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Growth and reproduction of earthworms *Eisenia fetida* in textile mill sludge

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Abstract

The present study aimed to management of Textile Mill Sludge (TMS) by vermicomposting. TMS mixed with Predigested manure (PM), the mixture of Farm Yard Manure (FYM) and Dry leaves (DL) using the Earthworm *Eisenia fetida.* The maximum growth and reproduction of *E. fetida* was reported in the 50% TMS with PM. The TMS increased than 50% the growth of *E. fetida* reduced. The parameters pH, Electrical conductivity, NPK were analyzed and the NPK values significantly increased in the vermicompost. The experiment was carried out 75 days. This result proved this vermicomposting was simple and economical alternative technology for recycling of TMS using the earthworms *E. fetida*.

Key words

Textile Mill Sludge (TMS), Vermicomposting, Predigested manure (PM), *Eisenia fetida*

Introduction

Textile Mill Sludge (TMS) generated from the bleaching, dyeing and printing operations of textile mills in Tirupur, Tamil Nadu is managed through destructive method, land filling practices and incineration. The sludge also is disposed into the agriculture fields, open way-side dumps and left to pollute the surface or ground water causing public health hazard (Garg and Kaushik, 2005). The present study aims at converting TMS into a value added fertilizer by combining organic amendments with it and produce vermicompost using the earthworm, *E. fetida* (Savigny).

Since TMS is reported to contain organic and inorganic nutrients and NPK (Machiraju, 2011), recycling of waste through vermitechnology reduces the problems of waste disposal (Kale, 2000). Different types of solid wastes are digested by earthworms with subsequent production of vermicompost. Sludge from paper mill, rich in nitrogen and phosphorous is converted to vermicompost (Elivira *et al.*,1998). Earthworms are used for composting organic wastes such as cattle dung, municipal sludge, sericulture wastes, paper mill wastes, agriculture residues and domestic wastes (Gunadi *et al.*, 2002; Gajalakshmi *et al.*, 2002 and Sinha *et al.,* 2002).

Garg and Kaushik (2005) demonstrated that vermicomposting is an alternate technology for the recycling of textile mill sludge using epigeic earthworms. Vermitechnology can be used in the management of paper mill wastes (Medhi *et al.*, 2005) and nutrient rich industrial wastes from sugar industry and municipal sludge (Reddy *et al.*, 2006).

E. fetida an epigeic earthworm speices, feeds on inorganic wastes (Garg and Kaushik, 2005) and its decomposition efficiency surpasses that of *Perionyx sansibaricus* (Perrier) (Suthar, 2007). In the present study the survival, growth and reproductive potential of *E. fetida* on TMS was assessed for a period of 75 days.

Materials and methods

Procurement of earthworm and TMS

E. fetida was obtained from the vermiculture farm in the Vivekanantha Kendra at Kanyakumari and maintained in regular vermicompost pits. Textile mill sludge (TMS) was obtained from the textile treatment plant of a textile factory at Tirupur. The sludge was dried in shade prior to use in vermicomposting.

Preparation of compost bed

Equal quantities of Farm Yard Manure and the dry leaves were mixed in a pit (5' x 5' x 4') for decomposition. The moisture content of the mixture was increased by spraying adequate quantities of water. The mixture was turned over manually every fortnight in order to vent out volatile gases. After 45 days when the temperature decreased considerably, watering was stopped and the predigested manure (PM) was collected from the pit and dried. The predigested manure was mixed with TMS in different ratios. The mixture consisted of six sets, P1- P6. P1 consisted entirely of predigested manure; P2, PM and TMS in 3:1 ratio; P3, 3:2 ratio; P4, 1:1 ratio; P5, 3:4 ratio and P6 in 3:5 ratio. For this experiment equal amount (4 kg/trough) of mixture was used.

Each mixture was taken in six different plastic troughs (75x50x 30 cm) and fifteen adult *E. fetida* were inoculated into each trough, covered with nylon mesh to prevent entry of insects. The troughs were maintained at ambient temperature and kept in a shady place under PVC roofing. The predigested manure (PM) without TMS was the control. The troughs were sprinkled with water to maintain enough humidity. Total number of earthworms was counted at fortnightly intervals.

