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RESEARCH ARTICLE

Studies on the Vermiconversion of different leaf wastes by using *Eudrilus Eugeniae* (Kinberg)

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Abstract

The vermicomposting of *Parthenium hysterophorus* , *Vitex negundo* and *Calotropis procera* mixed with biogas plant slurry (BPS) in 2:1 ratios in 45 days experiment. In all the treatments, a decrease in pH and OC total but increase in EC, N total, P total, Ca total, K total and heavy metals was recorded. Our results demonstrate that if *Vitex* is mixed 2:1 with BPS and vermicomposted employing *E. eugeniae* its manurial value can be increased.

Introduction

Vermicomposting is a microbial composting of organic wastes through earthworm activity (Domínguez *et al.*, 2001). Microbes are responsible for the biochemical degradation of organic matters whilst earthworms are the important drivers to condition the substrate and alter the biological activity (Domínguez *et al.*,2001). Traditionally vermicompost has been generated with animal manure (especially of the rumens) as the substrate and has been recognized as a good soil conditioner and fertilizer (Ismail, 1997). In recent years, other substrates have also been vermicomposted and the products have been found to be as good as the manure-based vermicompost (Gajalakshmi and Abbasi, 2003a Gajalakshmi *et al.,* 2002, 2005b). These findings have opened up the possibility of turning biowastes such as the organic fraction of the municipal solid waste, crop wastes, weeds, leaf litter etc., into gainful vermicompost.

Parthenium hysterophorus is an annual herbaceous terrestrial weed native to the Americas, which occurs in most of the tropical countries of the world. Owing to the absence of effective natural enemies, its allelopathic effect and photo- and thermo- insensitivity, it grows luxuriantly all through the year suppressing native vegetation, there by threatening natural diversity. It has infested millions of hectares of land including agricultural fields, wastelands, grazing lands and along highways, where it is also a human health hazard, causing allergic dermatitis and respiratory problems (Towers *et al.* 1977). At present, it is one of the most troublesome weeds in India, spreading rapidly in forests, pastures and agricultural lands. Several attempts have been made for its prevention, eradication and control, but to date without success (Kavita and Nagendra, 2000). Hence, huge quantities of this weed are annually produced in India, but its economic use as food source is impaired by its toxicity. This is why vermicomposting might be a useful alternative to convert biomass from this species to a useful material that could be used as soil conditioner.

Vitex negundo is a large, aromatic shrub with quadrangular whitish tomentose branchlets.The leaves posseses discutient properties and is applied to rheumatic swellings of the joints and in sprains. The plant has anti-inflammatory, antibacterial, antifungal and analgesic activities. *Calotropis procera* grows as a weed in many areas of India, but it is also purposefully planted. The plants root system has been shown to break up and cultivate cropland. It is a useful green manure and will be planted and plowed in before the “real” crop is sown. *Calotropis* improves soils nutrients and improves moisture binding, an important property in some of the more

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arid croplands of India. The plant is tolerant of dry and salty conditions and can easily be established in over cultivated areas to help improve the soil conditions and reinvigorate the land.

The present research was taken up to utilize a noxious and problematic weed through vermitechnology, which not only manage the weed but may provide a valuable product in the form of vermicompost.

Material and Methods

Earthworm cultures

Eudrilus eugeniae was obtained from a vermicomposting unit of Sri Parasakthi College for Women, Courtallam. The stock culture of the earthworm was maintained in using cement tank 69x42x30 cm dimensions partially decomposed bio-waste and cow dung as growth medium in laboratory condition. This was further used in the vermicomposting experiment.

Leaves of Parthenium (*Parthenium hysterophorus*), Nochi (*Vitex negundo)* and Yerkku *(Calotropis gigantea*) plants collected from the Sri Parasakthi College campus were washed,shade dried and cut into pieces of 3-4 cm length. The vermipits were prepared in the dimension of 125x62.5x25 cm. In which 4kg of dried leaf litter mixed with 2kg of biogas plant slurry (2:1) and biogas plant slurry was used as control. Control and treatments was triplicate.

To each vermipits 20 adult 40 days old earthworm's *E. eugeniae* were introduced from the stock culture after pre-composting of the raw materials. The experiment was conducted in dark room in ambient temperature. The moisture levels in the experimental containers were maintained at 70±10% (Yadav and Garg, 2009).

