Quest Journals
Journal of Research in Agriculture and Animal Science
Volume 9 ~ Issue 9 (2022) pp: 81-87
ISSN(Online) : 2321-9459
www.questjournals.org

Research Paper

Culture of Earthworm, *Perionyx excavatus* (Perrier) and Nutrient Analysis Using Municipal Solid Waste

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ABSTRACT
In the present day, major environmental factors like air, water, soil are getting polluted due to the various natural and anthropogenic activities like dumping of municipal solid waste (MSW) within proper treatment, discharging waste water into the domestic water bodies etc. More seriously, it leads to fly breeding and other infectious diseases in the society. It is estimated that 1.0 to 1.1 Kg of solid waste generated per day/person in a well developed city. This study is aimed at correcting above environmental problems. Since, the rate of cocoon production and body weight gain / loss of the earthworm, Perionyx excavatus kept in 0, 25, 50, 75 and 100 per cent substrate ratio (PSR) prepared from partly decomposed MSW with soil for 30 days were determined. Though the worms kept in soil alone showed 100% survival value with weight loss after 30 days, only meager amount of cocoons were laid during the course of study due to less organic matter present in the soil. The worms kept in all MSW media produced relatively more cocoons than the control. The levels of soil parameters such as pH, EC and macro nutrients (N, P and K) present in the samples of partly decomposed, vermicompost of MSW were determined. While vermicomposting, the levels of nutrients in all PSR media were drastically increased over raw samples. The results proved beyond any doubt that the culture medium containing MSW was the best one as far as cocoon production and growth of earthworm are concerned.
KEY WORDS: *Perionyx excavatus, MSW, Vermicompost, Nutrient Content, Cocoon Production*

Received 12 Sep, 2022; Revised 25 Sep., 2022; Accepted 28 Sep., 2022 © The author(s) 2022.
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I. INTRODUCTION

Due to increased human population there is an increase of various types of organic wastes such as agricultural, domestic, municipal and industrial wastes. These wastes cause serious threat to man and his environment in many ways. Leaving aside industrial non-degradable waste, other decomposable organic wastes can be recycled with the help of earthworm activities and can be used as an alternative source to chemical fertilizers. Hence, there is a need to have information on daily, monthly and annual turnover of these wastes at different levels both in rural and in urban areas. In Tamil Nadu, the unsegregated MSW generated are collected and are either disposed in low- lying areas or water bodies or disposed along the roadside and are set on fire causing air pollution. The leachate from the dumped solid wastes has caused water pollution, odour nuisance are mainly caused due to the putrefaction of the organic matter present in the unsegregated MSW.

Decomposition and stabilization of solid organic waste material has been taking place in nature ever since life appeared on this planet. Composting is the process of decomposition and stabilization of organic matter under controlled condition. Waste materials that are organic in nature, such as plant material, food scraps, and paper products, can be recycled using biological composting and digestion processes to decompose the organic matter. It is a biological process in which micro-organisms, mainly fungi and bacteria, convert degradable organic waste into humus like substance.

Epigeic earthworm, *P. excavatus* lives in organic horizons and ingests large amounts of undecomposed litter. It produces ephemeral burrows into the mineral soil during its diapauses period. This species is relatively exposed to climatic fluctuations and predator pressures, and tends to be small with rapid generation times. The specimens of this earthworm are generally small to medium sized, deeply pigmented, flat ventrally, tolerant to disturbance and have short life cycle, higher fecundity and regeneration capacity. Utilizing the surface feeding habit of this earthworm, large masses of organic wastes can be converted into organic fertilizer within a short span of time. The biology and life cycle of this earthworm have been studied by Hallatt *et al.* (1). The aim of the present study was to study the growth, cocoon production and nutrient analysis of vermicompost produced during vermicomposting process of MSW admixed with soil by using *P. excavates* (Perrier).

II. MATEREIALS AND METHODS

2.1 Collection of Municipality Solid Waste

Partially decomposed MSW of about 200 kg were collected from municipality waste dumping area located at new bus stand, Salem, Tamil nadu, India.

