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Efficiency of Millipede and Earthworm in the Conversion of Organic Wastes

G. Rajkumar, B. Ramanathan and P. Alagesan

PG & Research Department of Zoology, Yadava College, Madurai – 625 014, Tamil Nadu, India

Abstract: *Purpose*: The present research work was carried out with the aim of analysing the efficiency of millipede and earthworm; and exploration of millicomposting and vermicomposting process with the help of millipede, *Spinnotarsus colosseus* and earthworm *Eisenia foetida* by using kitchen wastes. Both millicompost and vermicompost are ecofriendly and economically viable to farmers to replace the chemical fertilizers. Methods: Millicompost and vermicompost were produced with kitchen waste of Yadava college hostel. Macronutrients such as carbon, nitrogen, phosphorus, potassium and calcium were estimated at initial (0) day, 20th, 40th and 60th days of experiments. *Results*: Millicompost showed rich in macronutrients nitrogen, phosphorus, potassium and Ca (nitrogen 1.07, phosphorus 0.52, potassium 0.85 and calcium 1.22) at 60th day fallowed by vermicompost (nitrogen 0.89, phosphorus 0.38, potassium 0.63 and calcium 1.03) than in conventional compost was (nitrogen 0.85, phosphorus 0.33, potassium 0.55 and calcium 0.78). An ideal C/N ration was observed in compost procured by millipedes (30.36) after 60 days of experiments. *Conclusion*: The chemical analysis of harvested millicompost and vermicompost showed an outstanding composition of macronutrients when compared to conventional compost.

Key words: *Spinnotarsus colosseus* · *Eisenia foetida* · Millicompost · Vermicompost

INTRODUCTION

In the modern age of development the increasing quantity of solid waste is one of the growing problems in both developed and developing countries. The rapid increase in the volume of waste is one aspect of the environmental crisis, accompanying global development [1]. Extensive use of chemical fertilizers and pesticide in agriculture negatively impacts the soil and plants as chemical and pesticide residues are present in nutritional products and they accumulate in the food web and environment. Therefore, developing innovative agricultural practices that employ organic composts and environment friendly products will enhance the agricultural sector towards a greener future and production of wholesome and nontoxic food products at affordable prices year – round. In addition, innovative agricultural practice are required to meet the demands of Governments and companies [2]. All human activities generate some kind of by-products or waste, which are apparently of no use to us and have to be discarded. Solid waste management is essential to maintain healthy environment. The common solid wastes produced by the towns and cities are mainly the organic wastes, which include kitchen wastes, vegetable market waste, sewage sludge, animal excreta, weeds, coir waste, leaf litter, paper and pulp waste, agricultural residues, feed and fodder wastes and aquatic biomass [3]. Of late, Indian farmers and agricultural scientists have realized and are anxious to find alternatives perhaps, a non-chemical agriculture and have been revived their age – old traditional techniques of natural farming [4].

The compost prepared from organic materials using earthworms is a low cost and ecofriendly technology called vermicomposting. Vermicomposting is the process of producing compost by utilizing earthworms to turn the organic waste into high quality compost that consists mainly of worm cast in addition to decayed organic matter [5, 6]. Vermicomposting helps in the management of food, agricultural and animal wastes, which are transformed into agricultural compost that is then applied to enhance the production of nontoxic and nutritional crop [7]. Vermicomposting improves the physical, chemical and biological properties of the soil as well contribute to organic enrichment [8, 9].

Corresponding Author: G. Rajkumar, PG & Research department of Zoology,
Yadava College, Madurai – 625 014, Tamil Nadu, India.

