Enhancing the post consumer waste management through vermicomposting along with bioinoculumn

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Abstract *This experiment was designed to manage the post consumer waste in an eco friendly manner. Vermicomposting is the process which stabilizes the waste materials with the help of earthworms and microorganisms thereby turning it into organic manure. This study investigates the enhancement of the vermicomposting process by the addition of bioinoculumn along with the post consumer waste (PCW) namely the artificial paper banana leaf waste (APBL). Two sets of experiments were prepared, Set A contains APBL and cow dung (CD) with Eudrillus eugeniae and Set B contains APBL+ CD+ Eudrillus eugeniae along with bioinoculumn to enhance the degradation process. After treatment, nutrient content of vermicompost were analyzed using SEM-EDX. Results highlight that the addition of Bacillus sp increases the rate of degradation of APBL in set B, facilitating the completion of the process within a period of 50 days compared to normal of 90 days period. During the process the plastic that are coated in APBL got separated and also an increased yield of plastic from APBL was noted in Set B. Additionally the effect of prepared vermicompost were checked with the plant growth response which also showed good yield in set B. FT-IR results confirms that the functional group present in the Set B showed high degree of reduction compared to Set A. Therefore the addition of bioinoculmn during vermicomposting to manage the post consumer waste as well as to prepare organic fertilizer was justified.*

Keywords *Artificial paper banana leaf waste, Eudrilus eugeniae, SEM-EDX, FT-IR*

I. INTRODUCTION

Solid waste management in Indian cities is of major concern over the past few years. The rise in urban population and an absence of an effective management mechanism has resulted in the current state of solid waste generation [1]. Nowadays as the lifestyle changes, especially in the larger cities, which are leading to the use of more packaging materials, the amount of Municipal Solid Waste (MSW) generated per capita is estimated to increase at a rate of 1–1.33% annually [2]. In the urban population the MSW is growing upto 2.7% to 3.5% per annum. Hence the yearly increase in the overall quantity of solid waste in the cities is estimated to be more than 5 per cent [3]. The Energy and Resources Institute (TERI) has estimated that waste generation will exceed 260 million tonnes per year by 2047—more than five times the present level [4]. Therefore greater attention needs to be focused towards devising appropriate and effective mechanism for solid waste treatment. Post consumer waste (PCW) is the one which refers to the wastes which could not be used for the production of any another product. Artificial paper banana leaf (APBL) waste is one among the PCW which is manufactured in such a way similar to the shape and size to the natural banana leaf. This could be used in hotels, canteens, marriages and other function for the replacement of natural banana leaf. After usage this waste is ultimately thrown into the landfill site as it has no recycling value. Vermicomposting is an appropriate technology for managing such wastes with the aid of earthworms [5]. Though the decomposition of this substrate is a complex and prolonged process, the addition of bioinoculumn would enhance the decomposition process [6].

Earthworms are soil inhabiting animals and are regarded as farmer's friend. Earthworms convert the post consumer waste into better end product and provide solution to the problem of cellulosic waste degradation [7]. Hence they are recognized as efficient bioconvertor of cellulosic waste into high grade compost. The rate of degradation of different cellulosic wastes due to the activity of two different types of earthworm has been studied in vitro [8]. Also the role of microorganisms along with those earthworms in improving soil fertility was investigated [9]. Though the degradation of paper wastes were reported [10] there are only limited studies dealing with the enhancement process using bioinoculum.

Therefore the present investigation was carried out (1) to determine and compare the efficiency of *Eudrilus eugenia* for the decomposition of APBL waste at different stages of vermicomposting. (2) To check the possibility of reducing the time taken for degradation due to the addition of bioinoculumn and analyse the physicochemical parameters of the resultant compost using SEM-EDX and quantify the separated plastics. (3) To study the functional group present in the vermicompost sample using FT-IR. (4) To compare the efficiency of the prepared vermicompost (Set A and Set B) in plant growth.

II Materials and methods

Experimental setup

APBL waste was procured from Shopping malls of Trichy, Tamil nadu, India. Pure bacillus strains were obtained from American Type Culture Collection, (ATCC) 1947. Set A contains APBL + Cow Dung (CD) (1:1 ratio) along with *Eudrilus eugenia* (20 nos.) and Set B contains APBL + CD (1:1 ratio) + *Eudrilus eugenia* (20 nos.) along with 50ml broth of pure bacillus strain. The experiments were carried out in the 20 x 30 cm vermin reactors. Sampling was done once in every 15 days. Moisture was maintained at about 60% [11]. Finally the earthworms and cocoons were removed manually and the vermicompost was chemically analyzed.

Chemical Analysis

Nutrient content like carbon(C), Nitrogen(N), Sodium(Na), Potassium(K), Magnesium(Mg), Aluminium(Al), Calcium(Ca), Iron(Fe), Choride(Cl), Sulphur(S), Silicon(Si), Oxygen(o), Calcium(Ca), Phosphrous(P) were analysed using SEM-EDX model: Philips XL30 Scanning Electron Microscopes and EDX.

