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ORIGINAL ARTICLE

VERMICOMPOSTING OF MUNICIPAL SOLID WASTE USING AN EARTHWORM *PERIONYX EXCAVATUS*

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ABSTRACT

The production of Municipal solid waste (MSW) now – a – days shows a remarkable increase with varying characteristics due to ever increasing population and anthropogenic activities and MSW management has became an important issue when its safe disposal is concerned. MSW was vermicomposted in combination with goat manure (GM) using *P. excavatus* for 60 days. The growth and reproduction were observed at the interval of 15 days. The growth rate and reproduction was increased in all experimental media particularly in T_7 mixture and control. This result showed that the nutrient content (NPK) significantly increased in MSW vermicompost.

Keywords: Municipal solid waste, Goat manure, *P. excavatus*, Growth, Reproduction and Nutrient contents.

1.INDRODUCTION

Rapid urbanization, industrialization and agricultural practices have led to dumping of organic solid wastes caused a serious threat to the environment. The management of MSW requires proper infrastructure, maintenances and improvement of all activities. The difficulties in providing the desired level of public service in the urban centres are often attributed to the poor financial status of the managing municipal corporation (Mor *et al*., 2006). The processing of MSW by vermicomposting is an eco – friendly approach result in the production of organic fertilizer. Animal waste are considered as important resources that fertilizer crop fields, enhancement organic matters and improve soil conditions, but are a source of environment pollution too. In India the live stock dung are produced annually million of tons as the rate of goat manure 0.70 kg animal^{-1} day^{-1} (Garg *et al*., 2006).

Many studies have been made on the vermicomposting of different waste include cattle dung (Kaushik and Garg, 2003), horse waste (Hartenstein *et al*., 1979 and Darani *et al*., 2010), leaf litters (Karmegam and Daniel, 2000 and Manimegala *et al*., 2008) and fly ash (Sarojini *et al*., 2009 and Manimegala *et al*., 2009) etc. Few studies are available on total MSW management through vermicomposting. They are confined only along with cow dung i.e., MSW + CD using *L. mauritii* and *E. fetida* (Kaviraj and Sharma, 2003); market waste + cow dung (Karthikeyan *et al*., 2007); MSW + CD using *P. ceylanensis* (John paul *et al*., 2011), MSW + bedding materials using *L. mauritii* (Ananthakrishnasamy and Gunasekaran, 2014) and cow dung and Sugar Industry Waste using *E. eugeniae, P. excavatus and E. fetida. Earthworm* (Umamaheswari and Suresh, 2015). Hence the present attempt was made to vermicompost the MSW using *P. excavatus* along with goat manure to evaluate the quantity of nutrient content and the growth of earthworms.

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2.MATERIALS AND METHODS

A). Municipal solid waste (MSW)

MSW was collected from sethiathope town panchayat, Cuddalore (dt), Tamilnadu, in India. After removing the glass pieces, metals, plastics and polythene covers. MSW was dried and brought by using jute bags to the laboratory.

B). Goat manure (GM)

The fresh GM was collected from dairy yard at the Faculty of Agriculture, Annamalai University, Chidambaram, Tamilnadu. It was sun dried, powered and stored in jute bags.

C). *Perionyx excavatus*

P. excavatus was obtained from stock culture of our Vermi-biotechnology division, Department of Zoology, Annamalai University. The worms were adapted to laboratory conditions before inoculating into each plastic trough. 15 g of sexually mature *P. excavatus* were used for this study.

D). Experimental plan

The duration of the experimental period was 60 days. Six vermicomposting treatments were recognized having different proportions of MSW and GM. The feed substrate that has

been subjected to thermophilic pre-composting 15–20 days prior to vermicomposting. 15 g of earthworms were introduced in 100% (dry weight basis) of feed mixture. The composition of feeds in different substrate proportions was given below:

Treatments	Proportions	Weight (g)
C-Control	GM	100%
T_6- MSW+GM	1:9	10%+90%
T_7- MSW+GM	2:8	20%+80%
T_8- MSW+GM	3:7	30%+70%
T_9- MSW+GM	4:6	40%+60%
T_{10}- MSW+GM	5:5	50%+50%

Each vermicompost was established in six observations. All the samples were kept in dark place at a laboratory temperature of 25-29°C. The moisture content was maintained at 70±10% by periodic sprinkling of tap water throughout the study period and by covering the vermicompost with jute clothes. During the study period no extra feed added at any stage. The worm biomass (g) was weighed in an electronic balance. The growth and reproductive parameters like biomass, number of cocoon production and number of hatchlings were counted once in 15 days by hand sorting. Then all the weighted earthworms were transferred to their respective experimental treatments.

