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Research Article

MUNICIPAL SOLID WASTE AS THE PROSPECTIVE SUBSTRATE FOR EARTHWORM *EISENIA FETIDA* TO CONVERT WASTE INTO MANURE

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ABSTRACT

Organic wastes or bio-wastes are not "waste" but prospective bio-resources. Management of bio-waste by technical methods has become a burning issue in the present time**.** In the present study cow dung (CD), Mango litter (ML) and Municipal solid waste (MSW) was treated with earthworm *Eisenia fetida* in different mixture ratios of the substrate. Waste was converted into organic manure along with increase in biomass and number of earthworms. This is supposed to be due to the rich concentration of OC, N, P and microbial population.

Keywords: Cowdung, Municipal solid waste, *Eisenia fetida*, Organic manure, Mango litter.

INTRODUCTION

The history of vermitechnology, international, national and regional status of vermibiotechnology; species of earthworms and substrate for vermicomposting, appropriate environment to bring out the effective vermicomposting, useful microorganisms present in the vermicompost is discussed in this chapter. To determine the objectives of the present study various issues are discussed with reviewed literature. Waste is a discarded or useless material generated by various human and animal activities. Waste can often be a subjective concept, as some people's discard may have value to others. Hence sometimes it is said that "one man's trash is another man's treasure (Ananthavalli *et al*., 2019). The bio-wastes or the organic wastes include the wastes such as: industrial wastes, agricultural wastes, kitchen wastes, aquatic and terrestrial weeds, leaf litters, municipal solid wastes and certain other organic wastes. The quantity and quality of solid waste materials produced by human activities create waste disposal crisis which ultimately demands promising recycling or alternate ways for resource recovery. According to press information Bureau, India produces 62 million tonnes of waste per year with an average annual growth rate of 4% (PIB 2016).The generation of 10.11million tons of paper in India per year with an average increase of 2.6% of global paper production approximately produces 3.033 million tons of PMS per annum (Goel & Kalamdhad, 2017; WGR, 2011).PMS generated from paper mill industries need to be properly amended with several other organic materials, taking into account its poor nitrogen content and broad C/N ratio, for the production of compost (Simão *et al*., 2018), or vermicompost (Fernández-Gómez *et al*., 2015) with desirable qualities.

The agronomy industries also release unlimited quantities of organic waste while their operation. Normally these bio-wastes are thrown out in open areas which occupied large portion of cultivated land, gets decayed in the fields during rainy season causing environmental pollution and other health related risks. Open waste dumping decreases the fertility of land that could have been used for food production and hence pollutes soil, water and air (Prabha & Jayraaj, 2006). Fish and crop productivity is badly affected by terrestrial and aquatic weeds especially water hyacinth. Increased growth of population in urban areas in turn has increased the problem of municipal wastes. Domestic solid waste which is mostly organic contributes to about 70-80% to that of total solid urban waste (Suthar, 2007). On an average the municipal solid waste (MSW) collection in India is 72% and about 70% of the cities donot have enough waste transportation facilities (Singhal & Pandey, 2001). In India the traditional land filling and burning of

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large rural and urban bio-wastes is a long process and is associated with pathogenic microorganisms; land filling treatment is also dangerous which can lead to heavy metal pollution of soil and water sources; burning will directly affect the air and will lead to air pollution. In Asian countries the metropolitan population growth rate is approximately 4% per year. With this growth rate about 52% of Asian population will be living in city centres by 2025. In India the urban population growth will be 31.8% which is more than that of entire population of the US (census of India 2011). This crisis is more prominent in developing countries like in Asia and Africa (Allen, 1953). Per capita generation of municipal solid waste (MSW) has increased appreciably with better life style and social status of the urban populations. The disposal of these solid wastes requires more land, which is a high challenge in urban areas. The aim of the present study is to study the production of vermicompost and Growth and reproduction of earthworm *Eisenia fetida.*

MATERIALS AND METHODS

Municipal solid waste (MSW)

MSW was collected from Omakkulam dumping site, Chidambaram area of Cuddalore District, Tamil Nadu (India). After removing plastics, polythene, glass pieces and pebbles, MSW was brought to the laboratory and then dried for 2 days.

Cow dung

Cow dung is deemed as highly suitable natural feed for earthworms. Hence Cow dung (CD) is selected for the present study for the conversion of Municipal Solid Waste (MSW) into vermicompost. Cow dung in dried and powdered form was collected from the dairy farm at the faculty of agriculture, Annamalai University.