Similarly, millipedes are known to be macrodetrivores, terrestrial arthropods feeding on decaying vegetables matter and mineral soil and are represented by more than 80, 000 species. They are essentially soil-dwelling and in some ecosystems, they are more important than worms as agents of soil and nutrient turnover. Although millipedes are often called 'thousand leggers', they actually have far fewer legs and each body segment has two pairs of short legs. Millipedes do not bite or pose any danger to humans. Martens *et al*. [10] reported that earthworms and millipedes are important members of the detritus food web in the agricultural ecosystem and both use manure as the food source. . Like earthworms, millipedes improve the soil structure and enrich the soil with nutrients. Even though millipedes are the major saprophagous fauna, very little informations are available on using millipedes for compost production. Millipedes are essentially important soil animals and in some ecosystem, they are more important than earthworms as agents of soil and nutrient turn-over [10]. Therefore, the present study was undertaken to analyze the efficiency of millipede and earthworm in composting kitchen wastes and estimate the macronutrients like carbon, nitrogen, phosphorus, calcium and potassium in millicompost and vermicompost.

MATERIALS AND METHODS

Experimental Species and Substrates: The adult millipede, *Spinnotarsus colosseus* was collected from the reserve forest of Alagarmalai Hills (Fig. 1) and earthworm, *Eisenia foetida* was obtained from the Sakthivermiery, near Vadipatty, Madurai District, Tamil Nadu (Fig. 2). They were acclimatized to the laboratory conditions for one month before the start of the experiment. Kitchen vegetable wastes were obtained from the kitchen yard ofMathariWomens Hostel, Yadava College, Madurai.

Fig. 1: *Spinnotarsus colosseus*

Fig. 2: *Eisenia foetida*

Experimental Design: The wastes were shredded into small pieces and dried for a week and then subjected to predigestion. The prepared kitchen vegetable waste was mixed with equal amount of fresh cow dung and kept in plastic troughs separately and allowed for predigestion by sprinkling water. After 30 days, the predigested materials were subjected to composting with millipedes and earthworm. Five kilograms of the predigested, Kitchen vegetable wastes were taken in separate three rectangular culture troughs of equal size (47× 32× 16 cm). Among the 3 troughs, the first one was without the composting organisms and labeled as 'Conventional compost' or control. In the remaining two troughs, in first one 50 individual of millipede species, *Spinnotarsus colosseus* were introduced and labeled as 'Millicompost'. Similarly in the second trough, 50 earthworm species, *Eisenia foetida* were introduced and labeled as 'Vermicompost'. Water was sprinkled at regular intervals in all the troughs to maintain moisture content of 65-75% at temperature 25°C. The troughs were covered with wet muslin cloth to prevent the invasion of foreign materials and the escape of millipedes and earthworm. The biocomposting process was continued for a period of 60 days. Spraying of water was stopped two days before the harvest. The composting experiment was conducted in triplicate. Before, introducing the millipedes and earthworm into the troughs i.e. on the initial (0) day and after 20^{th}, 40^{th} and 60^{th} day, samples of conventional compost, millicompost and vermicompost were collected for macronutrient analysis.

Estimations of Macronutrients: To quantify the organic Carbon in the compost, Walkley and Black's rapid titration method was followedJackson [11]. Total nitrogen was determined using MicroKjeldhal method by Umbreit [12].Phosphorus was estimated by Vogel's technique [13].

Available potassium and calcium were detected using Flame photometer (Elico; Model CL 378). All the samples were analysed in triplicates and the mean results were recorded.

RESULTS

In millipede introduced trough in the 20th day, the appearance of compost in the form of faecal pellets millipede was clearly observed when compared to earthworm introduced trough. In 60th day large amount (4.5 Kg) of compost harvested in millibed and (3.7 kg) of compost harvested in vermibed. The size of the compost (pellet) is larger in millipede trough when compared to earthworm trough.

