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Research Article

Utilization of Municipal Solid Waste mixed with Horse dung by using earthworm *Perionyx excavates*

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Abstract

Solid waste generation is a natural phenomenon and amount of waste produced is directly proportional to the population growth. Rapid urbanization, industrialization and agricultural practices have led to dumping of organic solid wastes caused a serious threat to the environment. In the present study an effort has been made to convert the municipal solid waste (MSW) into manure by the earthworm *Perionyx excavatus* under laboratory conditions. The experimental media were prepared on dry weight basis by mixing the MSW and horse dung (HD). The growth and reproduction were observed at the interval of 15 days over a period of 60 days. The growth rate (biomass) and reproduction (number of cocoons and hatchlings) of *Perionyx excavatus* was increased in all experimental media MSW + HD mixtures and control. The results showed that the unutilized and enormously available MSW can be vermicompost into valuable organic manure that can be utilized for sustainable agriculture.

Keywords: Municipal solid waste, Horse dung, Biomass, Cocoons and Hatchlings.

1.Introduction

Municipal solid waste such as rubbish, institutional waste, street sweeping waste, industrial waste, food waste, construction demolition waste, commercial waste, and sanitation waste. MSW contains recyclables (paper, plastic, glass, metals, etc.), toxic substances (paints, pesticides, used batteries, medicines), compostable organic matter (fruit and vegetable peels, food waste) and soil waste (blood stained cotton, sanitary napkins, disposable syringes) (Jha *et al*., 2003). Solid waste management (SWM) is a major environmental problem of our countries. India produces around 3000 million tones of organic wastes annually (Alok, 2010). One of the important contemporary environmental problems in urban areas is huge generation of MSW (Pokhrel and Viraraghavan, 2005). Rapid industrialization and population explosion in India has led to the migration of people from villages to cities, which generate thousands of tons of MSW daily. According to Ananthakrishnasamy *et al*. 2013 the MSW generation rates in small towns are lower than those of metro cities and the per capita generation rate of MSW in India ranges from 0.2 to 0.5 kg/day.

Animal waste are considered as important resources for fertilizer crop fields, enhancement organic matters and improve soil conditions, but are a source of environment pollution too. Horse manure is a good source of nutrients and a popular totalling to many home. A 1000-pound horse produces 40-50 pounds of manure every day, so millions of tones of horse droppings are produced, but at present in our country, horse droppings are not considered for their economic values.

Vermicomposting is a bio-oxidation and stabilization of organic material concerning the joint action of earthworms and microorganisms, where negligible organic waste resources are renewed into nutrient rich

plant growth media i.e. vermicompost. Vermicomposting has been recently recognized as one of the most appropriate methods to stabilize organic waste. *Perionyx excavatus* is an earthworm found commonly over a large area of tropical Asia. This is an epigeic species which lives in organic wastes and high moisture contents and adequate amounts of suitable organic material are required for populations to become fully established and for them to process organic wastes efficiently.

Growth and reproduction of different species of earthworms using different materials such as flax seeds (Kosteka, 1999), cattle manure and goat manure (Loh *et al.*, 2005), pressmud (Parthasarathi, 2007), leaf litter of *Leucaena glauca* (Manimegala *et al.*, 2008),fly ash mixed with cashew leaf litter (Manimegala *et al*.,2009),fly ash and horse dung (Dharani *et al*.,2010), fly ash mixed with press mud, cow dung and crop residue (Anbalagan and Manivannan,2012) and Jackfruit leaf litter with bedding material (Revathi *et al*.,2014) have been studied. The objectives of the present study was aim to evaluate the growth and reproduction of *P. excavatus* in the process of vermicomposting of municipal solid waste with horse dung.

2. Materials and methods

2.1 Municipal solid waste (MSW)

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

2.2 Horse dung (HD)

The fresh (HD) was collected from Pagadappadi, Salem district, Tamilnadu. HD that had been subjected to thermophilic pre composting for 15-25 days.

2.3 *Perionyx excavates*

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.

2.4 Experimental design

The duration of the experimental period was 60 days. Six vermicomposting treatments were recognized having different proportions of MSW and HD.The feed substrate that has been subjected to thermophilic pre- composting 15-30 days prior to vermicomposting. 15 g of earthworms were introduced in 1000 g (dry weight basis) of feed mixture. The composition of feeds in different substrate proportions was given below:

Treatments	Proportions	Weight (g)
C-Control	HD	1000g
T_1-MSW+HD	1:9	100+900
T_2- MSW+HD	2:8	200+800
T_3- MSW+HD	3:7	300+700
T_4- MSW+HD	4:6	400+600
T_5- MSW+HD	5:5	500+500

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.

