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Research article

DYNAMICS OF BIOLOGICAL, PHYSICAL AND CHEMICAL PARAMETERS DURING VERMICOMPOSTING OF MARKET WASTE MIXED WITH COW DUNG

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ABSTRACT: Vegetable-market solid waste is produced in millions of tones in urban areas and poses a problem of safe disposal. A study (100 days duration) was conducted to evaluate the efficiency of some of the exotic earthworm species *Eisenia foetida* and *Eudrillus eugenia* for decomposition of vegetable solid waste (VW) into valuable vermicompost. Vegetable waste was mixed with cow dung in 1:1 ratio to produce vermicompost. The period of vermicomposting was about seven weeks. The vermicompost caused a decrease in organic carbon (TOC) and Total organic mater (TOM) accompanied by an increase in Total Nitrogen (TKN) , available Phosphorus , Electrical conductivity (EC) , and pH was noticed. The nutrient-rich vermicompost with acceptable C: N ratio ranges (<20:1) indicates its agronomic potential. Waste mixtures also supported the earthworm growth and reproduction rates in vermibeds. The Microbial study of vermicompost revealed the presence of *Klebsiella, Micrococcus, Pseudomonas and Corynebacterium* species which have facilitated the degradation process. FT-IR (Fourier Transform Infrared Spectroscopy) analysis clearly revealed the degradation of organic matter using different earthworm species. The result suggests that vermicomposting can be an efficient technology to convert negligible vegetable-market solid wastes into nutrient-rich biofertilizer.
Keywords: Vermicomposting, Vegetable wastes, Eudrilus eugeniae, Eisenia foetida and FT-IR

INTRODUCTION

Every year, human, livestock and crops produce approximately 38 billion metric tons of organic wastes worldwide. The safe disposal and environmentally friendly management of these wastes have become a global priority. In India, the amount of waste generated per capita is estimated to increase at a rate of 1–1.33% tones annually [11]. In such conditions, the total waste generated in 2047 would be approximately above 260 million tons, more than five times the present level. This enormous increase in solid waste will have significant impacts in terms of the land required for disposing this waste as well as on methane emissions etc., Moreover, 40–60% solid wastes in India are of organic nature and open dumping of such garbage creates the issue of environmental pollution. [8] Suggest that organic waste can be converted into some useful products for agriculture and industries, if processed through cost-effective technique. Organic waste recycling is an efficient and environmental friendly technology to convert wastes into the value-added products. Composting is the most economical and sustainable option for onsite organic waste management as it is easy to operate and can be conducted in contained space. The decomposition of complex organic waste resources into odor-free humus-like substances through the action of earthworms is termed vermicomposting. The vermicomposting is stabilization of organic material through the joint action of earthworms and microorganisms. [5]. While microbes are responsible for biochemical degradation of organic matter, earthworms are the important drivers of the process, conditioning the substrate and altering the biological activity. In vermibeds, earthworms maintain aerobic conditions in the organic wastes, ingest solid, convert a portion of the organics into worm biomass and respiration products, and expel the remaining partially stabilized product, i.e., vermicompost. Vermicompost is a stabilized product having greater contents of most nutrients in forms that are readily taken up by the plants. Several epigeic earthworms, e.g., *Eisenia foetida*, *Perionyx excavatus*, *P. sansibaricus*, *Eudrilus eugeniae* and *Eisenia andrei* have been identified as detritus feeders and can be used potentially to minimize the wastes from different sources [13].

The present study is therefore aimed in utilizing vegetable wastes along with cow dung for the preparation of vermicompost using the earthworm species such as *Eudrillus eugenia and Eisenia foetida* and also to monitor the physico chemical characteristics along with the bacterial population in the resultant vermicomposts prepared. A one-way analysis of variance was therefore conducted for each response studied. The prepared vermicompost was subjected to Fourier Transform Infrared Spectroscopy (FT–IR) analysis in order to interpret the degree of stabilization of the organic matter.

MATERIAL AND METHODS

The cow dung, vegetable wastes and two different earthworm species were used for the waste degradation process. The different kind of waste preparation includes **(C1)** - vegetable waste + cow dung (**Control**), (**C2**) **-** vegetable waste + cow dung + earthworm ***Eisenia foetida*** and **(C3)** – vegetable waste + cow dung + earthworm ***Eudrillus eugenia.***

Three different set of experiments were conducted. The first set of experiment was carried without earthworm as control. The second set of experiment was undertaken to study the role of *Eisenia foetida* on the quality of vermicompost produced. The third set of experiment was undertaken to study the role of *Eudrillus eugenia* on the quality of vermicompost produced This was studied in terms of various parameters such as pH, EC, TOC, TKN, TOM, C:N ratio, Phosphorus and bacterial population.