Experimental Design

The vermibeds were prepared using leaf wastes in vermipits and watering was done regularly to moist the medium. Mulching was done by using paddy straw to prevent evaporation. The experimental tanks were arranged in a shadow to avoid direct sun light. Three treatments were taken for vermicomposting of leaf materials; For leaf wastes the feed ratios introduced into the vermibed (in triplicates) are 100% Biogas plant slurry (BPS) (C) control (T_0) BPS:*Parthenium* (T_1);BPS: *Calotropis* (T_2);BPS: *Vitex* (T_3);

After 45 days from the date of commencement of the experiment the vermicompost produced by the earthworms was harvested for analysis. The vermicompost was harvested after the appearance of black granular structure on the surface of the composting medium. Watering of the composting medium was discontinued four days before the harvesting.

Compost Analysis

About 110g of homogenized wet samples (free from earthworms, hatchlings and cocoons) were taken out at 45th day of composting period. Triplicate samples were collected and stored at 4ºC for stability parameters, The pH and EC were determined using a double distilled water suspension of each waste in the ratio of 1:10 (w/v) that had been agitated mechanically for 30 min and filtered through Whatman No.1 filter paper. Total organic carbon (TOC) was measured using the method of Nelson and Sommers (1982). Total Nitrogen (TN) 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) procedure. Total available phosphorus (TAP) was analyzed using the colorimetric method with molybdenum in sulphuric acid. Total potassium (TK) was determined after digesting the sample in diacid mixture (concentrated HNO_3: concentrated $HClO_4$, 4:1, v/v), by flame photometer. (Bansal and Kapoor, 2000). Heavy metals' content in the vermicompost was determined by using diacid digest of the sample. Analysis was done using atomic absorption spectrophotometer (AAS). Standard solutions were prepared by using the nitrate salts of the estimated heavy metals.

Results and Discussion

Manurial quality of vermicompost produced in different treatment

The vermicompost produced from different treatments was homogeneous than the initial feed mixtures. Significant changes in physico-chemical characteristics of waste biogas plant slurry and *Parthenium)* were observed at the end (Table 1).

pH

pH is an important parameter in the vermicompost for promoting plant growth**.**There was a decrease in pH of all the treatments (T_0 – T_3) relative to their initial values during vermicomposting (Table 1). Initially pH values in different treatments were in range of 5.9±0.153 to 6.71±0.07 and in final vermicompost it ranged from 6.97±0.06 to 7.77±0.22 Maximum reduction was recorded in T_0, while minimum was recorded in T_3. Gupta *et al.*, (2007) also reported reduction in pH during vermicomposting of water hyacinth. Suthar (2009) has reported 12.3 and 14.7% reduction in pH than initial levels in cattle wastes vermicomposting. Elvira *et al.,* (1998) concluded that production of CO_2 and organic acids by the joint action of earthworms and microbial decomposition during vermicomposting lowers the pH of substrate.

Table-1 Variation in chemical constituents during vermicomposting of leaf litters with biogas plant slurry supplement

Treatments	Days	pH	EC	TN	TP	TK	Organic carbon %	Calcium%	Magnesium%	Copper%	Zinc %	Iron(Fe)
T_0	1st day	5.9± 0.153	0.67± 0.01	0.50 ±0.02	0.28± 0.03	0.36± 0.02	42.37± 0.57	0.78± 0.03	0.60± 0.01	157.6± 2.51	12.1± 0.17	593± 2.64
	45th day	6.97 ±0.06	0.97± 0.01	0.98 ±0.04	1.05± 0.04	1.00± 0.03	36.15± 0.16	1.41± 0.03	0.96± 0.02	194± 4.00	16.96 ±0.66	697.6± 6.80
T_1 Parthenium	1st day	6.71 ±0.07	0.82± 0.02	0.51 ±0.05	0.513 ±0.01	0.33± 0.03	46± 0.20	1.65± 0.05	0.31±0.01	126.93 ±2.63	11.74 ±0.78	719.21 ±5.75
	45th day	7.77 ±0.22	1.60± 0.00	1.66 ±0.02	1.75± 0.01	0.45± 0.005*	37.48± 0.02*	3.22± 0.01*	0.96±0.01*	823.3± 1.52*	46.3± 0.5*	1477 ±2.64
T_2 *Calotropis*	1st day	6.66 ±0.14	0.84± 0.01	0.53 ±0.01	0.356 ±0.02	0.40± 0.01	45.44± 1.35	1.6± 0.02	0.266±0.01	182.43 ±1.70	16.29 ±0.56	823.20 ±19.4
	45th day	7.51 ±0.01	1.89± 0.01	1.80 ±0.01	1.89± 0.01	1.12± 0.01*	34.83± 0.037*	4.84± 0.02	0.63±0.01	958± 2.00*	63.3± 0.57*	2077± 2.64
T_3 *Vitex*	1st day	6.01 ±0.01	0.85± 0.017	0.93 ±0.04	0.31± 0.02	0.45± 0.02	40.8± 1.85	1.623 ±0.05	0.506±0.02	157.6± 2.51	27.23 ±0.58	608.6± 2.48
	45th day	7.68 ±0.18	1.88± 0.01	1.29 ±0.01	2.23± 0.01	1.46± 0.04	26.71± 0.02	3.4± 0.01	1.5± 0.0017	680± 2.00	62.1± 0.45	1481.6 ±1.52