2.2 Collection and Maintenance of Earthworms

Specimens of adult earthworm, *P.excavatus* were collected in the cow dung pit, Sivathapuram village, Salem. The worms were kept in large trays with substrate medium, 50% cow dung and 50% soil and maintained under the laboratory condition (temperature 30 ± 2^0 C) for 15 days. Care was taken to see that the worms collected from the site, which did not experience any pesticide treatment. Adult worms with the size, 14 to 18 cm in length and 900 to 1000 mg in weight were used (2).

2.3 Collection of Soil

Dry soil was taken from Government Arts College (Autonomous), Salem -7, was manually powdered and stored in polyethylene bags.

2.4 Procurement of Plastic Pots

Ten plastic pots of equal size (24 cm diameter and 25 cm height) were purchased from Salem, Tamil Nadu, for vermiculture study.

2.5 Removal of Non-degradable matter

The unwanted non-degradable matters such as plastics, glass pieces, polyethylene papers and stones were removed from the organic material before proceeding to vermicomposting.

2.6 Separation of Core Particles

The collected partly decomposed materials were powdered manually using thick wooden rod. The powdered materials were sieved separately through a sieve net (1 mm × 1 mm) to obtain a medium with a particle size less than 1 mm as suggested by Reinecke and Venter (3) and were stored in polyethylene bags for vermiculture and nutrients analysis study.

2.7 Preparation of Substrates for Cocoon production Study

Two sets of five per cent substrate ratios (PSR) such as 0, 25, 50, 75 and 100 were prepared using dry soil and powdered MSW with volume by volume basis and mixed well. Four liters of substrate in each per cent ratio was taken in a plastic pot and sufficient volume of water was added into it to ensure optimum moisture condition as suggested by Martin (4). To assess the rate of cocoon production in the above said two sets of media, 12 adult earthworms were introduced into each pot. Two sets of control (soil alone as substrate) experiments with 12 earthworms in each were also maintained simultaneously along with these media. Regular watering is a must for this culture study to provide optimum moisture condition to the earthworms. All the pots were covered with cotton clothes to protect the earthworms free from their predators such as frog, ant, rat, squirrel, centipede, millipede and termites. Cocoons produced by earthworms were collected and recorded once in six days for a period of one month. Simultaneously the earthworm body weight was also taken and recorded once in six days at the same time of cocoon collection. Survival of earthworm was also observed in the above said media during the course of study. Rate of cocoon production was calculated at weekly as well as at daily basis (2).

2.8 Physico-Chemical Analysis

The levels of pH and electrical conductivity (EC) were measured in all the PSR samples of MSW before and after vermicomposting practice with *P. excavatus* for one month. Macronutrients such as nitrogen, phosphorus, potassium were also estimated by using standard method ((5) in the above samples at Soil Testing Laboratory, Tamil Nadu Agriculture Department, Salem, Tamil Nadu.

2.9 Calculation

Data collected during reproductive study were used to calculate the growth and reproductive parameters by Udayakumar and Parthasarathi (2).

Per cent weight change (PWC)

$$PWC = \frac{\text{Final body weight - Initial body weight}}{\text{Initial body weight}} \times 100$$

Cocoon production rate (CPR)

$$CPR\ (C/W/D) = \frac{\text{Total cocoons produced} \div \text{No. of worms used}}{\text{Period of cocoon collection (days)}}$$

III. RESULTS AND DISCUSSION

3.1 Cocoon production study

Rate of cocoon production of *P. excavatus* exposed to partly decomposed MSW media (0, 25, 50, 75 and 100 PSR) for 30 days are given in table 1. The earthworms showed in soil alone (control) showed 100% survival, only a meager amount of cocoons (2) were laid for the entire period of study (30 days). However, the earthworm produced relatively more cocoons if they were in 50 PSR dose of MSW with a maximum production rate 0.0486 cocoon/worm/day. The cocoon production observed during study period, the worms kept in 50 PSR media produced relatively more cocoons (13) during 24^{th} days of cocoon collection over other PSR media. The rate of cocoon production observed in these earthworms showed an increasing trend from the lower PSR to higher PSR and after 50 PSR dose in *P. excavatus* their production rates revealed a declining trend.