Physico-chemical characterization of mixtures and vermicompost samples

Hydrogen ion concentration (pH), Electrical Conductivity (EC), Organic Carbon (OC), Nitrogen (N), Phosphorus (P) and Potassium (K) of the mixtures and vermicomposts were analysed using standard procedures. The samples of mixture and vermicomposts were individually homogenized for the physico-chemical analyses. The samples were mixed with distilled water to make a suspension of each mixture in the ratio 1:10 (w/v). The suspensions were agitated mechanically for 30 minutes and filtered using Whatman No. 1 filter paper. The pH of the samples was determined by using pH meter (Systronics pH meter) and Electrical Conductivity (EC) was determined using conductivity meter. OC was measured using the method of Nelson and Sommers (1982). The K and N was determined after digesting the sample with concentrated H_2SO_4 and concentrated $HClO_4$ (9:1 v/v) according to Bremner and Mulvaney (1982). Total phosphorus was analyzed using the colorimetric method with molybdenum in H_2SO_4. Total Potassium was determined after digesting the sample in a diacid mixture (Concentrated HNO_3, Concentrated $HClO_4$ 4:1 v/v), and emission was read using a flame photometer (Elico CL22 D) (Bansal and Kapoor, 2000).

Results and Discussion

In all the experimental sets, the biomass of *E. fetida* increased steeply. Better growth is observed in P4 where the amendments and the sludge are in equal ratio. *E. fetida* thrives well in the TMS with amendments whereas it can not survive in the fresh TMS. Addition of atleast 30 percent cowdung was essential for the survival of earthworms in the fresh TMS (Gargand Kausik, 2005). The results clearly showed that the TMS combined with amendments has positive effects on the growth and reproduction of *E. fetida* and the largest number of young and adult earthworms was observed in P4 (217±6.6).

Nutrition is an essential factor determining the growth of organisms. The optimal growth, maturation, cocoon production and reproductive potential of earthworms have been reported to depend on the quality and quantity of the available feed and various physicochemical parameters (Karmegam and Daniel, 2000). The potential of earthworms as waste processors has been well documented (Suthar, 2007). Greater percentage of Solid Textile Mill Sludge in the feed mixture significantly affected the biomass and cocoon production (Koushik and Garg, 2004). The results show that the PM with 30 to 50 percent TMS can be a suitable growth medium for *E. fetida.* The biomass and cocoon production were observed to have an inverse relationship with the percentage of fly ash mixed with bedding materials (Sarojini *et al*., 2009). In this study, the TMS mixed with PM up to 50 percent is directly proportional to the growth and reproduction of *E. fetida* and above 60 percent the growth declined.

The pH value slightly increased in all the experimental media. The overall increase of pH may be attributed to the decomposition of nitrogenous substrates resulting in the production of ammonia, (Muthukumaravel *et al*., 2008).

Perumalsamy, (2007) found that the worm *E. fetida* is capable of ingesting and excreting organic materials at a high rate. The FYM influenced the rate of vermicomposition and increased the amount of macronutrients in the vermicompost (Vasanthi *et al*., 2005).

Table 1. Comparison of selected characteristics of formed vermicompost with initial organic mixture

	pH		EC (m S/cm)		OC (%)	
Experi-mental sets	Initial mixture	Formed vermicom post	Initial mixture	Formed vermicom post	Initial mixture	Formed vermicom post
P1	6.7± 0.1	7.03± 0.57	1.08± 0.01	1.78± 0.02	18.2± 0.30	13.0± 0.15
P2	6.73± 0.057 (o.45)*	7.16± 0.57 (1.85)*	1.34± 0.02 (-28.7)	1.64± 0.032 (-7.87)*	19.3± 0.45 (6.04)*	14.0± 0.15 (7.69)*
P3	6.9± 0.1 (2.98)*	7± 0.1 (-0.43) *	2.083±0.095 (-92.87)	3.12± 0.032 (-75.28)	28.3± 0.49 (-55.49)	18.4± 0.32 (-41.53)
P4	7.06± 0.57 (5.37) *	7.16± 0.057 (1.85) *	1.89±0.0173 (-75)	3.84± 0.102 (-115.73)	31.2± 0.32 (-71.42)	24.4± 0.35 (-87.69)
P5	7.06± 0.57 (1.46) *	7.2± 0.1 (2.42) *	2.036±0.095 (-88.51)	3.806±0.147 (-113.82)	27.8± 0.45 (-52.74)	23.2± 0.4 (-78.46)
P6	7.2± 0.1 (7.46) *	7.3± 0.1 (3.84) *	2.06± 0.125 (-90.74)	8.63± 0.121 (-384.83)	26.2± 0.41 (-43.95)	21.1± 0.25 (-62.3)

Table 2. Comparison of selected plant nutritive factors of formed Vermicompost with initial organic mixture

