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Post-Consumer Waste Management by Virtue of Vermicomposting Enriched with Leaf Litter

Karthika Arumugam, Vasanthy Muthunarayanan *, Seetha Devi Ganesan, Swabna Vivek and Susila Sugumar

Department of Environmental Biotechnology, Bharathidasan University,

Tiruchirappalli, Tamil Nadu, India

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Abstract: Dried leaf waste is the major garbage of the environment. Though they are the very rich source of nitrogen and phosphorus. Our aim is to utilize the dried leaf wastes in an eco-friendly manner. Vermicomposting is a method of bio oxidation and stabilization of organic matter with the help of earthworms and microorganisms thereby turning waste into valuable soil amendments. The intensive objective of this study is to investigate the enhancement of vermicomposting by the addition of leaf litter (nitrogen source) along with the post-consumer waste (PCW), the artificial paper banana leaf waste (APBL) .Four different sets were prepared for this study, which includes artificial paper banana leaf waste and cowdung with Eisenia fetida (set A1) with Eudrilus eugenia (Set A2), artificial paper banana leaf waste, cow dung and leaf litter with Eisenia fetida (set B1), with Eudrilus eugenia (set B2) to carry out the degradation process in an eminent way. These materials were left for precomposting followed by the introduction of earth worms. Physico-chemical parameters (pH, Electrical conductivity (EC), Total organic matter (TOM), Total Nitrogen (TKN), C: N and Total Phosphorus) were analyzed. We have found that the aging of vermicompost reduce the microbial biomass. The FTIR spectrum analysis showed reduction of aliphatic compounds in the vermicompost. Coherently, we have found that the addition of leaf litter certainly augmented the PCW degradation apparently within a period of 50days, but degradation without leaf litter took 90days. Thus the addition of leaf litter is justified.

Keywords: Post-consumer waste, artificial paper banana leaf, Eisenia fetida, Eudrilus Eugenia.

INTRODUCTION

Solid waste management in Indian cities is one of the major concerns over the past few years. The rise in urban population and an absence of an effective management system had resulted in this current distress state of solid waste management. Hence greater attention needs to be focused on devising appropriate and effective mechanism for this waste treatment and its management. Post-consumer waste (PCW) is produced by the end consumer of a material stream. It refers to the waste which could not be used for the production of any another product.). APBL waste is one of the PCW which is manufactured in such a way similar to the shape and size to the natural plantain leaf in order to compensate the enormous need for natural banana leaf. This paper leaf which is used in private and public sectors such as hotels, marriage functions etc. After usage this waste is ultimately thrown into the landfill site as it has no recycling value till now. Vermicomposting is an appropriate technology for managing this kind of waste. Though the decomposition of this substrate is a complex and prolonged process, we ought to study decomposition process by adding of leaf litter (nitrogen source) which would enhance the decomposition by micro and macro organism and favors its reuse as well. Earthworms are soil inhabitating animals, called as farmer's friend. These convert the waste into better end products and provide a valuable solution to the problem of cellulosic waste degradation[1]. These worms have been recognized as an efficient live bio convertor for cellulosic wastes which would convert into high grade compost. The rate of degradation of different cellulosic wastes due to the activity of two different genus of earthworm such as *Eisenia fetida* and *Eudrilus eugenia* have been studied invitro[2.] Also the role of microorganisms along with these earthworms in improving soil fertility was investigated[3]. Though the degradation of paper wastes were reported[4] there are only limited studies dealing with the enhancement process using other cellulose source such as leaf litter. Therefore we proposed a study to find out the efficiency of natural cellulose waste in augmenting the process of vermicoposting, we have set up a study analysis which postulates the following objectives such as, to determine and compare the competence of *Eisenia fetida and Eudrillus eugenia* for the decomposition of APBL waste at different stages of vermicomposting and to reduce the usual time of degradation through the addition of leaf litter.