Quantification of plastic

The earthworm separates the plastic from APBL waste by consuming it. After the completion of process the plastic were settled around the rim of the tub. The separated plastics were collected manually and quantified using weighing balance.

Fourier Transform Infrared Spectroscopy

FT-IR spectra of the different vermicompost samples were recorded using a Perkin Elmer FT-IR. FT-IR spectrometer in the spectral range of 4,000-400 cm^{-1} was used. The samples were mixed with spectroscopic grade KBr and were made in the form of pellets at a pressure of about 1 MPa. The pellets were about 13 mm in diameter and 1 mm in thickness.

III Results and Discussion

Nutrient quality of vermicompost

SEM-EDX analysis was performed for both set A and set B at the end of the process, based on the obtained result, the quantity of the minerals in set A was found to be less compared to that in set B. Only five amounts of elements like Carbon (C), Nitrogen (N), Oxygen (O), Silicon (Si), Calcium (Ca) which were 22.28%, 5.85%,52.32%,19.41%,0.16% found respectively in Set A (Table 1).

Table 1. Nutrient content of Set A experiments after 90 days

Element	Weight%	Atomic%
C	22.28	29.74
N	5.84	6.68
O	52.32	52.43
Si	19.41	11.08
Ca	0.16	0.06

While in Set B fourteen amounts of elements such as Carbon (C), Nitrogen (N), Oxygen (O), F, Sodium (Na), Magnesium (Mg), Aluminium (Al), Silicon (Si), Phosphorus (P), Sulphur (S), Chloride (Cl), Potassium (K), Calcium (Ca), Iron (Fe) which were 41.2%, 2.83%,42.95%, 0.57%, 0.21%, 0.31%, 0.81%, 9.50%, 0.15%, 0.25%, 0.08%, 0.12%, 0.74%, 0.26% found respectively (Table 2). The important macronutrients like Phosphorus (P) and Potassium (K), Sodium (Na), Magnesium (Mg), Aluminium (Al), were essential elements for plant growth which were present in Set B (Fig. 1a) and not in Set A (Fig. 1b). Similarly the chemical analysis of vermicompost were done using SEM-EDX using different earthworms like *Eudrilus eugenia, Pheretima peguana* were studied by Sawanya et al., [12] and *Esenia feotida* by Malgarzata et al., [13]. Hence it is to be noted that both the quality and quantity of the compost got increased in set B and the over all time requirement for the completion of process also got decreased to 50 days from 90 days.

Table 2. Nutrient content of Set B experiments after 50 days

Element	Weight%	Atomic%
C	41.20	50.60
N	2.83	2.98
O	42.95	39.60

F	0.57	0.44
Na	0.21	0.14
Mg	0.31	0.19
Al	0.81	0.44
Si	9.50	4.99
P	0.15	0.07
S	0.25	0.12
Cl	0.08	0.03
K	0.12	0.05
Ca	0.74	0.27
Fe	0.26	0.07

The SEM image of set A shows the few aggregates of lignin and cellulosic fibers. However, in the set B the disaggregation of the cellulose and lignin matrix are clearly viewed. This could be due to the action of bio inoculumn which has the ability to finely degrade the APBL waste.

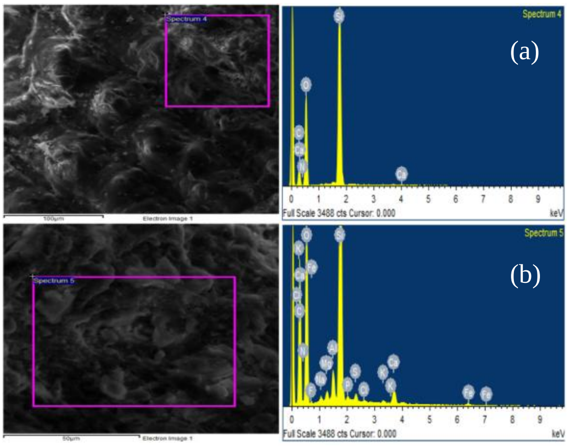

Fig. 1 (a) SEM- EDX spectrum of vermicompost in Set A; (b) SEM-EDX spectrum of vermicompost in Set B

Earthworms have the ability to separate the plastic from post consumer waste like paper cup and APBL waste [14]. But along with the bioinoculum the plastic is separated effectively was noted. The quantity of the plastic obtained from the Set B (465g) is higher compared to Set A (457g) Fig. 3. represents the overall process of vermicomposting.