2.5 Statistical analysis

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

3. Result and Discussion

3.1 Growth and Reproduction of *P.excavatus* in different treatments

During the experimental period of 60 days, worms' growth well in all the substrates and no mortality was observed in all different mixtures. There was gradual increase in individual biomass and fecundity rate in all treatments and control. On 15th day the biomass of worms were (20.41±1.27 in C, 19.42±1.18 in T_1, 22.04±0.85 in T_2, 18.14±0.94 in T_3, 17.60±1.02 in T_4 and 16.98±1.65 in T_5). The maximum earthworm biomass was observed in sample T_2 followed by sample C and T_1 in 15th day. The minimum worm biomass was recorded in sample T_5, however biomass gain by worms in sample T_4 was insignificant ($p<0.05$) with sample T_3 (Table 1). Maximum worm biomass was attained in 60th days in all the samples, where T_2 show the highest biomass when compared with others. The worm biomass production in T_2 was (-74.78 percent change over the initial) and the minimum worm biomass production in sample T_5 was (-41.63 percent change over the initial) on 60th respectively. The biomass increased in T_2 it is due to fatigue of food. Earthworms obtained their nourishment from organic resources and decomposing animals. Neuhauser *et al*. (1980) found that *E. fetida* increased weight, which was reliant on population density and food type. Food is an essential factor to determine the maximum growth of an organism. The optimal growth of earthworms has been reported to depend on the quality and quantity of the available feed and various physicochemical parameters (Karmegam and Daneil, 2000). In this context, the present study confirmed that the municipal solid waste and horse dung enhanced the growth of *P. excavatus.* Hence our result is accordance with the finding of of Banu *et al.* (2005) and Loh *et al.* (2005) in which they have stated that the enhanced growth of earthworms are appropriate to more nutrients and friendly environment to earthworms. T_2 showed the highest biomass when compared with other treatments and the reason might be due the higher palatability of food (MSW and HD).

Table-1 Role of Municipal solid waste and horse dung on the biomass (grams) of *P.excavatus* ($P<0.05$)

Substrate Proportions	Vermicomposting days				
	Initial (0)	**15**	**30**	**45**	**60**
C	15.68±0.93	20.41±1.27 (-30.16)	22.45±1.78 (-43.17)	24.96±1.01 (-59.18)	25.82±1.38 (-64.66)
T_1	15.76±0.94	19.42±1.18 (-23.22)	21.87±0.99 (-38.76)	23.25±0.88 (-47.52)	24.09±2.04 (-52.85)
T_2	15.43±1.04	22.04±0.85 (-42.83)	24.53±1.38 (-58.97)	25.68±1.03 (-66.42)	26.97±0.96 (-74.78)
T_3	15.60±1.00	18.14±0.94 (-16.28)	21.10±2.42 (-35.25)	22.81±1.06 (-46.21)	23.74±1.44 (-52.17)
T_4	15.52±1.42	17.60±1.02 (-13.40)	20.87±1.91 (-34.47)	21.65±2.45 (-39.49)	22.63±1.47 (-45.81)
T_5	15.45±1.34	16.98±1.65 (-9.91)	19.69±1.19 (-27.44)	20.53±1.64 (-32.88)	21.79±2.46 (-41.63)

(ANOVA)

Analysis of variance	**Sum of square**	**Mean of square**	**F-value**	**P-value**
Rows	54.50407	10.90081	14.44821	4.69E-06
Columns	287.9546	71.98865	95.41555	9.84E-13

C – Control (HD alone), T_1– (10% MSW + 90%), T_2 – (20% MSW + 80% HD), T_3 – (30% MSW + 70% HD), T_4– (40% MSW + 60%HD), T_5– (50 % MSW + 50%HD), Initial (0) – Worm unworked substrates, Mean ± SD of six observations, (+/–) – Percent change of increase or decrease over the initial.

The reproductive potential of *P.excavatus* was gradually increased in all treatments and control. The maximum rate of cocoon production in T_2 was 37.4±1.57 on 15th day, 44.8±1.47 on 30th day, 53.6±2.51 on 45th day and 54.3±1.85 on 60th day followed by sample C, T_1,T_3, T_4 and T_5 .The minimum rate of cocoon production was recorded in sample T_5 25.2±1.58 on 15th day, 31.4±1.45 on 30th day, 37.6±2.15 on 45th day and 39.3±2.02 on 60th day. The total number of cocoon production in T_2 (20% MSW+80% HD) was higher than the other treatments (Table 2). Since, T_2 shows the highest cocoons production in our experiment and it is due to the highest nutrient quality content in the feed mixtures. The high 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 (Padmavathiamma *et al.*, 2008).