This results was in confirmation with the reported results of Bakthavathsalam and Ramakrishnan (6) and Bakthavathsalam and Birmanandhi (7) were they respectively used five (0, 25, 50, 75 and 100) and six (0, 20, 25, 50, 75 and 100) PSR cow dung media and observed more cocoons in 50 PSR over other media. From these results it is inferred that the medium with 20 PSR of MSW is considered as a good substrate among the five culture media studied with *P. excavatus* under laboratory condition for the production of cocoons.

Kale *et al.* (8) have also observed greater production of cocoons by the same species using different organic wastes such as cow dung, sheep dung, horse dung, poultry manure and sludge from biogas plant. The rate of cocoon production observed in the present study irrespective of PSR media used was not in consistent with the results observed by Ramalingam (9) and Bakthavathsalam and Ramakrishnan (6) in the *L. mauririi* species respectively cultured exclusively under press mud medium and 50 PSR cow dung medium where they found higher values of cocoon per worm per day respectively.

3.2 Body weight Change

Body weight of adult *P. excavatus* exposed to different partly docomposed media (0, 25, 50, 75 and 100 PSR) for 30 days are given in table 2. A gradual increase from the beginning till the 18 days was noticed in the body weight of *P. excavatus* exposed to 25 – 100 PSR media. However, the same worms kept in soil (0 PSR) for 30 days showed a reduction of 50.48 in their body weight over their initial values. Though the worm kept in MSW in general showed increased body weight gain values at the end (after 30 days), the earthworm in 50 PSR dose showed relatively a very high value (50.12) over other PSR doses. Body weight observed in these earthworms showed an increasing trend from the lower PSR to higher PSR and after 50 PSR dose in *P. excavatus* their production rates revealed a declining trend.

Contrary to the present results only a meagre gain value was noticed in the adult earthworms of *L.mauritii* cultured under paddy chaff powder (35.5%) by Bakthavathsalam and Geetha (10), *O.tyrtaeum* cultured under maize and wheat leaves (45.3 and 45.9% respectively) by Bisht *et al*. (11), *L.mauritii* cultured under press mud and cow dung (6.75 and 7.81% respectively) by Bakthavathsalam (12), and *E.eugeniae* cultured under paddy straw waste (12.3%), coir waste + *Eichhornia crassipes* + cow dung + poultry excreta mixture (24.5%) and coir waste + water lily + goat droppings + poultry excreta mixture (9.19%) respectively by Subramaniyan and Bakthavathsalam (13), Bakthavathsalam *et al*. (14) and Bakthavathsalam *et al*. (15). However the weight gain values observed in adult *L.mauritii* cultured under weed plant materials (128.5%) by Bakthavathsalam and Geetha (10) and in adult *E.eugeniae* cultured under green gram waste (115%) by Jayaseelan and Bakthavathsalam (16) were not in confirmation with those of present and of reported results.

3.3 Macronurtrients Analysis

The levels of physico – chemical parameters such as pH, EC and macro nutrients (N, P and K) measured / determined in the samples of partly decomposed and *P.excavatus* exposed MSW are given in table 3. The pH values measured in the samples of partly decomposed MSW showed slightly basic in nature was noticed. The samples obtained after vermicomposting practice which indicates that the pH value was reduced during vermicomposting. The levels of electrical conductivity (as a measure of soluble salts level) measured in all the PSR samples obtained before vermicomposting showed relatively more values than the samples obtained after vermicomposting practice which indicate that the soluble salts level was reduced during vermicomposting and it also revealed in their pH levels. The availability of several plant nutrients and other elements present any soil depends upon the pH value of the organic manure. In the present analysis though there are changes in pH during vermicomposting but their pH level was relatively more as reported by Brady (17). Of the three macronutrients (N, P and K) analysed in the raw and vermicomposed samples, the levels of potassium was relatively very high when compared to other macronutrients. It is important to note here that the present study with MSW, while vermicomposting the earhworm, *P. excavatus* drastically increased the levels of all macro nutrients in all the PSR media over the levels prevailed in the raw samples.