Mango litter

Mango litter was collected from Mango Orchard of Horticulture Department, faculty of Agriculture, Annamalai University,Annamalai Nagar Chidambaram. The collected mango litter was kept for pre- composting for one month. Then it was used for the preparation of bedding material (BM).

Pre-composting

The mango litter was put for pre-composting for about 30 days in cement tanks, allowed to get degraded by microbes and be suitable for earthworm to digest it. Then this pre-decomposed feed stock was subjected to vermicomposting for another 60 days by *E. fetida.*

Preparation of Bedding Material (BM)

The cow dung, one month pre-decomposed mango litter and dried MSW are then kept as such for 20 days and used for the preparation of substrate for vermiculture.

Preparation of different experimental media

Combinations of different substrate materials (MSW, CD and ML) to serve as experimental media were prepared in ten different proportions (Table 1).

Inoculation of earthworms

After the pre-composting process 15 grams (per kg of substrate) of (30 ± 2 *E.fetida*, each weighing about 500 ± 20 mg) sexually mature, clitellate *E. fetida* (52 – 55days old) were introduced in plastic buckets containing 3 kg substrate. The experiment was then maintained for a period of 60 days.

Growth and reproduction of *E. fetida*

Growth (biomass) and reproduction (cocoon and hatchling number) were observed and recorded at different time intervals such as 0^{th}, 20^{th},40^{th} and 60 days. The cocoons and hatchlings were counted by hand sorting method and the biomass of worms were weighed and recorded by using electronic balance.

Collection of vermicompost samples for analysis

The samples were collected from initial substrates (0-day) and vermi-composts on 20^{th}, 40^{th}, and 60^{th} days. The samples were taken in polythene bags for analysis in laboratory.

Statistical analysis

The mean biomass and reproduction (cocoon and hatchlings) was calculated by standard deviation (SD), percentage increase or decrease (final biomass) over initial values. The data was further analysed statistically (significance of difference of 0.05 levels) by using two-way analysis of variance (ANOVA).

RESULTS AND DISCUSSION

The growth (increase in biomass), cocoon production and hatchling of *Eisenia fetida* were observed on 20^{th}, 40^{th} and 60^{th} days in all the media including control. The results observed at the end are listed in (Table 1-3) and Figure 1 shows the changes in growth of *Eisenia fetida*. The variation in growth observed on the 60^{th} day in *E. fetida* is ranked in the following order with higher individual weight achieved in T1 treatment followed by T4, T2, T3, T8, T6, T7, T5 , T10 and T9 treatments. The maximum growth rate (mg worm^{-1}day^{-1}) for *E. fetida* was observed in T1 (14.30 ± 0.40) followed by T4 (12.70 ± 1.32), T2 (9.80 ± 2.00), T3 (9.05 ± 0.60), T8 (8.76 ± 1.10), T6 (8.16 ± 1.80), T7 (7.36 ± 0.50), T5 (7.15 ± 1.50), T10 (6.26 ± 1.10) and T9 (4.53 ± 2.10). The growth rate is considered as an excellent comparative index to compare the growth and biomass of earthworms in different substrate combinations during experimentation period.

Table 1. Experimental setup for vermicomposting of mango leaf litter and MSW along with cow dung.

Treatment No	Details of treatment.	Ratio of substrates	Quantity of wastes (kg).			
			Mango tree litter (ML)	Municipal solid waste(MSW)	Cow dung (CD)	Total
T1	CD (control)	1:0	0	0	3	3
T2	ML+CD	1:1	1.5	0	1.5	3
T3	MSW+CD	1:1	0	1.5	1.5	3
T4	ML+MSW+CD	1:1:1	1	1	1	3
T5	ML+MSW	1:1	1.5	1.5	0	3
T6	ML+CD	2:1	2.0	0	1.0	3
T7	MSW+CD	2:1		2.0	1	3
T8	ML+MSW+CD	2:2:1	1.2	1.2	0.6	3
T9	ML+MSW	2:1	2	1	0	3
T10	ML+MSW	1:2	1	2	0	3

T1-T10 is the substrates used for *E. fetida* in different ratios. After the preparation of substrates in different proportions, water was sprinkled and kept as such for 20 days.

Table 2. Individual biomass and growth rate in different substrate treatments.