Composting process experiments

Experiments were performed in three plastic containers (measuring 0.56 m × 0.38 m × 0.25 m length × breadth × depth) which were filled with the feed mixture. The first two containers with feed mixtures were subjected for vermicomposting using *Eisenia foetida* and *Eudrillus eugenia* .The optimized initial feed mixture (w/w) ratios used was 500 g vegetable waste, 500 g cow dung slurry. The plastic containers were labeled as C1, C2 and C3. The mixtures were turned over manually everyday for a period of 15 days in order to eliminate volatile substances that are toxic to the earthworms. After 15 days, 50g of *Eudrillus eugenia* earthworms were introduced into the second containers named as C2. About 50g of *Eisenia foetida* were introduced into the third containers named as C3. The moisture content was maintained at 60–70% throughout the study period by periodic sprinkling of adequate quantities of water. The samples were taken and were analyzed for the physico-chemical parameters.

Chemical analysis

The pH and EC were estimated using the pH meter (Elico model LI–127) and Electrical conductivity meter (Elico model LI 80), respectively. These values were recorded continuously throughout the experimental period. The moisture determination was made as per Tandon [14]. Organic carbon analysis of compost extracts were estimated using the Walky and Black method [16]. The total nitrogen content of the manure was estimated by the micro Kjeldahl method as per Tandon [14].

Fourier Transform Infrared Spectroscopy (FTIR)

Two milligrams of finely ground compost was mixed with 400mg of KBr and was compressed under vacuum for 10 min. The FT-IR spectra were then recorded on KBr pellets between 4000 and 400 cm^{-1}, at a rate of 16nm/s, using a PerkinElmer 1600 FTIR spectrophotometer, with precautions taken to avoid moisture uptake. [9].

Identification of bacterial colonies from vermicompost samples:

The microorganisms isolated from the soil were identified by employing the schematic procedure outlined by [4] which includes Gram staining and biochemical tests. Viable plate count was determined by the dilution method and the results were expressed as CFU of mesophilic bacteria. Petri plates were incubated at 28°C for the growth of the mesophilic bacteria.

RESULTS AND DISCUSSION

Variation in pH, EC and Phosphorus:

As shown in fig 1,2 and 3 there are changes observed in the pH of final stage product when compared to initial stage. The pH has increased to alkaline in all the bins namely C1, C2 and C3. This pH increase in the end product confirms the release of ammonia from the nitrogenous compounds followed by the completion of the process. This observation is in accordance with the observations of [7]. Whereas the EC has shown an increase in its value from 365.48±0.01 - 454.54 ±0.01 µs/cm in C1, 357.61 ±0.01 - 412.90 ±0.01 µs/cm in C2 and 344.81 ±0.01 - 398.01 ±0.01 µs/cm in C3. (Fig: 1,2 and 3).

The EC value of C2 and C3 were significantly different from EC value of C1 ie. ($P<0.05$) This increase in EC may be due to loss of organic matter and release of different mineral salts in available forms such as phosphate, ammonium, potassium ions etc [6]. The phosphorus content in the C1, C2 and C3 sample has got increased finally (fig 1,2 and 3).The initial TP ranged between 0.82±0.01 in C1, 0.81±0.01 in C2 and 0.72±0.01 in C3 but, the final TP in vermicompost was in the range of 1.1±0.01,1.06±0.01 and 0.97±0.01. Hence the phosphrous value of C2 and C3 were significantly different from phosphrous value of C1 ($P<0.05$). The worm activity is performed partly by earthworm gut phosphates and further release of TP might be attributed to the P- solubilizing microorganisms present in worm casts [11].

Variation in TOC, TOM, TKN, C: N:

There was a marked reduction in the TOC and TOM (fig 1,2 and 3) in the final vermicompost prepared from vegetable waste using both *Eisenia foetida* and *Eudrillus eugenia*. Data revealed that the TOC loss was highest in C3 (19.64±0.18 to 12.24±0.18) than in C2 (22.01±0.18 to13.01±0.18) and in C1 (22.64±0.18 to 15.2±0.18). The decrease in TOC after vermicomposting indicates the net organic matter stabilization in the substrate due to combined action of earthworms and microorganisms. [5]. Whereas the TKN has shown an increase from 0.55-1.23% for vermicompost prepared from vegetable waste using *Eisenia foetida* and from 0.62 to 1.34 % for vermicompost prepared from vegetable waste using *Eudrillus euginea*. In our experiment, the difference in the TKN value of C2 and C3 are significantly different from C1 ($P<0.05$). The losses in organic carbon might be responsible for nitrogen addition. During the process of vermicomposting, the earthworms enhanced the nitrogen mineralization in the substrate, so that the mineral nitrogen is retained in the nitrate form [2]. The C:N (fig 1,2 and 3) ratio has reduced substantially from 28.98±0.01 to 10.2±0.01 in vermicompost prepared from vegetable wastes using *Eisenia foetida* (C2)and it has reduced from 35.5±0.01 to 11.31±0.01 in vermicompost prepared from vegetable waste using *Eudrillus euginea* (C3). Whereas in C1 the reduction was from 28.98±0.01 to 10.14±0.01. The drift in C:N ratio reflects TOC decrease due to loss of carbon as CO_2 through microbial respiration and a higher proportion of total nitrogen content in the final vermicompost added by the combined action of earthworms and microflora. Decline of C: N ratio to less than 20 indicates an advanced degree of organic matter stabilization and reflects a satisfactory degree of maturity of organic wastes. Our results conclude the role of earthworms in much more rapid decomposition and rates of mineralization of organic matter.[10].

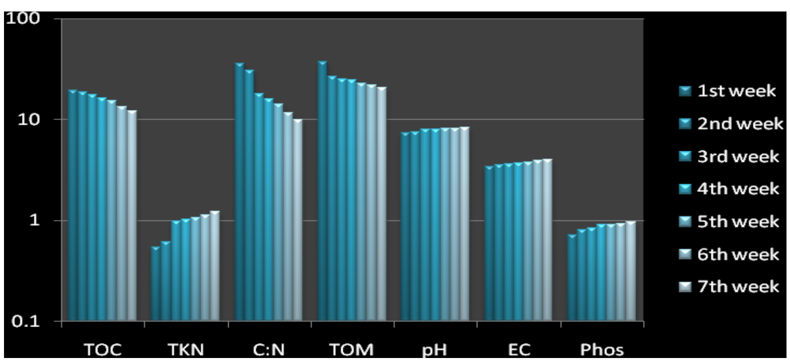

Fig 1Comparison of physico chemical parameters in C1(Control)

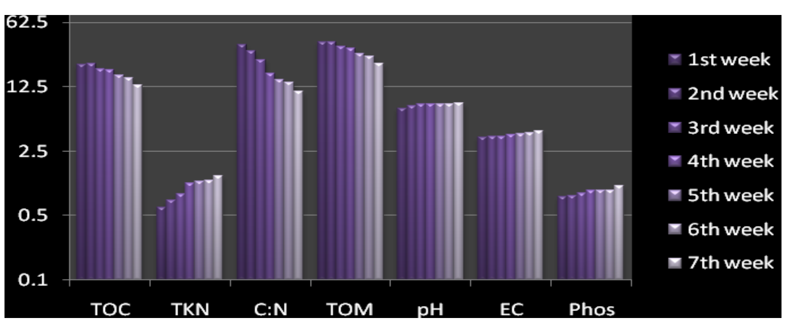

Fig 2 Comparison of physico chemical parameters in C2(*Esenia fetida*)

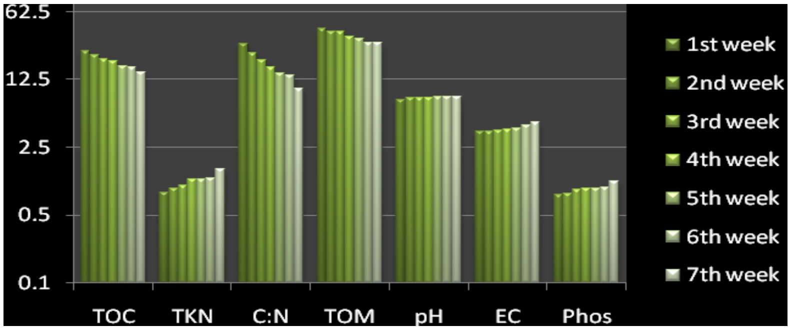

Fig 3Comparison of physico chemical parameters in C3 (*Eudrillus Eugenia*)

Isolation and Identification of Microorganisms

The bacterial genus identified in the vermicompost were *Pseudomonas, Enterobactor, Klebsiella sp.,* and *Micrococcus sp.,* and the THB population clearly suggests the reduction of the bacterial population during the composting using earthworms as shown in Table 1 and 2.