P < 0.05 - Significant * - non – significant

Electrical conductivity

The electrical conductivity (EC) of vermicompost was higher than initial waste mixtures. The EC of vermicompost ranged from 0.67±0.01 (T_0) to 1.89±0.01 mS /cm (T_0). EC values of those vermicompost were higher which contained higher biogas slurry concentration. This indicates that mineralization rate and salt formation was higher in higher biogas slurry containing treatments. Higher EC of vermicompost may be due to the presence of more soluble salts in final products after worm activities.

Organic Carbon

Organic carbon was lesser in the vermicompost, when compared to the initial level. in all the treatment. The maximum reduction is in *Vitex* compost (26.71±0.02), the minimum reduction in the organic carbon and it was recorded in 34.83±0.03 *Calotropis* compost and 37.48±0.02 in *parthenium* compost. Earthworms modify substrate conditions, which consequently promotes the carbon losses from the substrates through microbial respiration in the form of CO_2 and even through mineralization of organic matter (Kaushik and Garg, 2003). The values of Organic carbon content in vermicompost obtained from T_0 was significantly different from other treatments (P<0.05).

Total Nitrogen

Vermicomposting resulted in significant increase in Total Nitrogen in different treatments. Total Nitrogen content increased in the range of 0.50±0.02 – 1.80± 0.01 in different treatments (Table1). Maximum nitrogen content was observed in *Calotropis* compost 1.80±0.01 followed by *Parthenium* compost 1.66±0.02 and minimum nitrogen content was recorded in *Vitex* compost and it was found to be 1.29±0.01. Plaza *et al.* (2008) have reported that nitrogen increased significantly due to mineralization of C-rich materials and, possibly, to the action of N-fixing bacteria. The rapid increase in nutrients during initial stages of vermicomposting may be due to higher degradation and mineralization rate due to more food availability (Kale *et al.*, 1982). The difference in the Total Nitrogen content of the vermicompost obtained from different treatments was significant (P<0.05).

Total phosphorus

Phosphorus is an essential nutrient which is required for photosynthesis, energy transfers with in plants and for good flowering and fruit growth. It is taken up by plants in the form of inorganic ions: $H2PO^{-}_4$and $H2PO^{2-}_4$ (orthophosphates) (Hesse, 1971). Phosphorus is more important from plant maturation than plant growth. Phosphorus content is usually higher in vermicompost than parent material. Vermicompost material at the end showed higher concentrations of available P in all vermibeds than initial levels Table 1.The Phosphorus content was recorded to be maximum in the *Vitex* compost, increased phosphorus content was observed in the experiment over control from initial stages. In *Calotropis* compost and *Parthenium* compost it was 1.89±0.01 and 1.75±0.01 respectively. Ghosh *et al*., (1999) have reported that vermicomposting can be an efficient technology for the transformation of unavailable forms of phosphorus to easily available forms for plants. Increase in phosphorus content was attributed to direct action of worm gut enzymes and indirectly by stimulation of the micro flora. Vinotha *et al*., (2000) have also documented that micro flora present in the feed material play an important role in enhanced phosphorus in worm cast. According to the addition of phosphorus to vermicompost also prevents nitrogen loss through ammonia volatilization.