MATERIALS AND METHODS

Experimental setup: APBL waste was procured from Shopping malls of Tiruchirappalli, Tamil nadu, India. Leaf litter was collected from Bharathidasan University campus, Tiruchirappalli, Tamil Nadu, India. APBL and Leaf litter were mixed in different ratios and were used as substrate for the pre decomposition process. Set A1 contains APBL waste +cow dung (1:1 ratio) along with *Eisenia fetida,* Set A2 has *Eudrilus eugenia* instead of *Eisenia fetida,* Set B1 contains APBL waste + cow dung + leaf litter (1:1:1 ratio) along with *Eisenia fetida* and set B2 has *Eudrilus Eugenia* instead of *Eisenia fetida.* The experiments were carried out in the vermi reactors (20X30 cm) and a control bin was maintained without earthworms. Sampling was done once in every 15 days. Atmospheric moisture was maintained in the vermibin at 60%[5]. After the complete decomposition the earthworms and cocoons were removed manually and the vermicompost was further analyzed.

Chemical Analysis: Total carbon and Total Nitrogen in the vermicompost were determined by Walkly Black method[6] and by Kjeldahl method[7]. The pH level was determined by pH meter (model 600 Eutech). Electrical conductivity was measured by Electrical Conductivity meter (Model L180 Elico). In addition total phosphorus level was also determined by Vanadate molybdate reagent method[8].

Enumeration and isolation of microorganism: Microbial plate count was done as per Travors and Cook [9]. About 1gm of vermicompost was stirred with 100ml sterile distilled water in a conical flask. The supernatant was serially diluted to $10^{3,}$ 10^4 and 10^5 times and the total heterotropic population of bacteria was estimated in nutrient agar medium. Isolated organisms were identified by performing biochemical tests[10.]

Statistical Analysis: The datas were represented as mean and standard deviation of 3 replicates. One-way analysis of variance (ANOVA) was performed to evaluate any significant difference exists among treatments ($p<0.05$). (SPSS version 16.0).

Fourier Transform Infrared Spectroscopy: FT-IR spectra of control and four different vermicompost samples were recorded using Perkin Elmer. FTIR spectrometer in the spectral range of 4,000- 400 $cm^{-1.}$ 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.

RESULTS AND DISCUSSION

Nutrient quality of vermicompos: this proposed study analyzed that the earthworms employed for the composting process has modified the physical and chemical properties of the APB leaf waste. The manural value of the vermicompost depends on several factors such as natural feed substrate, aeration, moisture, temperature,species of earthworm employed for the composting process[6]. Hence it is essential to measure various physico chemical characteristics such as pH, Electrical conductivity, Total organic carbon, Total Kjeldhal nitrogen,Carbon: nitrogen ratio and Total available Phosphrous to quantify the dynamics of the vermicomposting process. Physico chemical characteristics of the vermicompost samples of set A (A1 and A2) and Set B (B1 and B2) at different time intervals were represented in **Fig 1 and Fig 2**