Table-1: Isolation of heterotrophic bacteria

S.No	Compost	Total Heterotrophic bacterial population (CFU/ml)	
		Before	After
1	S1	THTC	67 X 10¯4
2	S2	THTC	97 10¯4
3	S3	THTC	96 X 10¯4

Table: 2 Identification of isolated organism using Biochemical test

S.No.	Isolated colonies	Shape	Gram staining	Motility	Indole	MR	VP	TSI	Citrate	Oxidase	Catalase	Urease	Name of the genus
1	S1	Cocci	Gram positive	Non motile	-ve	-ve	-ve	-ve	- ve	-ve	+ve	+v	***Micrococcus***
2	S2	Rods	Gram positive	Non motile	-ve	-ve	+ve	-ve	+ve	-ve	+ve	+ve	***Klebsiella***
3	S3	Rods	Gram negative	Motile	-ve	-ve	-ve	-ve	+ve	+ve	+ve	-ve	***Pseudomonas***
4	S4	Rods	Gram positive	Motile	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve	***Coryne bacterium***

FT-IR analysis

The chemical structure of the material can be obtained through FTIR analysis. The presence or absence of bands in the spectra which are due to functional groups or metabolite products indicates the degradation or stabilization of the bio waste during bioconversion process. The FT-IR spectra of vegetable waste in C1, C2 and C3 were shown in (Fig4). The present study of FT-IR are well interpreted based on references of [16, 5 and 9].

A broad band at around 3934–3933 cm^{-1} due to O-H stretching vibration was found in all the materials. Similarly, two distinct peaks around 1595 cm^{-1} and 1363 cm^{-1} in C3 and C2 sample shows that the transmission got increased so the intensity of the peaks got decreased proving that there is slight reduction in aromatic compound. Further the disappearance of peaks at 2927 cm^{-1} in C3 sample and a peak around 2927-2930 cm^{-1} in C2 sample shows the slight degradation in aliphatic compounds. Compared to C1, the peaks around 1050 cm^{-1} and 1079 cm^{-1} in C3 and C2 sample indicates that the transmission has got increased so that the intensity of the peaks has got decreased proves the slight degradation of polysaccharides. Compared to C1, there are some changes in C2 and C3 sample. FT-IR spectra proves that the aliphatic, aromatic and polysaccharide regions leveled off during the experimental process, indicating that vermicomposting had become more uniform and stable at the end of the process.

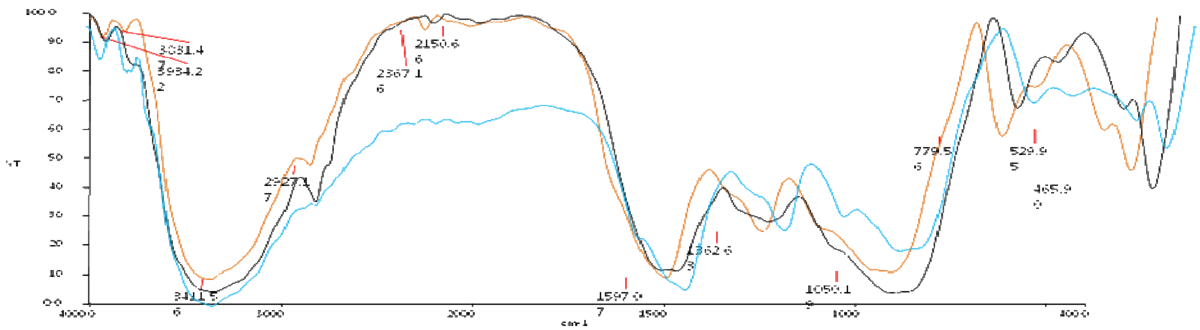

Fig 4: comparision of the FTIR spectra of vegetable waste in C1, C2 and C3

CONCLUSION

Hence in the present study a higher degree of organic matter stabilization has been achieved in both vermicompost preparations. On the basis of C: N ratio, the maturity and organic matter stabilization is found be higher with vermicompost prepared from vegetable wastes using *Eudrillus eugenia* than using *Eisenia foetida* sp. This study thus demonstrates the role of earthworms and microbial population in cow dung to result in rapid decomposition and higher rates of mineralization of wastes (Vegetable waste). The FTIR spectroscopy of the vermicompost showed reduction in aliphatic as well as aromatic compound from the vegetable waste and increase in nitrogen containing compounds which clearly confirms the higher degree of degradation thereby facilitating solid waste management and reducing pollution.

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