E). Nutrient contents of vermicompost

The newly formed vermicomposts from all the experimental plastic containers were collected after 15th, 30th and 60th day and air-dried, weighed, sieved and stored in polythene bags for nutrient analysis. The total NPK content of the composts were estimated by Kjeldhal method, calorimetric method and flame photometry method, respectively, according to the standard method of Tandon (1993).

F). Statistical analysis

Earthworm mean biomass, reproduction, NPK, standard deviation (SD), percent increase or decreases 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).

3.RESULTS

Growth and reproduction of *P. excavatus*

The growth (biomass) and reproduction (cocoon and hatchlings) of *P. excavatus* cultured on different feed substrates are given in Table – 1 to 3. Table – 1 show the obtained values of growth of earthworms, the biomass gradually increased up to 60th day in all proportions. Among these experimental ratios T_7 shows higher biomass and was followed by C, T_6, T_8, T_9 and T_{10}. The maximum growth rate was recorded in T_7 (24.16±1.76g), it was followed by C (23.45±1.12g), T_6 (22.71±1.45g), T_8 (20.11±1.23g), T_9 (19.76±1.20g) and T_{10} (19.32±1.05g) respectively on 60th day. The growth of earthworms in T_7 (58.63%) increase percent change over the initial on 60th day vermicompost.

The production of cocoons by *P. excavatus* in different feed substrates is presented in Table – 2. The adult clitellate worms started to produce cocoons on 15th day the maximum number of cocoons were observed in T_7 (35.2±1.92) and the minimum number was observed in T_{10} (22.2±1.47). The cocoon production was gradually increased after 15th day up to 60th day. The total number of cocoon production in C (170.4±1.14), T_6 (157.6±1.45), T_7 (179.2±1.48), T_8 (145.9±0.98), T_9 (133.3±1.83) and T_{10} (119.7±1.16) was observed.

The production of hatchlings at varied in different substrate proportions. The number of hatchlings production was observed in control and treatments on 30th day. The more number of hatchlings was recorded in T_7 (71.1±1.43) and it was followed by C, T_6, T_8, T_9 and T_{10} on 60th day vermicomposts.

Nutrient content of vermicomposts

The changes observed in the availability of N, P and K of various proportions are presented in Table – 4. The gradually increased content of N, P and K was observed in the vermicomposts obtained from all the experiments and control. On 60th day the nitrogen content of the vermicompost in various proportions were in the order on the basis of percent change over the initial T_7 (83.5%) > C (77.7%) > T_6 (71.4%) > T_8 (63.4%) > T_9 (61.0%) and T_{10} (59.0%).

The maximum mineralization of phosphorus was observed in T_7 (1.16), it was followed by C (1.12), T_6 (1.05), T_8 (0.87), T_9 (0.78) and T_{10} (0.71) on 60th day in the vermicomposts of *P. excavatus*.

The content of potassium increased in all observations from the initial value. The mineralization of K was maximum in T_7 (1.36) and minimum quantity in T_{10} (1.00) on 60th day vermicomposts.

4.DISCUSSIONS

In the present investigation it was clearly observed that the highest growth and reproduction of *P. excavatus* was observed in T_7 (20% MSW + 80% GM). The growth of earthworms is depending on the quality of the availability of food, adequate temperature and moisture content (Kale and Bano, 1991). According to Manimegala *et al*. (2009) the maximum worm biomass and reproduction was observed in FA + CLI + CD (3: 3.5: 3.5) ratio of fly ash mixture, it may be due to higher N content and higher microbial content in the vermicompost.

Similarly to the present investigation John paul *et al*. (2011) stated that the biomass, number of cocoons by *P. ceylanensis* increase with the increase of CD incorporation in MSW (i.e., 10% CD: 1% MSW) mixtures. They reported that the cattle dung increased suitability of MSW for both microbes and earthworms. Ananthkrishnasamy and Gunasekaran (2014) stated that the growth and reproduction of *E. eugeniae* were increased in MSW + BM mixtures, particularly in E_3 (60%BM + 40% MSW). The reason might be due to rich in nitrogen and phosphorus in the experiment.