The pH value at neutral level should be considered important in retaining nitrogen since it is lost as volatile Ammonia at high pH (18) and the pH range, 6-7 seems to promote the availability of plant nutrients (17). In the present analysis though there are changes in pH during vermicomposting process but their pH levels were maintained at the safe range around 7 as suggested by Brady (17).

The soluble salts level was greatly reduced during vermicomposting as suggested by Uthayakumar and Bakthavathsalam (19) in vegetable market waste after exposure to *L.mauritii*, Bakthavathsalam *et al.* (14) in an organic mixture containing coir waste, *E. crassipes,* cow dung and poultry excreta and Bakthavathsalam *et al.* (15) in coir waste, water lily, goat droppings and poultry excreta mixture after exposure to *E.eugeniae.* The volatilization of ammonia and the precipitation of mineral salts could be the possible reason for the decreased level of EC observed during vermicomposting process (20).

The observed nutrients improved levels was in confirmation with the elevated levels of N, P and K in the vermicompost of fly ash and cow dung mixture after exposure to *L.mauritii* by Ananthakrishnasamy *et al.* (21), N, P, Fe, Zn and Cu in the vermicompost of green gram waste after exposure to *E. eugeniae* by Jayaseelan and Bakthavathsalam (22), OC, N, P, K, Ca, Mg, Zn, Fe, Cu and Mn in the vermicompost of vegetable market wastes after exposure to *L.mauritii* by Uthayakumar and Bakthavathsalam (19), OC, P, K, Ca, Mg, S, Zn, Cu, Fe and Mn in the vermicompost of organic mixture containing coir waste, *E.crassipes,* cow dung and poultry excreta after exposure to *E.eugeniae* by Bakthavathsalam *et al.* (14), OC, N, P, K, Mg, Zn, Cu, Fe and Mn in the vermicompost of an organic mixture (containing coir waste, water lily, goat droppings and poultry excreta) treated with *Trichoderma viride* after exposure to *E.eugeniae* by Bakthavathsalam *et al.* (15), S and Mn in the vermicasts of elephant dung after exposure to *E.eugeniae* by Sudha and Bakthavathsalam (23), OC, N, P, K, Na, Ca, Mg, S, Zn and Cu in the vermicompost of *Polyalthia* leaves after exposure to *E.eugeniae* by Umamaheswari and Bakthavathsalam (24) and OC, TP, TK, TCa, Fe, Mn and Cu in the vermicompost of *Pongamia* leaf litter after exposure to *L. mauritii* by Udayakumar and Parthasarathi (5).

IV. CONCLUSION

In conclusion, most of the MSW in India is dumped on land in an uncontrolled manner. Such inadequate disposal practices lead to problems that will impair human and animal health and result in economic, environmental and biological losses. Comparing the biological, chemical and thermal treatment options in the Indian scenario, perhaps the biological processing options get the priority. Composting and vermicomposting are successful and quite popular now in India instead of incineration. Hence, vermiculture practices are recommended for treating and converting the huge amount of MSW generated in the Salem city. This process will reduce the environmental damage. Also vermicompost is a valuable input for sustainable agriculture and wasteland development. Municipal Corporations will adopt the vermicompost technology to fetch revenue. Further studies are pla cultivation of black gram using this organic waste as proof of nutrient status for vermicompost.

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Table 1: Total cocoon production of earthworm, *P.excavatus* kept in different per cent substrate ratios (PSR) of partly decomposed MSW for one month.

Days	PSR				
	0 %	25 %	50 %	75 %	100 %
6 th day	-	-	-	-	-
12 th day	-	3	4	3	3
18 th day	-	3	7	7	4
24 th day	1	3	13	6	5
30 th day	1	7	11	10	8
TC	2	16	35	26	20
C/W/D	0.0027	0.0222	0.0486	0.0361	0.0277

Each table values are Mean of cocoons collected from two pots; Values of TC and C/W/D are represented total cocoons and cocoon production per day respectively collected from the two pots; TC= Total Cocoons; C/W/D= Cocoon/Worm/Day.