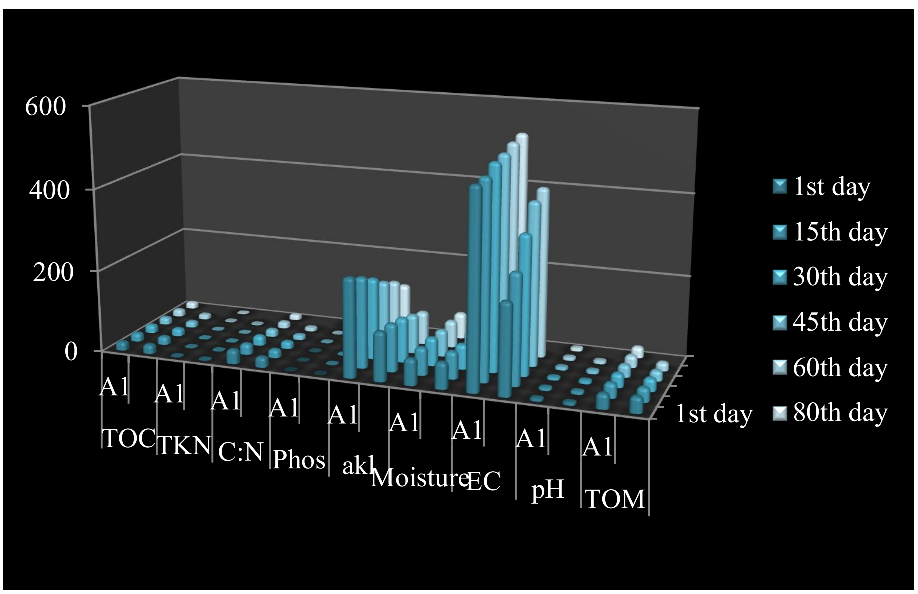

Fig.1: Physico chemical parameters of SET A

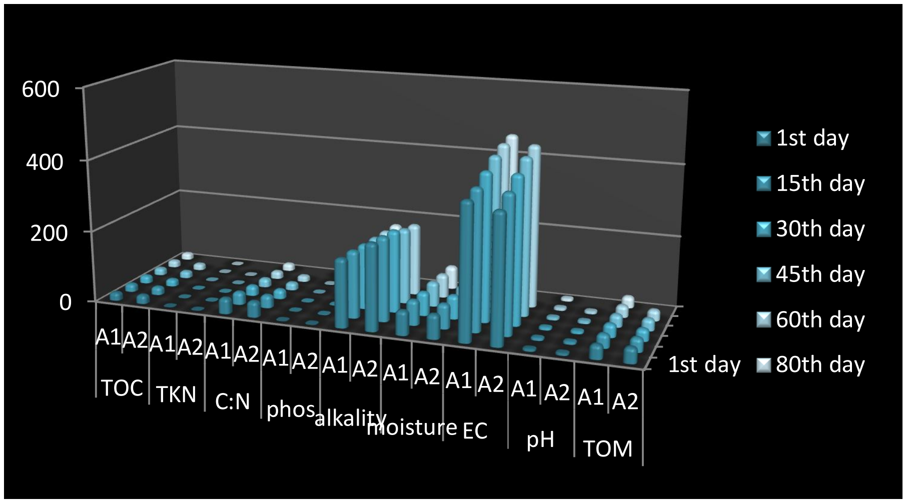

Fig.2: Physico chemical parameters of Set B

The pH of the vermicompost was in alkaline range (7-8) throughout the process in all the Sets A1, A2, B1 and B2. The pH value is the most frequent parameters used to characterize compost and vermicompost materials. Legislations in Italy, Belgium, and Spain suggest 6-8.5 range for pH value for this kind of organic amendments to ensure compatibility with most plants[11]. In our experiments the pH range in all Sets A1, A2, B1 and B2 were in alkaline range 7 - 8. The increase in pH may be attributed to mineralization of organic matter. Also the difference in the pH value was significant ($P<0.05$) in between sets A and set B. We have studied the electrical conductivity (EC) to characterize the end product quality of vermicompost. The increase in EC might be due to the loss of organic matter and release of different mineral salts in available forms such as phosphate, ammonium, and potassium etc[12]. In vermicompost set A1, the EC values have increased from 477.9 ± 0.05 Sm^{-1} to 523.2 ± 0.05 Sm^{-1} and in A2 the values have changed from 221.7 ± 0.05 Sm^{-1} to 413.2 ± 0.05 Sm^{-1}. Similarly in set B1 the EC got increased from 375.28 ± 0.05 Sm^{-1} to 467.28±0.05 Sm^{-1} and in set B2 it is from 356.28±0.05 to 462.11 ±0.05 $Sm^{-1.}$

The difference in the EC values of the sets A1 and A2, B1 and B2 are not significant ($P<0.05$) and statistically different when A1, A2 is compared with B1, B2 which could be attributed to the addition of cellulosic waste material to B1 and B2. Normally the TOC in final vermicompost sample was remarkably reduced at the end of the experiment. Data revealed that the loss of TOC was in range of about 21% to 15% in A1 and 22% to 12% in A2. The TOC reduction was directly related to cellulosic waste ie., the reduction was maximum for set B1 and B2 whereas minimum for set A1 and A2. This decrease in TOC during vermicomposting indicates net organic matter stabilization in the substrate due to combined action of earthworms and microorganism.

