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Bioconversion of Municipal Solid Waste by the Earthworm *Eudrilus eugeniae* (Kinberg)

Sriramulu Ananthakrishnasamy* **and Govindarajan Gunasekaran**
Department of Zoology, Annamalai University, Annamalai Nagar – 608 002, Tamil Nadu, INDIA

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Abstract

Rapid urbanization, industrialization and agricultural practices have led to dumping of organic solid wastes caused a serious threat to the environment. In the present investigation an attempt has been made to convert the municipal solid waste (MSW) into manure by the earthworm Eudrilus eugeniae under laboratory conditions. The experimental media were prepared on dry weight basis by mixing the municipal solid waste and bedding material (BM); E_1 – 20% BM + 80% MSW, E_2 – 40% BM + 60% MSW, E_3 – 60% BM + 40% MSW, E_4 – 80% BM + 20% MSW, controls (BM alone – C) were also maintained. The growth rate (biomass) and reproduction (number of cocoons and number hatchlings) of E. eugeniae was increased in all experimental media BM + MSW mixtures (E_1 – E_4) and control (C). The result showed that the unutilized and enormously available MSW can be vermicomposted into valuable organic manure that can be utilized for sustainable agriculture.

Keywords: Bedding material, municipal solid waste, *Eudrilus eugeniae,* Cocoons, Hatchlings.

Introduction

A rapid development in industries and growth in population in India has released to generate thousand tons of municipal solid waste (MSW) every day. Solid waste management (SWM) is a major environmental problem of our countries. India produces around 3000 million tonnes of organic wastes annually[1]. The processing of MSW by vermicomposting is an eco-friendly approach result in the production of organic fertilizr. The growth (biomass) and reproduction (cocoons and hatchlings) of earthworm in different culture media such as mixture of animal and vegetable wastes[2]; kitchen waste[3]; animal wastes[4]; water hyachinth[5]; different organic wastes[6]; baggase (sugar industrial waste)[7] were studied. The survey of literature indicated that reports on growth and reproduction are available more on organic wastes but information about growth and reproduction of earthworm on municipal solid waste (MSW) are scanty. Hence it was aimed to study the growth and reproduction of earthworm and which will help us to have an idea about best combination of bedding material (BM) with MSW.

Material and Methods

The breeding stocks of *Eudrilus eugeniae* were maintained in the Department of Zoology, Annamalai University. Cow dung was used as substrate to maintain the adult worms; moisture content of 60 – 70% was continuously maintained by sprinkling water on the stock culture of the cement tank. This stock culture in the cement tank were covered with gunny bag and maintained at room temperature (27± 2°) inside the animal house. MSW was collected from Sethiathope town Panchayat, Cuddalore District, Tamil Nadu. After removing the plastics, polythene, metal scraps and glass pieces MSW was dried and brought by using jute bags to the laboratory. Urine and straw free cow dung was collected from dairy yard at the Faculty of Agriculture, Annamalai University. It was sun dried, powdered and stored in jute bags. The pressmud was collected from M.R.K Co-operative Sugar Mill, Sethiathope. The collected pressmud was cured for a month to remove the odour. Then it was used for the preparation of Bedding Material (BM). The cow dung and one month old cured pressmud was used for the preparation of bedding material and they were equally mixed on dry weight basis and kept as such for 15 days and used for the preparation of substrate for vermiculture.

Combinations of bedding material and municipal solid waste in four proportions were prepared in the following orders: C – BM (Bedding material) alone (Control) 500 gram CD + 500 gram PM + 200 gram soil; 1. E_1 - 20% + 80% (BM + MSW) 200g BM + 800g MSW + 200g soil; 2. E_2 - 40% + 60% (BM + MSW) 400g BM + 600g MSW + 200g soil; 3. E_3 - 60% + 40% (BM + MSW) 600g BM +400g MSW+ 200g soil; 4. E_4 - 80% + 20% (BM + MSW) 800g BM + 200g MSW+ 200g soil mixed W/W. After the preparation of substrates in the above different proportions, water was sprinkled and kept as such for thermophilic composting for 15 days.

After the completion of thermophilic composting fifteen grams of sexually mature, clitellate *Eudrilus eugeniae* (approx. 38 days old) were introduced in plastic troughs separately; containing 1 Kg substrate + 200 g of soil. Bedding material alone was used as control, separately for *E. eugeniae* as C. Six replications in each experimental treatment have been maintained for 60 days. Earthworm's growth (biomass) and reproduction (Cocoon and

hatchling number) were recorded in different time intervals like 15, 30, 45 and 60 days. Every time cocoons and hatchlings were counted by hand sorting and the biomass of worms were weighed using electronic balance and recorded. For earthworm's mean biomass and reproduction (cocoon and hatchlings) standard deviation (SD), percentage increase or decreases (final biomass) over initial values were calculated. Further, the data were analyzed statistically (significance of difference of 0.05 levels) by using two - way analysis of variance, (ANOVA).