Treatment	Initial biomass (worm^{-1} mg)	Max. weight achieved (worm^{-1} mg)	Net weight achieved	Mean biomass
T1	555±3.20	998±2.50	443±1.10	14.30±0.40
T2	543±2.10	845±2.11	294±1.13	9.80±2.00
T3	551±3.00	823±3.22	287±1.10	9.05±0.60
T4	536±3.50	924±3.25	381±1.22	12.70±1.32
T5	547±2.10	750±1.50	218±1.15	7.15±1.50
T6	551±1.50	796±3.44	245±1.12	8.16±1.80
T7	549±1.20	770±2.11	221±1.13	7.36±0.50
T8	532±3.50	810±1.80	263±1.00	8.76±1.10
T9	544±2.30	690±1.50	136±1.50	4.53±2.10
T10	554±1.90	732±2.10	188±1.25	6.26±1.10

Mean values followed by different letters are statistically different (ANOVA, Tukey’s t test $P<0.05$.

Table 3. Number of cocoons and hatchlings produced by *Eisenia fetida* during the vermicomposting period.

Treatment	Total no. of cocoons	Total no. of hatchlings	Cocoon produced per worm per day
T1	60.4±4.60	76.6±1.20	2.01±0.10
T2	50.5±3.00	54.5±2.50	1.68±0.15
T3	44.7±1.50	49.1±1.30	1.49±0.05
T4	51.8±2.10	51.8±2.10	1.71±0.22
T5	36.1±3.30	39.5±2.40	1.20±0.25
T6	41.6±3.50	45.2±1.20	1.38±0.65
T7	38.7±2.30	41.1±2.10	1.29±0.09
T8	44.2±1,20	46.1±1.35	1.47±0.10
T9	30.1±4.50	32.6±2.30	1.00±0.20
T10	34.2±2.20	36.8±3.50	1.14±0.32

*Results are reported as mean ± standard deviation; mean values followed by different letters are statisticallydifferent (Tukey’s t test $P<0.05$).

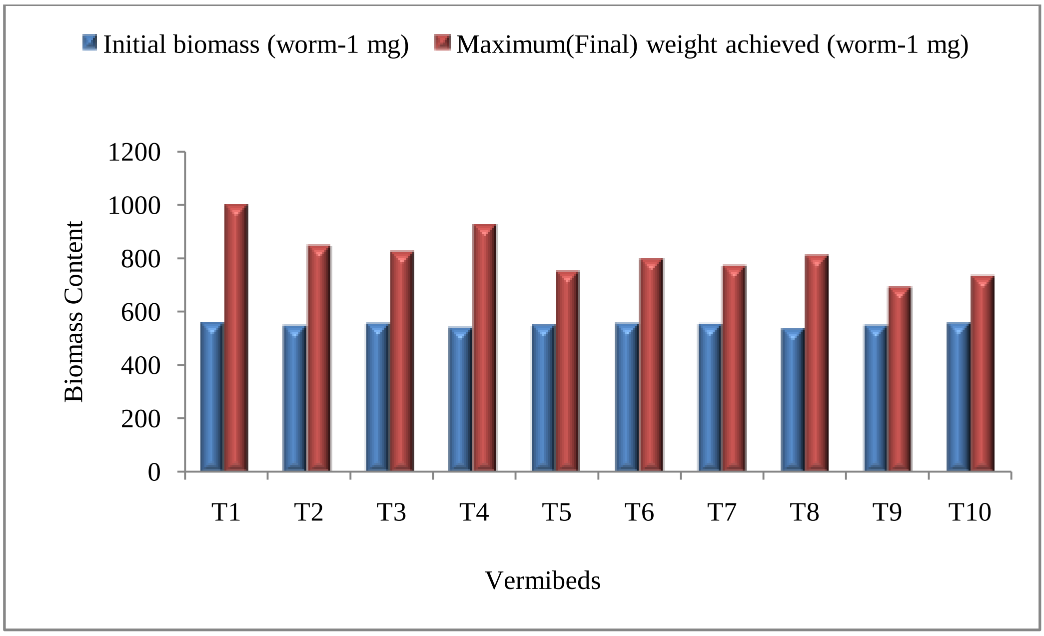

Figure 1. Initial and final biomass of *Eisenia fetida* in different substrate treatments.