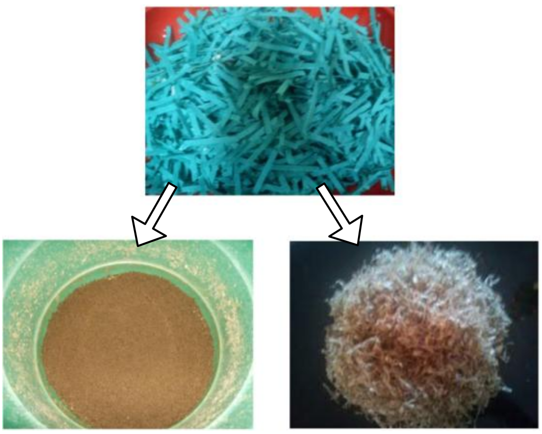

Fig. 3 Overall Process of vermicomposting of APBL waste in Set B.

Table 3: Separation of plastic and compost yield from APBL waste: Set A and Set B

Sample	Plastic separated (g)	Compost yield (g)	Days
Set A	290 ± 0.003	457 ± 0.003	90
Set B	295 ± 0.003	465 ± 0.003	50

The prepared vermicompost from APBL waste was utilized to study growth of Banthi flowering plant. As it is easly available and fast growing plant, hence it was chosen and grown in a pot for up to 1 month of period to compare the efficiency of the prepared vermicompost from Set A and Set B vermin reactors. Fig. 4. shows that the plant growth was effective in set B vermicompost compare to set A vermicompost as evident from long stem growth and more flowers.

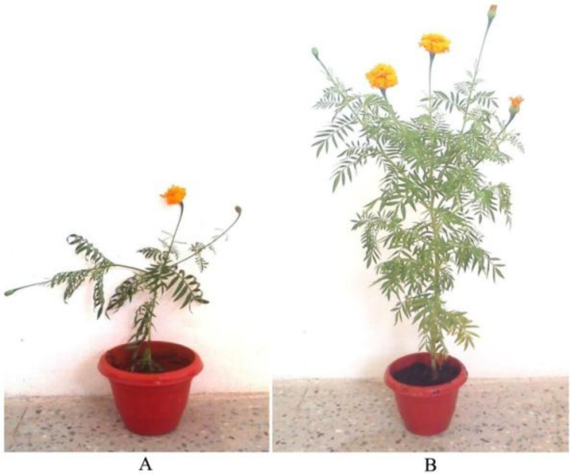

Fig. 4 Comparison of vermicompost prepared from Set A and Set B on plant growth

FT-IR spectra of set A and set B is figuratively represented in Fig. 5. A strong hydrogen bond was observed at 3931 cm^{-1} due to OH stretch. Also the band at peak range of 2925 cm^{-1} is present which represents the cellulose, hemicelluloses, fat and lipid [15]. The band at 1433 cm^{-1} and 1641 cm^{-1} confirms the presence of lignin.

Hence by comparing the set A and set B there is much reduction shown in the peak range of 3404 cm^{-1}, 2858 cm^{-1}, 1723 cm^{-1}, 1380 cm^{-1}, 1033 cm^{-1}. This indicates the change in alkane, cellulose, hemicelluloses and lignin respectively [15]. The spectra confirms the reduction of aromatic structure, polypeptides and polysaccharides. The reduction in the functional group in set B shows that the fine degradation occurred in short period of time (50 days). This is found to be achieved by the addition of bioinoculumn, as all the conditions were maintained similar in Set A and Set B except the Bioinoculum addition.

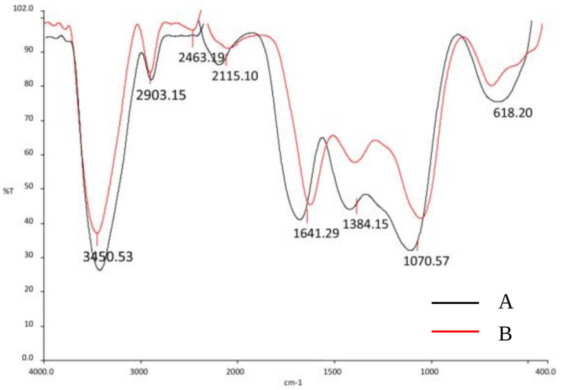

Fig. 5 FT-IR spectra analysis of Set A and Set B

IV Conclusion

The present study concludes that vermicomposting of APBL waste can prove an effective technology for recovery of high nutrient levels, viz., nitrogen, phosphorus and carbon. Our SEM-EDX results demonstrate that the addition of bioinoculumn in vermin reactors enhances the degradation process and also yields additional nutrient rich compost. This could be effectively used in growing several plants. The FT-IR spectroscopy of the vermicompost showed degradation of lipids, carbohydrate and nitrogenous substances. Finally, it was concluded that if paper cups waste and cow dung are blended in appropriate quantities along with the bioinoculumn, it would be converted into a good quality vermicompost as well the quality of solid waste dumped in the landfills would be appreciably reduced.

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