cellulose and lignin degrading microbes in cowdung, which help in initial degradation of the agro-wastes. When earthworms are added, the worms first start feeding on the residual cow-dung and then go onto feed the agro-waste substrates and quickly convert them vermicompost and thereby decreasing total time for whole process. Vermicomposting with raw banana leaf waste was faster when compared with vermicomposting of dry banana leaf waste. When comparing with Control, the Electrical Conductivity decreased after vermicomposting. The reduction in Electrical conductivity indicates the utilization of soluble salts by microorganisms and earthworms. Also, Total Organic Carbon showed lower results for all vermicomposts. This may be due to enhanced oxidation of organic carbon, as the results of the increased microbial activity. C:N for all treatment units were within the limits.

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REFERENCES

1. Ales, H., and Marketa, D. (2016) 'Effect of composting and vermicomposting on properties of particle size fractions', *Journal of Bioresource Technology,* 186-195
2. Ali, A., and Nadali, A. (2017) 'Investigating the efficiency of co-composting and vermicomposting of vinasse with the mixture of cow manure wastes, bagasse, and natural zeolite', *Journal of Waste Management,* 117-126
3. Anchal, S., and Rajiv, G. (2018) 'Impact of open dumping of municipal solid waste on soil properties in mountainous region' , *Journal of Rock Sciences and Geotechnical Engineering,* 47-51
4. Anup, J., and Goutham, K. (2018) 'Quantifying the relative role of phytase and phosphatase enzymes in phosphorus mineralization during vermicomposting of fibrous tea factory waste', *Journal of Ecological Engineering,* 97-103
5. Asha., and Thripathi, N. (2008) 'Vermicomposting: A Better Option for Organic Solid Waste Management', *Journal of Human Ecology,* 724-801
6. Azeem, K., Luqman R., Nida S., and Usman A., (2015), 'A review on vermicomposting of organic wastes' , *Environmental Process and Sustainable Energy,*. 434-441
7. Borah, M., and Mahanta P. (2007), 'Study of quality parameters in vermicomposting' , *Indian Journal of Biotechnology* , 1324-1336
8. David, A., Salustiano, M., (2017) 'Product quality and microbial dynamics during vermicomposting and maturation of compost from pig manure', *Journal of Environmental Management,* 498-507
9. Kui H., and Yongzhi C. (2018) 'Effects of earthworms on the fate of tetracycline and fluoroquinolone resistance genes of sewage sludge during vermicomposting', *Journal of Bioresource Technology,* Volume 32-39
10. Karthika, A., and Sreenivasagan, R. (2018) 'Investigation on paper cup waste degradation by bacterial consortium and *Eudrillus eugeinea* through vermicomposting', *Journal of Resources Conservation and Management,* Volume 74, pp. 174-188
11. Krishnakumar, Y., Neha, G., and Vinit, k. (2015), 'A review on current status of municipal solid waste management in India' ,*Journal of Environmental Sciences,* Volume 2, pp.69-78
12. Norman Q., and Peter B. (2005) 'Effects of vermicomposts produced from cattle manure, food waste and paper waste on the growth and yield of peppers in the field', *Journal of Ecological Engineering,* 297-306
13. Nuhaa S. (2018) 'Preliminary evaluation of pathogenic bacteria loading on organic

Municipal Solid Waste compost and vermicompost', *Journal of Environmental Management*, 763-767
14. Ramachandra. (2006), 'Management of municipal solid waste', *Commonwealth Of Learning*, 415-422
15. Satpal S., and Shyamala M. (2016), 'Sustainable Municipal Solid Waste Management in India: A Policy Agenda' , *Journal of Environmental Sciences*, 507-523
16. Surindra S. (2009), 'Vermicomposting of vegetable-market solid waste using Eisenia fetida : Impact of bulking material on earthworm growth and decomposition rate' , *Journal on Ecological Engineering*, 1564-1578
17. Sharholy. (2014) 'Municipal solid waste management in Indian cities – A review', *Journal of Waste Management*, 16-32
18. Shymala M., and Sing S. (2015) 'Sustainable Municipal Solid Waste Management in India: A Policy Agenda', *Journal of Environmental Sciences*, 150-157
19. Swati, A., Yadav, A., Garg, V K. (2012) 'Nutrient Recycling from Industrial Solid Wastes and Weeds by Vermiprocessing Using Earthworms', *Journal of Ecological Engineering*, 747-758
20. Subratha H., (2017) 'Fate and bioavailability of heavy metals during vermicomposting of various organic wastes—A review', *Journal of Safety and Environment*, 30-45
21. Yadav A., Yadav A., Garg V K., (2012) 'Nutrient Recycling from Industrial Solid Wastes and Weeds by Vermiprocessing Using Earthworms', *Journal of Ecological Engineering*, 747-758