It has been reported that earthworms modify the substrate conditions, which subsequently enhance the carbon losses from the substrate through microbial respiration in the form[13] of CO_2. Normally 20-43% loss of organic carbon as CO_2 was observed during vermicomposting of cellulosic waste. Hence it is clear and visible that the maximum reduction of TOC in Set B1 and B2 is definitely due to the addition of cellulosic wastes. The TKN content in all vermireactors enhanced at the end of the vermicomposting period. The increment was maximum when cellulosic wastes were added. There is an increase in TKN content of the feed mixture from 0.61 ± 0.005 to 1.15 ± 0.005 in B1 and 0.89 ± 0.005 to 1.23 ± 0.005 in B2. In set A1 the TKN changed from 0.51 ± 0.005 to 10.92 ± 0.005 and in

A2 it is from 0.55 ± 0.005 to 1.04 ± 0.005. In our experiment the increase in TKN content was significantly more in Set B1 and B2 when compared to set A1 and A2. This may be due to the addition of cellulosic waste, which would make the earthworms to enhance the nitrogen mineralization in the substrate, so that the mineral nitrogen is retained in the nitrate form [14]. The C: N ratio is normally used as an index for indicating the maturity of organic wastes decomposition. As evident from the fig1, C: N ratio has got decreased from initial too final in both the sets. In set A1 it got decreased from 44 to 28%, and in set A2 it got decreased from 40% to 22%. Similarly in set B1 it got decreased from 34 to 13% and in set B2 it is from 30% to 19%. According to Senesi *et al*.[15] C: N < 20 indicate an advanced degree of organic matter stabilization and reflect a satisfactory degree of maturity of organic wastes. Hence in the present study, high degree of organic matter stabilization was achieved in set B1 and B2 than in set A1 and A2. Also it was found that there was a rapid reduction in C: N ratio after inoculation of cellulosic waste. The drift in C: N ratio reflects TOC reduction due to loss of carbon as CO_2 through microbial respiration and higher proportion of total nitrogen content in the final vermicompost must be due to the combined action of earthworms and micro flora.

The vermicomposting process requires moisture content of 70 to 90% . In composting the optimum moisture content varied[16] from 50 to 70%. In our experiment the moisture content was maintained around 60 to 70 % in all the sets throughout the process. After 90 days of experiment the worms worked in both set A and set B exhibit about 2 fold increase in total phosphorus (TP) in the final vermicompost compared to the phosphorus content in the initial stage. In set A1 the initial value 0.036 ± 0.005 where as in final it got increased to 0.093 ± 0.005 and in set A2 the initial value was 0.24 ± 0.005 where as in final it got increased to 1.12 ± 0.005. Similarly in set B1 the TP got increased from 0.62 ± 0.005 to 0.75 ± 0.005 whereas in set B2 it got increased from 0.93 ± 0.005 to 1.31 ± 0.005. This shows that there is significant difference in the phosphorus value ($p>0.05$) between set A and set B [17] reported that the release of phosphorus in available form is partly by earthworm gut phosphate solublizing microorganism in casts. The increased percentage of total phosphorus were high in set B1 and B2 than in set A1 and A2 which indicates the higher microbial activity due to addition of cellulosic waste during composting which in turn has been helpful for more mineralization of the waste employed.

Microbial population: Microbial colony counting by dilution plate method revealed that the THB total heterotrophic bacterial count in set A1 was $25x10^3$ and in set A2 it was $45x10^3$. In set B1 it was $50 x10^3$ and in set B2 it was 70x103. Hence the addition of cellulosic waste has showed the highest abundance of microbes. Application of leaf litter in the substrate must have enhanced the population of the above mentioned microorganisms in the vermicompost irrespective of the substrate used for earthworm feedingBacterial isolates appeared white and yellow in colour, irregular to round shaped colony, and small to medium sized colony on nutrient agar. Microscopic observation revealed that out of 4 different isolates 3 were rod-shaped and remaining 1 were in cocci shape. The results presented in **Table 1** were matched with those presented in Bergey's Manual of Determinative Bacteriology[18]. These characteristics suggest that isolates belong to genera *Bacillus, Pseudomonas, Micrococcus, Corynebacterium*