Table-2 Role of Municipal solid waste and horse dung on the cocoons production (numbers) of *P.excavatus* (P<0.05)

Substrate Proportions	Vermicomposting days					Total no. of cocoons
	Initial (0)	15	30	45	60	
C	0	34.2±1.58	41.8±1.78	51.6±1.87	53.6±1.62	176.4±1.14
T_1	0	32.8±1.92	37.6±1.58	46.3±2.54	50.3±1.53	163.2±1.30
T_2	0	37.4±1.57	44.8±1.47	53.6±2.51	54.3±1.85	185.9±1.68
T_3	0	30.8±2.58	34.6±1.81	43.6±1.72	47.3±2.01	157.5±1.55
T_4	0	27.4±1.14	32.5±1.58	39.3±2.09	41.3±1.50	141.8±1.64
T_5	0	25.2±1.58	31.4±1.45	37.6±2.15	39.3±2.02	132.4±2.07

(ANOVA)

Analysis of variance	Sum of square	Mean of square	F-value	P-value
Rows	497.6627	99.53253	13.363	8.4E-06
Columns	8844.025	2211.006	296.8444	1.69E-17

C – Control (HD alone), T_1– (10% MSW + 90%), T_2 – (20% MSW + 80% HD), T_3 – (30% MSW + 70% HD), T_4– (40% MSW + 60%HD), T_5– (50 % MSW + 50%HD), Initial (0) – Worm unworked substrates, Mean ± SD of six observations, (+/–) – Percent change of increase or decrease over the initial.

The number of hatchlings varied in different substrate proportions. The number of hatchlings production was observed in all treatments and control. The maximum number of hatchlings was recorded in sample T_2 was (total number of hatchlings 194.4±2.01) and minimum number in sample T_5 (total number of hatchlings 138.2±1.78) (Table 3).Our results showed that the maximum number of hatchlings production were observed in T_2, and it was followed by T_1, C and they were followed by T_3, T_4 and T_5. Garcia and Fragoso (2002) reported that the presence of some growth-retarding substances in waste substance is also important to determine the earthworm's hatchlings producing efficiency. In the present enhanced growth and reproduction of *P.excavatus* were observed in all the treatments and control. The highest biomass, cocoon and hatchlings number of *P.excavatus* were observed in T_2 (MSW 20% + HD 80%) than the other treatments. Manimegala *et al.*, 2008 reported that the composition of 2:3 leaf litter and cow dung might be a better combination as it showed better growth and reproduction. According to Sorojini *et al*., 2009 have designate that the highest growth and reproduction of *E. fetida* in BM alone and 10% FA mixed with bedding material seems to be the better combination than 20%, 30%, 40% and 50% FA. Anbalagan and Manivannan, 2012 results showed that maximum earthworm biomass and reproduction was observed in the T_5 treatment. It provides such ideal physico-chemical changes. According to Revathi *et al.*, 2014 results show the higher biomass, cocoon and hatchlings number of earthworms were observed in C and T_4 than the other treatments T_1, T_2, T_3 and T_5. The *P.excavatus* readily accepts the horse dung as a good nutrient source (Garg *et al.*, 2005) and the horse manure is a very valuable and underutilized resource.

Table-3 Role of Municipal solid waste and horse dung on the hatchlings production (numbers) of *P.excavatus* (P<0.05)

Substrate proportions	Vermicomposting days					Total no. of hatchlings
	Initial(0)	15	30	45	60	
C	0	0	44.3±1.58	61.8±1.46	68.4±1.14	172.6±1.58
T_1	0	0	41.6±2.07	59.4±1.14	65.7±1.39	164.3±1.46
T_2	0	0	53.1±1.38	68.2±1.30	75.7±1.58	194.4±2.01
T_3	0	0	40.6±2.04	52.8±1.92	62.8±1.35	151.4±2.07
T_4	0	0	37.8±1.30	48.5±1.28	59.2±1.29	145.5±1.58
T_5	0	0	35.4±1.14	46.2±1.30	57.6±2.12	138.2±1.78

(ANOVA)

Analysis of variance	Sum of square	Mean of square	F-value	P-value
Rows	444.1337	88.82673	5.487626	0.002441
Columns	22885.74	5721.435	353.4645	3.03E-18

C – Control (HD alone), T_1– (10% MSW + 90%), T_2 – (20% MSW + 80% HD), T_3 – (30% MSW + 70% HD), T_4– (40% MSW + 60%HD), T_5– (50 % MSW + 50%HD), Initial (0) – Worm unworked substrates, Mean ± SD of six observations, (+/–) – Percent change of increase or decrease over the initial.

4. Conclusion

In the present study, worm biomass, cocoons and mean number of hatchlings was estimated from organic substrates prepared with MSW and HD in different substrate proportions. The maximum growth and reproduction of *Perionyx excavatus* was observed and recorded in T_2 (20% MSW + 80% HD). These results confirmed that the municipal solid waste and horse dung are good substrate feed for vermiculture via vermicomposting process it can help to minimized MSW and the compost utilized as biofertilizer.

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