The maximum gain in biomass and growth rate in treatments may be due to the palatableness and acceptability of the substrates by *E. fetida*, however the minimum biomass in the treatments with higher proportion ML was probably due to the less organic carbon content and other growth supporting substances. The result from the present work, in the context of change in individual weight of earthworms with the stocking density confirms the results of various other researchers (Tamizhazhagan *et al*., 2016; Tripathi & Bhardwaj, 2004). The difference in growth rate among different treatments in the present study seems to be closely related to the quality of organic waste. The cocoon production in *Eisenia fetida* differed among different treatments and maximum number of cocoons obtained at the end (Table 3.2.)Were in T1 (60.4 ± 4.6), T4 (51.8 ± 2.1), T2 (50.5 ± 1.5), T3 (44.7 ± 2.3), T8 (44.2 ± 3.0), T6 (41.6 ± 2.2), T7 (38.7 ± 1.2) T5 (36.1± 3.3), T10 (34.2 ± 3.5) and T9 (30.1 ± 4.50). Cocoon production ($worm^{-1}$) and reproduction rate (cocoon $worm^{-1}day^{-1}$) varied significantly among different treatments ($p<0.05$).

The hatchling production of *E.fetida* is listed in Table - 3.2. Hatchlings were recorded on 20th day,40th day and 60th day in all the treatments, the hatchlings number were found to be increasing upto 60th day. The number of hatchlings at the end were recorded to be highest in T1 (76.6 ± 1.2) followed by T4 (60.1 ± 2.1), T2 (54.5 ± 1.3), T3 (49.1 ± 2.1), T8 (46.1 ± 2.5), T6 (45.2 ± 3.5), T7 (41.1 ± 2.4), T5 (39.5 ± 1.2), T10 (36.8 ± 3.50) and T9 (32.6 ± 2.30) respectively. Consequently, the observed results of this study also suggested that higher proportions of ML with MSW and CD alone in the treatments were not much suitable for growth and reproduction for *Eisenia fetida*. Therefore it may be concluded that production of cocoons in different substrate mixtures during vermicomposting could be directly related to the quality of the substrate. The present study reveals that biochemical characteristics of substrate stock may be of primary importance for rearing of earthworms on different organic waste resources. So, the difference in cocoon and hatchlings production among the treatments for both worms could be due to variation in quality of the substrate combinations (Suthar, 2007). Dominguez *et al*., (2001) proposed that pre-composting of the substrate is also an essential requisite to avoid the earthworm mortality during vermicomposting. In the present study, the earthworm mortality was higher in the treatments, which contained more proportion of ML or100%of ML. The data suggests that the mixing of some other materials (e.g. CD and MSW) in ML before vermicomposting not only enhanced the rates of decomposition but at the same time also decreased the rate of worm mortality during decomposition process. Vermicomposting provides the production patterns of earthworm growth (biomass) and number of cocoons. Vermicomposting results in the transformation of a portion of organic matter into biomass of earthworms and respiratory products, and release some of the ingested material as partially stabilized vermicompost. Growth rate, cocoon and hatchlings production of *E. fetida* in the treatments were recorded periodically for 60 days. The significant changes in growth and reproduction in all the substrate treatments for *E. fetida* over the studied period of 60 days are illustrated in Table 3.1. Generally *E. fetida* showed significant ($P<0.05$) differencein production of biomass and reproduction potential i.e., maximum biomass achieved, biomass gain (mg worm-1), growth rate (mg worm-1day-1), total number of cocoons, total hatchlings number and reproduction rate (cocoon worm^{-1}day^{-1}) among different treatments. The growth rate is considered as an excellent comparative index to compare the growth and biomass of earthworms in different substrate combinations during experimentation period. The maximum gain in biomass and growth rate in treatments may be due to the suitability and acceptability of the substrates by *E. fetida*, however the minimum biomass in the treatments with higher proportion of ML was probably due to the less organic carbon content and other growth supporting substances. The difference in growth rate among different treatments in the present study seems to be closely related to the quality of organic waste.

The cocoon production and hatchling numbers in *Eisenia fetida* differed among different treatments and maximum number of cocoons obtainedattheendwereinT1 followed by T4,T2, T3, T8, T6, T7, T5, T10, and T9. Similarly, total numbers of hatchlings were recorded in T1, T4, T2, T3, T8, T6, T7, T5, T10, and T9. The observed results of this study also suggested that higher proportions of ML with MSW and CD alone in the treatments were not much suitable for growth and reproduction for *Eisenia fetida*. Therefore it may be concluded that production of cocoons in different substrate mixtures during vermicomposting could be directly related to the quality of the substrate. The present study reveals that biochemical characteristics of the substrate are important for rearing of earthworms on different organic waste resources (Aira *et al*., 2006). So, the difference in cocoon and hatchlings production among the treatments for both worms could be due to variation in quality of the substrate combinations (Suthar, 2007). Brintha *et al*., (2015) suggested that the highest growth and reproduction of *Perionyx excavatus* was recorded in T2 (20% +80%) MSW mixed with HD (Horse dung) than the other treatments. This could be due to the presence of more generous quantity of organic materials. In the present study, the earthworm growth was lesser in the treatments, which contained more proportion of ML or100%of ML. The data suggests that the mixing of some other materials (e.g. CD and MSW) in ML before vermicomposting not only enhanced the rates of decomposition but at the same time also enhanced the rate of worm growth during decomposition process. (Jayakumar *et al*., 2018) reported that after the adding of PM and CD in appropriate quantities to the PD, it can be used as a raw material in the vermicomposting using *E.eugeniae* and *E. fetida* for nutrients recovery for organic forming.