Experime-ntal sets	N (%)		P (%)		K (%)	
	Initial Mixture	Formed vermicom post	Initial mixture	Formed vermicom post	Initial mixture	Formed vermicom post
P1	1.12± 15.27	1.57± 34.64	1.27± 0.025	1.75± 0.025	1.88± 0.25	2.07± 0.20
P2	1.20± 15.27 (7.142) *	1.65± 40.41 (5.095) *	1.31± 0.025 (3.14) *	1.96± 0.030 (-12)	6.85± 0.48 (-264.32)	8.40± 0.7 (-306.03)
P3	1.58± 26.45 (-41.07)	2.34± 37.85 (-49.044)	2.0± 0.057 (-57.48)	2.126±0.032 (-21)	6.82± 0.7 (-262.7)	8.03± 0.41 (-288.06)
P4	2.09± 30.55 (-86.6)	2.68± 28.86 (-70.7)	28.1± 0.025 (-121.25)	3.44± 0.03 (-99.41)	7.59± 0.76 (-303.62)	8.93± 0.27 (-331.64)
P5	1.99± 30.0 (-77.67)	2.34± 40.42 (-49.044)	1.92± 0.036 (-51.18)	2.75± 0.04 (-57.14)	7.60± 0.136 (-304.03)	9.05± 0.5 (-337.58)
P6	1.81± 25.16 (-61.6)	1.23± 36.05 (-43.31)	2.08± 0.045 (-120.41)	2.10± 0.015 (-20)	6.85± 0.90 (-264.3)	7.794± 0.9 (-276.52)

	15	30	45	60	75
Experimental Sets	No. of earthworms				
P1	19± 1	28 ±1	55±1	64±1	74.3±1.5
P2	21.3±0.57 (-12.11)	26±1 (-7.14)*	85.7±4.16 (-55.81)	93.7±1.15 (-46.41)	136.7±5.13 (83.98)
P3	19.3± 1.52 (1.58)*	40.3± 2.5 (-43.93)	108.7± 1.52 (-97.64)	123.3 ± 2.52 (-92.65)	149 ± 2 (-100.54)
P4	25.7 ±3.5 (-35.26)	42.3 ± 4.16 (-51.07)	118.3± 5.03 (-115.09)	169± 6.6 (-164.06)	217 ± 6.6 (-192.06)
P5	17 ± 1 (-10.53)	30.3 ± 3.8 (8.21)*	59.3 ± 1.52 (7.82)*	87.67 ± 3.79 (-36.98)	101 ± 7 (-35.94)
P6	15.3 ± 1.15 (-19.47)	17.3 ± 1.53 (-38.21)	18 ± 1 (-67.27)	12.77± 1.52 (-80.05)	10.3 ± 1.52 (-86.14)

Note- percent change over values in parentheses
'*' not significant; all other deviations significant at $p \leq 0.05$ (t-test)

In this study *E. fetida* utilized the organic content present in the PM mixed with the TMS. The NPK content increased in the experimental media. P4 showed the highest value of NPK than the other experimental media. In the P4, the biomass, growth, reproduction and macronutrients increased. In P4, the colour of the vermicompost is much darker than the other experiment media (P1, P2, P3, P5 and P6) indicating higher nutrient content. The increased nitrogen may be due to nitrogenous metabolic products of earthworms which are returned to the soil through casts, muco-proteins and earthworm tissue (Umamaheswari *et al.*, 2003).

Earthworms also have a great impact on nitrogen transformations in manure by enhancing nitrogen mineralization, so that mineral nitrogen was retained in the nitrate form (Ateyeh *et al.*, 2000). Addition of nitrogen in the form of mucus, nitrogenous excretory substances, growth stimulating hormones and enzymes from earthworms has also been reported (Tripathi and Bhardwaj, 2003). The amount of phosphorus and potassium in the feed mixtures increased gradually with incubation period which showed the efficiency of earthworms in mineralization and with the help of various bacteria and enzymes in the intestine of *E. fetida* (Garg and Kaushik, 2005). In this study, the total K and P increased after 75 days.

The better growth and reproductive ability of *E. fetida* and higher amount of NPK clearly indicated that 1:1 mixture of TMS and PM produced good quality vermicompost with higher quantity of nutrients.

The present investigation proves that this method suggests the best way for the utilization of TMS, converting it into a useful biofertilizer useful in agriculture. The survival percentage, biomass production and reproduction of earthworms are the best indicators to evaluate the success of the vermiculture process (Begum and Harikrishna, 2010). *E. fetida* helps to convert the TMS into a value added product. This investigation is helpful in avoiding the disposal of TMS into agricultural lands and open dumps thus saving large areas in the mill lost by the dumping of this sludge.

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