Results and Discussion

Growth (biomass) and reproduction (cocoon and hatchling) of *E. eugeniae* cultured on different feed substrates are given in table – 1 to 3. Table - 1 shows the obtained values of growth (biomass) of *E. eugeniae* in different treatment media over the study period. Initially all the experimental media *i.e*. C, E_1, E_2, E_3 and E_4 more or less 15 g of worms were weighed and inoculated. Thereafter the growth rate was gradually increased on 15^{th}, 30^{th}, 45^{th} and 60^{th} day. The maximum growth rate was recorded in E_3 (18.1 ± 1.19) followed by C (17.2 ± 1.12), E_4 (16.9 ± 1.12), E_2 (16.2 ± 1.21) and E_1 (15.7 ± 1.16) respectively on 15^{th} day. The growth rate was steadily increased upto 60^{th} day. The highest growth rate was obtained on 60^{th} and it was recorded in E_3 (24.7 ± 1.15), followed by C (22.4 ± 0.94), E_4 (20.9 ± 1.18), E_2 (19.9 ± 1.14) and E_1 (18.8 ± 0.99) respectively. Among the treatments the highest growth was recorded in E_3 and least growth was recorded in E_1. The present study clearly indicated that the growths of *E. eugeniae* were found in the following order: E_3> C > E_4 > E_2 > E_1.

The production of cocoons by *E. eugeniae* in different feed substrates are presented in table - 2. The adult clitellate worms started to produce of cocoons and they were found on 15^{th} day in all treatments. On 15^{th} day the maximum number of cocoons were recorded in E_3 (10.4 ± 0.90) and followed by C (9.1 ± 1.15), E_4 (8.2 ± 1.23), E_2 (7.6 ± 0.90) and E_1 (7.2 ± 0.95) respectively. The cocoons production was gradually increased after 15^{th} day till 60^{th} day. (*i.e.* end of the experimental period). The highest production of cocoons were recorded on 60^{th} day in E_3 (20.5 ± 1.16) followed by C (18.7 ± 1.19), E_4 (16.3 ± 1.14), E_2 (14.4 ± 1.17) and E_1 (13.6 ± 1.21). More number of cocoons were observed in E_3 (60.4) and least was observed in E_1 (39.6). The production of cocoons were in the order: E_3 > C > E_4 > E_2 > E_1.

The production of hatchlings of *E. eugeniae* are presented in table - 3. Hatchlings were observed on 30^{th} day in all treatments. From 30^{th} day to 60^{th} day the hatchling numbers were increased. More number of hatchlings were recorded in E_3 (19.9 ± 1.10), followed by C (17.7 ± 1.12), E_4 (15.8 ± 0.99), E_2 (14.5 ±1.11) and E_1 (13.0 ± 1.18) on 30^{th} day. Thereafter 45^{th} day also increased gradually. On 60^{th} day the numbers of hatchlings obtained were 32.3 ± 1.17 in E_3, 23.8 ± 1.36 in C, 21.4 ± 1.18 in E_4, 19.2 ± 1.25 in E_2 and 17.9 ± 1.21 in E_1 respectively. Among all the treatments the highest production of hatchlings were found in E_3 (76.6).

Table-1
Growth of *E. Eugeniae* during the vermicomposting of MSW (p<0.05)

Substrate Proportions	*E. eugeniae*				
	Vermicomposting Days				
	0 (Initial)	15	30	45	60
C	15.0±1.17	17.2±1.12	19.7±1.11	21.4±1.18	22.4±0.94 (49.33)
E_1	15.2±1.27	15.7±1.16	17.1±0.95	18.0±1.19	18.8±0.99 (23.68)
E_2	15.1±1.19	16.2±1.21	17.9±0.98	19.2±1.14	19.9±1.14 (31.79)
E_3	14.9±0.95	18.1±1.19	21.4±0.99	23.5±1.19	24.7±1.15 (65.77)
E_4	15.3±1.23	16.9±1.12	19.2±1.19	20.3±1.12	20.9±1.18 (36.60)

ANOVA

Analysis of variance	Sum of square	Df	Mean of square	F-value	P-value
Rows	37.748	4	9.437	9.561297	0.00038
Columns	133.32	4	33.33	33.769	1.29E-07
Error	15.792	16	0.987		

C – Control (BM alone), E_1 – (20% BM + 80% MSW), E_2 – (40% BM + 60% MSW), E_3 – (60% BM + 40% MSW), E_4– (80% BM + 20% MSW), Initial (0) – Worm unworked substrates, Mean ± SD of six observations, (+/–) – Percent change of increase or decrease over the initial.