Table – 1. Role of Municipal solid waste and goat manure on the biomass (grams) of *P.excavatus* (P<0.05)

Substrate proportions	Vermicomposting days				
	0	15	30	45	60
C	15.56±1.09	17.66±0.94 (13.49)	19.09±1.07 22.68)	21.17±1.28 (36.05)	23.45±1.12 (50.70)
T_6	15.14±1.11	16.95±0.88 (11.95)	18.49±0.87 (22.12)	20.41±0.71 (34.80)	22.71±1.45 (50.00)
T_7	15.23±1.03	19.01±1.58 (24.81)	21.32±1.45 (39.98)	22.22±1.49 (45.89)	24.16±1.76 (58.63)
T_8	15.12±1.12	16.55±1.00 (9.45)	17.04±1.17 (12.69)	18.73±0.82 (23.87)	20.11±1.23 (33.00)
T_9	15.24±1.47	15.88±1.87 (4.19)	16.66±0.79 (9.31)	18.39±1.58 (20.66)	19.76±1.20 (29.65)
T_{10}	15.22±1.08	15.54±1.16 (2.10)	16.53±1.18 (8.60)	17.85±1.46 (17.27)	19.32±1.05 (26.93)

(ANOVA)

Analysis of variance	Sum of square	Mean of square	F - value
Rows	47.8255	9.565099	13.18664
Columns	145.1443	36.28609	50.02475

C – Control (GM alone), T_6– (10% MSW + 90%GM), T_7 – (20% MSW + 80% GM), T_8 – (30% MSW + 70% GM), T_9– (40% MSW + 60%GM), T_{10}– (50 % MSW + 50%GM), Initial (0) – Worm unworked substrates, Mean ± SD of six observations, (+/–) – Percent change of increase or decrease over the initial.

Table – 2. Role of Municipal solid waste and goat manure on the cocoons production (numbers) of *P.excavatus* (P<0.05)

Substrate Proportions	Vemicomposting days					Total no. of cocoons
	0	15	30	45	60	
C	0	34.2±1.48	38.2±1.09	44.8±1.30	51.4±1.14	170.4±1.14
T_6	0	31.6±0.89	36.4±0.88	42.6±1.51	49.0±1.58	157.6±1.45
T_7	0	35.2±1.92	41.2±1.30	50.8±1.93	53.8±1.30	179.2±1.48
T_8	0	30.2±1.33	33.2±2.16	38.4±1.34	46.8±1.64	145.9±0.98
T_9	0	26.4±1.49	30.7±1.64	37.5±1.15	40.6±1.52	133.3±1.83
T_{10}	0	22.2±1.49	25.8±1.09	34.2±1.78	37.6±1.57	119.7±1.16

(ANOVA)

Analysis of variance	Sum of square	Mean of square	F - value
Rows	500.9707	100.1941	13.46701
Columns	7920.509	1980.127	266.1473

C – Control (GM alone), T_6– (10% MSW + 90%GM), T_7 – (20% MSW + 80% GM), T_8 – (30% MSW + 70% GM), T_9– (40% MSW + 60%GM), T_{10}– (50 % MSW + 50%GM), Initial (0) – Worm unworked substrates, Mean ± SD of six observations, (+/–) – Percent change of increase or decrease over the initial.

Table – 3. Role of Municipal solid waste and goat manure on the hatchlings production (numbers) of *P.excavatus* (P<0.05)

Substrate Proportions	Vermicomposting days					Total no. of hatchlings
	0	15	30	45	60	
C	0	0	43.4±1.14	59.0±1.58	67.2±1.30	168.6±2.07
T_6	0	0	40.2±1.64	56.6±1.94	62.2±2.68	158.2±1.48
T_7	0	0	48.8±1.48	64.9±1.88	71.1±1.43	183.6±0.70
T_8	0	0	38.6±0.85	52.7±1.22	58.8±0.93	147.3±0.87
T_9	0	0	34.7±1.70	43.8±1.24	52.5±0.91	128.2±0.86
T_{10}	0	0	33.4±1.81	36.6±1.96	46.6±1.69	116.6±0.83

(ANOVA)

Analysis of variance	Sum of variance	Mean of variance	F - value
Rows	626.447	125.2894	5.074349
Columns	19657.28	4914.32	199.035

C – Control (GM alone), T_6– (10% MSW + 90%GM), T_7 – (20% MSW + 80% GM), T_8 – (30% MSW + 70% GM), T_9– (40% MSW + 60%GM), T_{10}– (50 % MSW + 50%GM), Initial (0) – Worm unworked substrates, Mean ± SD of six observations, (+/–) – Percent change of increase or decrease over the initial.