The amount of macronutrients is presented in Table 1. The increasing percentage of macronutrients in the millicompost followed by vermicompost and conventional compost and shown in Figure 1. The total organic carbon of initial day was 46.02 and it decreased from4 5.3, 40.01 and 38.01 in the conventional compost, vermicompost and millicompost in 20th day. In 60th day the total organic carbon was the lowest in millicompost (32.49) fallowed by vermicompost (35.28) and 43.0 in conventional compost. Statistical analysis of correlation showed that a significant negative correlation was obtained between the millicompost, vermicompost and conventional compost. The total nitrogen content showed significant increase in the millicompost in 20th day (0.88), 40th day (1.04) and 60th day (1.07) when compare to vermicompost in 20th day (0.85), 40th day (0.87) and 60th day (0.89). There were no significant differences in conventional compost harvested in 20th (0.84), 40th (0.85) and 60th day (0.87). Statistically significant positive correlation was observed between the duration of three different composting and the nitrogen content.

At the initial stage, the C/N ratio was maximum (55.44) and it was found to be decrease with duration of composting. From the data, it was clear that the C/N ratio of kitchen vegetable wastes worked with earthworm and millipedes had been reduced significantly to lower levels than the conventional compost. At the end of 60 days of experiment the C/N ratio of the conventional compost was 50.58 and it decreased in the vermicompost (39.64) and millicompost (30.36) respectively.Analysis of correlation showed that a significant negative correlation was obtained between the duration of millicomposting and C/N ratio. Analysis of correlation showed that a significant negative correlation was obtained between the duration of millicomposting and C/N ratio.

The level of phosphorus at the commencement of composting on the initial day was (0.28%) and at the end of 20th, 40th and 60th day it was 0.29, 0.30 and 0.31 in the conventional compost respectively. A similar trend was obtained in millicompost (0.32, 0.34 and 0.38) fallowed by vermicompost (0.30, 0.32 and 0.34) respectively. A remarkably high level of phosphorus (0.38%) was noticed in compost worked with millipede *S. colosseus*. The relationship between the phosphorus and duration of millicomposting are statistically significant. The total potassium content of compost in initial day was 0.53 and it was slowly increased in 20th day (0.55), 40th day (0.53) and 60th day (0.56) in conventional compost. It was highly increased in 20th day (0.62), 40th day (0.68) and 60th day (0.72) in millicompost and it was 0.56, 0.58 and 0.61 in vermicompost of 20th, 40th and 60th day respectively. The similar trend was observed in calcium content. The calcium content of the 60th day conventional compost was 0.78% and it is increased from 1.03% in vermicompost to 1.22 % in millicompost. A modest correlation and positively significant statistical results were obtained for the potassium and calcium

Table 1: Nutrient composition (%) of millicompost and vermicompost of vegetable wastes processed by Millipede, (*S. colosseus*) and earthworm (*E. foetida*). Each value represents the mean (X ±SD) of 3 estimates

		Duration								
		20th day			40th day			60th day		
Parameters	Initial (0) Days	CC	VC	MC	CC	VC	MC	CC	VC	MC
Carbon	46.02±3.68	45.3±3.62	40.01±3.20	38.01±3.04	44.9±3.59	39.32±3.14	37.63±3.01	43.0±3.01	35.28±2.82	32.49±2.59
Nitrogen	0.83±0.06	0.84±0.06	0.85±0.05	0.88±0.07	0.85±0.06	0.87±0.06	1.04±0.08	0.87±0.06	0.89±0.06	1.07±0.08
Phosphorus	0.28±0.01	0.29±0.02	0.30±0.02	0.32±0.02	0.30±0.02	0.32±0.02	0.34±0.03	0.31±0.02	0.34±0.02	0.38±0.03
Potassium	0.53±0.04	0.54±0.04	0.56±0.04	0.62±0.05	0.55±0.04	0.58±0.04	0.68±0.05	0.56±0.04	0.61±0.05	0.72±0.07
Calcium	0.76±0.06	0.76±0.06	0.84±0.06	0.98±0.07	0.77±0.05	0.91±0.07	1.12±0.08	0.78±0.05	1.03±0.07	1.22±0.10
C/N ratio	55.44±4.43	55.3±3.87	47.07±3.29	43.19±3.88	52.82±4.22	45.19±3.61	36.18±3.25	50.58±4.55	39.64±2.77	30.36±2.42

CC: Conventional Compost VC: Vermicompost MC: Millicompost content at the different days of composts. Two way ANOVA indicates the significant variation ($P < 0.05$) in biochemical components of initial day (0 day), 20th, 40th and 60th day samples of conventional compost, vermiccompost and millicompost.