CONCLUSION

The growth and reproduction rate of *E. fetida* was increased in all the MSW, ML and CD substrate mixtures. This is supposed to be due to the rich concentration of OC, N, P and microbial population. The present study reveals that biochemical characteristics of substrate stock may be of primary importance for rearing of earthworms on different organic waste resources. So, the difference in cocoon and hatchlings production among the treatments for both worms could be due to variation in quality of the substrate combinations.

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REFERENCES

Aira, M., Monroy, F., & Domínguez, J. (2006). *Eisenia fetida* (Oligochaeta, Lumbricidae) activates fungal growth, triggering cellulose decomposition during vermicomposting. *Microbial Ecology, 52*(4), 738-747.

Allen, O. (1953). Experiments in soil bacteriology in 1st Ed: Burgess Pub. Co. Minneapolis. U.S.A. 127.

Ananthavalli, R., Ramadas, V., Paul, J. A. J., Selvi, B. K., & Karmegam, N. (2019). Vermistabilization of seaweeds using an indigenous earthworm species, Perionyx excavatus (Perrier). *Ecological Engineering, 130*, 23-31.

Brintha, N., Srijayam, M., Elampharithi, V., & Manimegala, G. (2015). Utilization of municipal solid waste mixed with horse dung by using earthworm *Perionyx excavates*. *International Journal of Advanced Research in Biological Sciences, 2*(3), 295-300.

Dominguez, J., Edwards, C. A., & Dominguez, J. (2001). The biology and population dynamics of Eudrilus eugeniae (Kinberg)(Oligochaeta) in cattle waste solids. *Pedobiologia, 45*(4), 341-353.

Fernández-Gómez, M. J., Nogales, R., Plante, A., Plaza, C., & Fernández, J. M. (2015). Application of a set of complementary techniques to understand how varying the proportion of two wastes affects humic acids produced by vermicomposting. *Waste Management, 35*, 81-88.

Goel, G., & Kalamdhad, A. S. (2017). An investigation on use of paper mill sludge in brick manufacturing. *Construction and Building Materials, 148*, 334-343.

Jayakumar, V., Murugan, S. S., & Manivannan, S. (2018). Biodyanamics of epigeic earthworm Eudrilus eugeniae and Eisenia fetida during recycling of poultry waste amended with different organic food sources. *International Archives of Science and Technology, 9*(4), 46-51.

Prabha, M. L., & Jayraaj, I. A. (2006). Comparative studies on the levels of vitamins during vermicomposting of fruit wastes by *Eudrilus eugeniae* and *Eisenia fetida*. *Applied Ecologyand Environmental Research*.5(1),57-61.

Simão, L., Hotza, D., Raupp-Pereira, F., Labrincha, J., & Montedo, O. R. K. (2018). Wastes from pulp and paper mills-a review of generation and recycling alternatives. *Cerâmica, 64*, 443-453.

Singhal, S., & Pandey, S. (2001). Solid waste management in India: status and future directions. *Information Monitor on Environmental Science, 6*(1), 1-4.

Suthar, S. (2007). Nutrient changes and biodynamics of epigeic earthworm *Perionyx excavatus* (Perrier) during recycling of some agriculture wastes. *Bioresource Technology, 98*(8), 1608-1614.

Tamizhazhagan, V., Pugazhendy, K., Sakthidasan, V., Revathi, K., & Baranitharan, M. (2016). Investigation of microbial count in the soil and earthworm gut (*Eudrilus Eugeniae*). *Innovare Journal of Agricultural Sciences, 4*(3), 7-9.

Tripathi, G., & Bhardwaj, P. (2004). Comparative studies on biomass production, life cycles and composting efficiency of Eisenia fetida (Savigny) and *Lampito mauritii* (Kinberg). *Bioresource Technology, 92*(3), 275-283.

WGR. (2011). Working Group Report on Pulp and Paper Sector for 12th Five Year Plan.