Table – 4. Nitrogen, Phosphorus and Potassium content (%) in the vermicompost from MSW with goat manure mixtures by *P. excavatus* (p< 0.05)

Substrate proportions	Vermicomposting days								
	Nitrogen			Phosphorus			Potassium		
	0	30	60	0	30	60	0	30	60
C	1.35±0.051	1.83±0.053	2.40±0.101 (77.7)	0.63±0.037	0.82±0.037	1.12±0.032 (77.7)	0.98±0.056	1.20±0.037	1.35±0.047 (37.75)
T_6	1.33±0.053	1.76±0.027	2.28±0.095 (71.4)	0.60±0.040	0.78±0.049	1.05±0.038 (75.0)	0.95±0.037	1.15±0.034	1.27±0.052 (33.68)
T_7	1.34±0.051	1.95±0.037	2.46±0.104 (83.5)	0.59±0.042	0.83±0.030	1.16±0.047 (96.6)	0.94±0.046	1.21±0.032	1.36±0.051 (44.68)
T_8	1.23±0.043	1.54±0.041	2.01±0.119 (63.0)	0.50±0.052	0.74±0.026	0.87±0.035 (74.0)	0.85±0.036	1.07±0.036	1.12±0.049 (31.76)
T_9	1.18±0.046	1.49±0.042	1.90±0.107 (61.0)	0.45±0.047	0.63±0.044	0.78±0.027 (73.3)	0.78±0.038	0.98±0.056	1.02±0.019 (30.76)
T_{10}	1.10±0.036	1.32±0.051	1.75±0.026 (59.0)	0.42±0.042	0.56±0.028	0.71±0.036 (69.0)	0.77±0.032	0.88±0.031	1.00±0.039 (29.87)

ANOVA

Analysis of variance	Sum of square	Mean of square	F – value	Analysis of variance	Sum of square	Mean of square	F – value	Analysis of variance	Sum of square	Mean of square	F – value
Rows	0.649978	0.129996	13.10586	Rows	0.239244	0.047849	14.05024	Rows	0.240444	0.48089	26.63385
Columns	2.322811	1.161406	117.0903	Columns	0.521544	0.260772	76.57259	Columns	0.294878	0.147439	81.65846

C – Control (GM alone), T_6– (10% MSW + 90%GM), T_7 – (20% MSW + 80% GM), T_8 – (30% MSW + 70% GM), T_9– (40% MSW + 60%GM), T_{10}– (50 % MSW + 50%GM), Initial (0) – Worm unworked substrates, Mean ± SD of six observations, (+/–) – Percent change of increase or decrease over the initial.

The inoculation of *P. excavatus* in the MSW + GM mixture increased the N, P and K content over 60 days period. During the vermicomposting process the highest level of N, P and K mineralization was obtained in T_7 (20% MSW + 80% GM) than the other treatments, it can be inferred that T_7 was the better feed mixture in terms of biomass increase.

Umamaheshwari and Vijayalakshmi (2003) reported that macronutrients such as N, P and K content increased significantly in the vermicompost. According to John paul *et al*. (2011) reported the higher percent increase of NPK in vermicompost of MSW + CD produced by *P. ceylanensis* than in compost in this study may be attributed to the mineralization process caused by earthworm action along with microorganisms on organic materials.

The present investigation is also supported by the recent study made by Jamaludin *et al*. (2012) they reported higher ratio of goat manure compared to spent mushroom substrate; 60:40 and 80:20 as feed material are able to produce higher quality of organic fertilizer with a greater mean value of N, P, K and C/N ratio.

Fall – in – line with our present study Ananthakrishnasamy and Gunasekaran (2014) reported that the highest amount of nutrients content (N, P and K) in T_4 (80% BM + 20% MSW) mixtures reflected the efficient worm activity and better combination of feed than the other treatments. (Umamaheswari and Suresh, 2015) reports shows that the highest reproduction rates, NPK and micronutrient contents of the wormcasts were achieved in the mixtures of CD + sugar industry waste (SIW), in order to better understand the mechanisms by which the bulking agents influence the growth of *E. fetida*, *P. excavatus* and *E. eugeniae*.

5.CONCLUSION

This work reports the possibility use of vermicomposting technology in MSW management. The vermicomposts produced from MSW + GM had more nutrient content. The *P. excavatus* was found to be suitable candidate for vermiconversion. The unutilized enormously available MSW could be vermicomposted along with any organic additives convert into the valuable organic manure.

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