DISCUSSION

The soil macrofauna are known to play a significant role in disintegration and decomposition of organic materials added to the soil [14]. Saprophagous invertebrates change the microenvironmental conditions of litter through aeration and rigorous mixing of litter in the soil [15]. Vermicomposting is a simple biotechnological process of composting, in which certain species of earthworms are used to enhance the process of waste conversion and produce a better end-product. Similarly, millicomposting is a novel technique, in which millipedes are employed for composting organic waste. Earthworms consume various organic wastes and reduce the volume by 40–60%. Generally earthworm eats organic wastes equivalent to its body weight and produces cast about 50% of the waste it consumes in a day, but mature millipedes eat organic waste about five times their weight [16].

Millicompost showed rich in macronutrients NPK and Ca (nitrogen 1.07, phosphorus 0.38, potassium 0.85 and calcium 1.22) at 60th day fallowed by vermicompost (nitrogen 0.89, phosphorus 0.34, potassium 0.61 and calcium 1.03)than in conventional compost was (nitrogen 0.87, phosphorus 0.31, potassium 0.56 and calcium 0.78).The results of the present investigation revealed that nitrogen, phosphorus, potassium and calcium were higher in millicompost fallowed by vermicompost than conventional compost. Hence, the following factors have been found to be different in millipede faeces versus the original litter [17]: (i) more available carbohydrates and amino acids; (ii) higher nitrogen levels; (iii) more moisture due to compaction of the pellets or otherwise; (iv) a pH of 6.5 and (v) the change in physical structure of the pellet compared to the parent litter. The presence of millipedes positively changes the concentration of many nutrients like phosphorus, calcium and magnesium [18]. Higher concentration of elements was found in compost derived from millipedes than that from earthworm. However, the concentration of nitrogen and phosphorus increased due to digestion and faecal pellet formation in millipede.

The present study manifested that among the composting species chosen for the present study, millipede, *S. collosseus* is highly efficient in composting the waste into useful organic manure than earthworm, *E. foetida*. Ambarish and Sridhar [19] reported increase in the concentration of N, P, K and Ca in compost produced with the help of millipede and earthworm. Prabhas *et al*. [20] showed that millicompost is superior and has a positive effect on plant growth over vermicompost and ordinary compost. Nicholson *et al*. [21] observed that ash and phosphorus were found to be high in faecal pellets of millipedes. The rise of pH and the availability of ammonia make millipede faeces very hospitable to microflora and other organisms [22, 23]. Similarly, McBrayer [24] reported that the faecal pellets of millipedes also increased pH, moisture and bacterial count; decreased fungal count and carbon than undigested leaf litter. The narrow C/N ratio in treated samples indicates the enhancement of respiration, influenced by the activities of *A. magna* reported by Aswini and Sridhar [25]. Bocock [26] found low C/N ratio in millipede faeces than in the ingested litter. Decline in C/N ration was seen between ingested leaf litter and faeces generated by *Glomeris Spp*. [27]. Since millicompost is superior in quality it is concluded that it would play a crucial role in sustainable agriculture.

CONCLUSION

Composting method is an alternative and a promising method to eliminate the environmental intimidations that impact human's health and environment. Both millicompost and vermicompost contain more exchangeable plant nutrients than conventional compost. Composting with millicompost contain high level of nutrients when compared to composting with vermicompost and conventional compost. It is significant to proliferation the awareness of farmer about the important of millicomposting and inspire more research on the millicompost technique as an alternative approach for using waste recycling. This study revealed a developed method that helped improve the quality of producing a nutrient rich environment rich millicompost from different wastes.

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