Table-1: Total heterotrophic bacterial count

Types	THBC
set A1	$25x10^3$
set A2	$45x10^3$
Set B1	$50 x10^3$
set B2	$70x10^3$

FT-IR analysis: FTIR spectra of all sets (A1, A2, B1 and B2) were figuratively represented in **(Fig 3, 4, 5 and 6.)** By comparing the initial and final stage 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 C-H stretch . The band at 1433 cm^{1} confirms the presence of amide group and 1641 cm^{-1} peaks indicates C=C aromatic group. This proves the partial mineralization of APB leaf waste. Comparing the initial and final stage spectra of B1 and B2 there is a presence of peak range of 3404 cm^{-1} ,2858 cm^{-1} ,1723 cm^{-1} , 1380 cm^{-1} , 1033 cm^{-1}.This indicate the change in –OH stretch, C-H stretch, aliphatic CH3 stretch and amide group respectively . This proves that the addition of nitrogen source along with the APB leaf waste shows some structural changes in both the sample B1 and B2 proving the nitrogen stabilization of the product. The reduced C:N ratio and these structural changes confirms the necessity of addition of cellulosic waste which acts as a nitrogen source as leaf litter and enhance the vermicompost process.

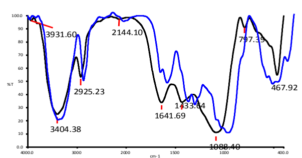

Fig.3: FTIR spectra of Set A1

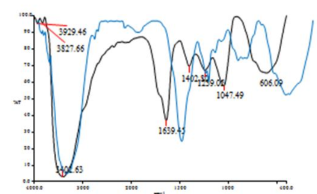

Fig.4: Ftir spectra of Set A2

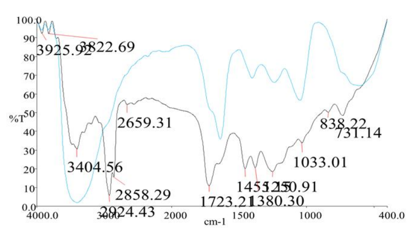

Fig.5: FTIR spectra of SetB1

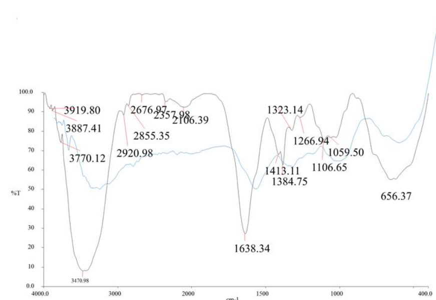

Fig.6: FTIR spectra of set B2

Table-2: Biochemical representation of isolated microorganism

Isolated colonies	shape	Gram staning	motility	indole	MR	VP	TSI	citrate	oxidase	catalas e	urease	Name of the genus
S1	Rods	Gram - ve	Non motile	-Ve	+ ve	-Ve	- ve	-Ve	+ ve	-Ve	-Ve	*shigella*
S2	Rods	Gram - ve	Motile	-Ve	+ ve	-Ve	+ ve	+ ve	-Ve	+ ve	+ ve	*proteus*
S3	Cocci	Gram + ve	Non motile	-Ve	+ ve	-Ve	+ ve	-Ve	-Ve	+ ve	+ ve	*Micro coccus*
S4	Rods	Gram - ve	Motile	-Ve	+ ve	-Ve	-Ve	-Ve	-Ve	+ ve	- ve	*salmonella*
S5	Cooci	Gram + ve	Non motile	- ve	+ ve	-Ve	+ ve	-Ve	+ ve	+ ve	+ ve	*Micro coccus*
S6	rods	Gram - ve	motile	- ve	+ ve	- ve	+ ve	+ ve	+ ve	+ ve	+ ve	*citrobacte r*

CONCLUSION

Hence in the present study a high degree of organic matter stabilization has been achieved in vermicompost preparation. On the basis of C: N ratio, the maturity and organic matter stabilization is found be higher with vermicompost using *Eudrilus eugenia* prepared from post consumer waste material than *Eisenia fetida*. This study thus demonstrates the role of earthworms and microbial population in rapid decomposition and rates of mineralization of APBL. This also proves the addition of leaf litter will enhance the degradation process. The FT-IR analysis clearly confirms the higher degree of degradation, since the spectra of the final compound has clearly depicted the presence of amide, aromatic and aliphatic a groups in the vermicompost samples.

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***Corresponding author: Vasanthy Muthunarayanan;** Department of Environmental Biotechnology, Bharathidasan University, Tiruchirappalli, Tamil Nadu, India