Total Potassium

Significant increase between treatments and control was noted in three different composting systems on the 45thday.Maximum increase was noted in *Vitex* compost 1.46±0.04 and *Calotropis* compost 1.12±0.01 respectively. The minimum potassium content was noticed in *Parthenium* compost 0.45±0.005 when compared to control. Suthar (2008) concluded that when organic waste passes through the gut of worm some quantity of organic minerals are then converted into more available forms (i.e. exchangeable forms). Vermicomposting plays an important role in microbial-mediated nutrient mineralization in wastes. The results of this study agree with previous reports that the vermicomposting process accelerates the microbial-mediate mineralization in waste and subsequently enriches the end product with more available forms of nutrients of agronomic importance.

Calcium

Calcium was higher in final product than initial levels in all feed mixtures (Table 1). Vermicompost waste mixtures have exchangeable Ca in the range of *Calotropis* compost 4.84±0.02, followed by *Vitex* compost 3.4±0.01, *Parthenium* compost 3.22±0.01 respectively.

Suthar (2008) reported that Ca metabolism in earthworm is primarily associated with gut secreted enzymes and further digestion in earthworm deposited casts by fugal hyphae and bacterial communities. However, in few endogeic and anecic worms the calcium gland is considered to play an important role in calcium secretion but in *E. fetida* such evidences is not clear. But here release of organically bound calcium in waste feed stocks is converted into free or plant available forms which makes vermicomposting techniques superiors than traditional composting method. The richness of waste feed stocks to be used for vermicomposting is also important and it directly contributes to calcium level in ready vermicompost. Nevertheless, further detailed studies are required to trace the Ca metabolism during vermicomposting process.

Magnesium

Trace nutrients, i.e. exchangeable Mg, extractable Fe and extractable Zn, showed drastic changes at the end of vermicomposting process. The maximum increase in Mg was in *Vitex* compost1.5±0.01, the minimum was noticed in *Parthenium* compost 0.96±0.01and *Calotropis (*0.63±0.01) respectively. The difference between vermicompost and compost was significant (P<0.05) in respect of total Mg content. Earthworm drives the mineralization process efficiently and transforms a large proportion of Mg from bind to free form (Suthar, 2008) which results higher concentration of Mg in the vermicompost (Suthar, 2008; Suthar, 2009).

Zinc

There was a significant increase over initial and control in all the treatments, after 45days of worm worked compost was found to be 63.3±0.57, 62.1±0.45 and 46.3±0.5 in *Calotropis* compost, *Vitex* compost and *Parthenium* compost respectively.

Total iron (Fe)

The initial and final iron content in the three different composting systems under investigation is given in table 1. After 45 days of composting the *Calotropis* compost 2077±2.64 had more iron than in the initial stage of composting. The range of iron content in worm worked composts were 1481.6±1.52 in *Vitex* compost and 1.477±2.64 in *Parthenium* compost). The difference in the Iron content of the vermicompost obtained from different treatments was significant ($P<0.05$).

Copper and Manganese

The metal (Mn, and Cu) concentrations of both compost and vermicompost were found higher than their initial value of the raw materials. The maximum manganese content was noticed in *Vitex* compost 909.3±15.3 and 312.6±2.25 and 207.6±1.15 in *Calotropis* and *Parthenium* compost respectively. The manganese content shows that there was significant difference over control at ($P<0.05$) level. The maximum copper content was noticed in *Calotropis* compost followed by *Parthenium* and *Vitex* compost respectively. The release of plant available forms of trace elements in vermicompost could be due to mineralization of partially digested worm faecal by detritus communities, such as bacteria and fungi. In general, earthworm fragments and modifies the physical structure of ingested wastes through muscular actions of foregut and consequently increases the surface area for microbial action (Suthar, 2008, 2010a). Such biological coordination results in high level of extractable or available trace elements in ready vermicompost. Kizilkaya (2004) stated that earthworm directly affects the availability of Zn in ready worm cats due to mineralization during passing of substrate through worm's gut.

CONCLUSION

The vermicompost were nutrient rich, odor free, more mature and stabilized than initial waste mixture. The management and nutrient recovery from leaf wastes has been attempted by vermicomposting after mixing it with biogas plant slurry in appropriate quantities. The final products were nutrient rich, odour free, more mature and stabilized. The results showed that carbon content was decreased during the process and nitrogen content was enhanced the product so obtained can be used in agricultural fields as manure. This study provides a platform for the utilization of leaf wastes amended with BPS for the process of vermicomposting. Our results demonstrate that if *Vitex* is mixed 2:1 with BPS and vermicomposted employing *E. eugeniae* its manurial value can be increased, so avoiding its harmful effects on the environment.

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