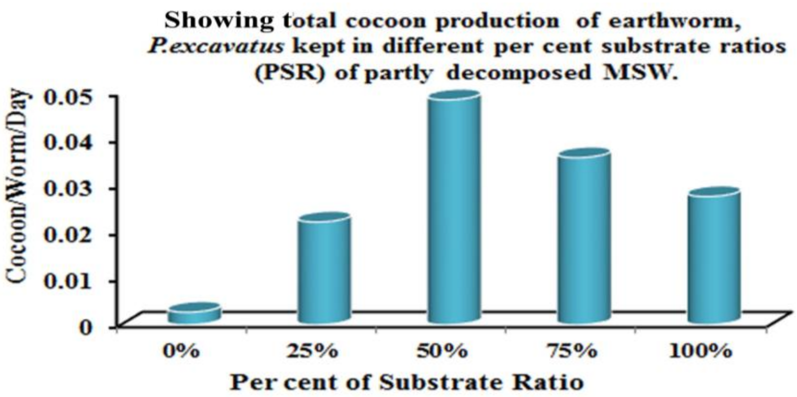

Table 2: Body weight changes of earthworm, *P.excavatus* cultured in partly decomposed MSW for one month.

Days	PSR				
	0 %	**25 %**	**50 %**	**75 %**	**100 %**
0 th day	20.60	21.45	20.55	23.80	23.20
6 th day	22.55	27.35	27.30	31.60	26.40
12 th day	24.00	30.35	31.40	34.90	28.65
18 th day	20.40	30.55	33.65	38.55	30.35
24 th day	16.00	29.50	32.85	37.50	29.55
30 th day	10.20	27.70	30.85	35.55	31.55
PWC	-50.48	29.13	50.12	49.15	35.99

Table values are Mean of total body weight of 12 earthworms measured from two pots; PWC=Per cent weight change.

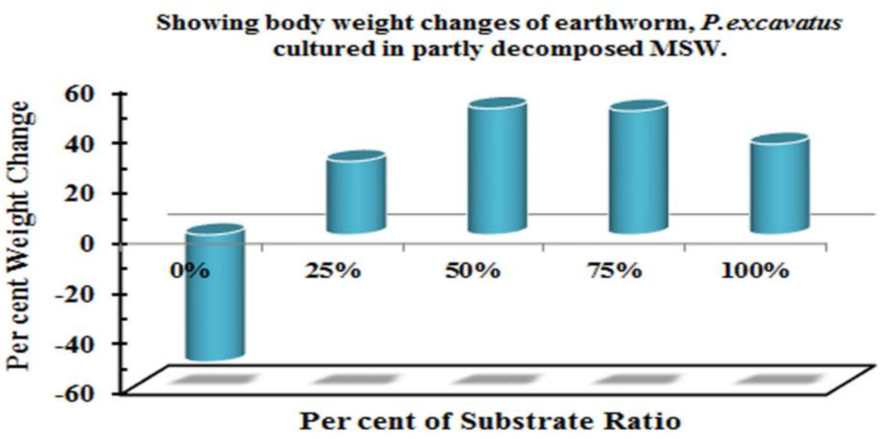

Table 3: Values showing the levels of pH, electrical conductivity (EC dSm^{-1}) and macronutrients (%) obtained in the samples of different per cent substrate ratios (PSR) in partly decomposed MSW before and after vermicomposting practice with *P.excavatus* for one month.

PSR	pH	EC(dSm^{-1})	Macronutrients		
			N %	P %	K %
0%	7.9	0.77	39	25	167
	7.8	0.60	310	164	295
25%	7.9	1.68	52	26	220
	7.6	0.70	319	184	400
50%	7.8	1.58	53	26	231
	7.6	0.90	328	190	410
75%	7.7	1.61	55	27	240
	7.5	1.20	340	195	417
100%	7.7	1.58	77	29	276
	7.4	1.30	361	198	420

Upper row indicates value obtained from samples before vermicomposting;
Lower row indicates value obtained from samples after vermicomposting.