Table-2
Cocoons laid by *E. eugeniae* during the vermicomposting of MSW (p<0.05)

Substrate Proportions	*E. eugeniae*					
	Vermicomposting Days					
	0 Initial	15	30	45	60	Total No. of Cocoons
C	-	9.1±1.15	10.3±0.98	13.6±0.90	18.7±1.19	51.7
E_1	-	7.2±0.95	8.7±1.14	10.1±1.17	13.6±1.21	39.6
E_2	-	7.6±0.90	8.7±1.12	10.8±1.12	14.7±1.17	41.8
E_3	-	10.4±0.90	12.6±1.19	16.9±1.16	20.5±1.16	60.4
E_4	-	8.2±1.23	9.0±1.14	11.2±1.20	16.3±1.14	44.7

ANOVA

Analysis of variance	Sum of square	Df	Mean of square	F-value	P-value
Rows	71.673	4	17.91825	23.57923	1.31E-05
Columns	198.626	3	66.20867	87.12622	2.06E-08
Error	9.119	12	0.759917		

C – Control (BM alone), E_1– (20% BM + 80% MSW), E_2 – (40% BM + 60% MSW), E_3 – (60% BM + 40%, MSW), E_4– (80% BM + 20% MSW), Initial (0) – Worm unworked substrates, Mean ± SD of six observations, (+/–) – Percent change of increase or decrease over the initial.

Table-3
Hatchlings of *E. eugeniae* during the vermicomposting of MSW (p<0.05)

Substrate Proportions	*E. eugeniae*				
	Vermicomposting Days				
	15	30	45	60	Total No. of Hatchlings
C	0	17.7±1.12	18.6±0.97	23.8±1.36	60.1
E_1	0	13.0±1.18	15.2±1.21	17.9±1.21	46.1
E_2	0	14.5±1.11	15.4±1.25	19.2±1.25	49.1
E_3	0	19.9±1.10	24.4±1.24	32.3±1.17	76.6
E_4	0	15.8±0.99	17.3±1.20	21.4±1.18	54.5

ANOVA

Analysis of variance	Sum of square	Df	Mean of square	F-value	P-value
Rows	145.212	4	36.303	6.190473	0.006099
Columns	1486.908	3	495.636	84.51702	2.45E-08
Error	70.372	12	5.864333		

C – Control (BM alone), E_1 – (20% BM + 80% MSW), E_2 – (40% BM + 60% MSW), E_3 – (60% BM + 40% MSW), E_4– (80% BM + 20% MSW), Initial (0) – Worm unworked substrates, Mean ± SD of six observations.
(+/–) – Percent change of increase or decrease over the initial.

In the present investigation it was clearly observed that the highest growth and reproduction was observed in *E. eugeniae* and it showed the maximum growth rate in E_3. The growth of earthworm are depend on the quality of the available food, adequate temperature and moisture found[8]. The attainment of sexual maturity in *E. eugeniae* was reported between 35 - 49 days[9] and between 35 - 45 days cultured on cattle manure[10]. The production of cocoons in *E. eugeniae* at the age of 46 days at 25^0C in fresh urine free cattle manure[11]. A linear relationship with size of the worm and cocoon size were noted[12]. Growth and reproduction in earthworms require OC, N and P which is obtained from litter, grit and microbes[13]. The N - content played a major role in the biomass gain and hatchlings success but not have affected the cocoon production[14].

The higher feeding rate of *E. eugeniae*, they had higher reproductive potential of 17 cocoons and 550 juveniles per 100g of compost in 41 days exceeded that for *L. mauritii* of 7 cocoons and 400 juveniles in 56 days reported[15]. Comparing our results with others in literature, the *E. eugeniae* was able to produce more number of cocoons and hatchlings in E_3 which are considered to be the best combination for the earthworm respectively. The reason for higher growth and reproductive rate shown by the earthworm *i.e.* in E_3 by *E. eugeniae* in the present study might by due to i. Rich in nitrogen and phosphorus in the experiment (E_3), ii. Highest microbial population, iii. Increased enzymatic activity which enables the earthworm for their suitability. The above results clearly suggest that the incorporation of bedding material (Pressmud and Cowdung) in

an appropriate ratio not only increases the selective palatability but also enhances the growth and reproduction of earthworms. The mixing of BM increased the suitability of MSW as feed substrate for microbes and earthworms[16].

Conclusion

The over population and industries in developed and developing countries have led to the production of large volumes of municipal solid waste (MSW). Earthworms have successful development in cow dung (CD) and pressmud (PM), hence in the present study the bedding material (BM) was prepared from CD and PM and mixed with MSW in different proportions to facilitate the earthworms to decompose the MSW. The growth rate (biomass) and reproduction (number of cocoons and hatchlings) of *E. eugeniae* were increased in all experimental media BM + MSW mixtures (E_1 –E_4 and control C), particularly the maximum growth and reproduction were observed and recorded in E_3 (60% BM + 40% MSW) by *E. eugeniae*.

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