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Research article

BIOCONVERSION OF FRUIT WASTE INTO VERMICOMPOST BY EMPLOYING *EUDRILLUS EUGENIAE AND EISENIA FOETIDA*

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ABSTRACT: The increasing waste generation rate, high collection cost and dwindling financial resources are the major problems faced by most of the developing countries for efficient solid waste management. In some cities, the organic wastes (Market waste, vegetable, Fruit, Garden waste) are dumped indiscriminately or littered on the streets causing environmental deterioration. Biological processes such as composting are followed by Vermicomposting to convert fruit waste as valuable nutrient source, namely manure. The aim of this study was to convert fruit waste amended with cow dung and soil into Vermicompost using both *Eisenia fetida* and *Eudrillus eugenia.* Fruit waste was mixed with cow dung in 1: 1 ratio and the two varieties of earthworm were introduced individually. Vermicomposting was performed for the period of 45 days. Vermicomposting of Fruit waste resulted in net reduction of TOC (Total Organic Carbon) (19.01-13.02%)and (19.01-12.88%), Phosphorus(0.75-1.06mg/L) and (0.82-1.08 mg/L) and C: N (Carbon: Nitrogen) ratio(21.80-11.21%), (20.79-10.81%) but it has resulted in an increase of TKN (Total Kjeldhal Nitrogen) (0.65-1.51%) and (0.67-1.54%), pH (7.86-8.5) and (7.66- 9.2)& EC (Electrical Conductivity) (312.48-354.13 Sm¯1) and (306.91-362.52 Sm¯1) with *Eudrillus Eugenia* and *Eisenia fetida respectively*. The Microbial study of vermicompost revealed the presence of *Klebsiella, Micrococcus, Pseudomonas and Enterobacter* species which have helped in degradation process. FTIR (Fourier Transform Infrared Spectroscopy) analysis clearly revealed the degradation of organic matter using different earthworm sps.
Keywords: Vermicomposting, fruit wastes, Eudrilus eugeniae, Eisenia fetida, FTIR

INTRODUCTION

Solid wastes are perceived as undesirable matter that is generated from human and animal activities. The sources of solid waste include various sectors such as residential, industrial, commercial, institutional and agricultural premises. The composition and characteristics of municipal solid waste (MSW) vary throughout the world, with variations noted in factors such as social and customary norms, standard of living, geographical location and climate. The processing of the organic fractions of MSW into useful organic amendments via thermophilic aerobic composting is a technique that has been used to address the issues of environmental pollution by biodegradable organic solid wastes, reduced reliance on chemical fertilizers, sustainable natural soil fertility, and the minimization of development of new dumps and landfills [15].

Solid wastes can be treated by using various methods such as biological treatment and physical treatment. Composting, which comes under biological treatment, has been reported as the best method for organic MSW management [13]. Vermicomposting is a simple biotechnological variant of the conventional composting process in which certain species of earthworms are used to enhance the process of biological waste decomposition and conversion to produce a better end product [8, 2 &12]. The use of earthworms for the biodegradation of organic wastes has been reported to be a positive development in the biological waste management [9]. The epigeic earth worm *Eisenia foetida* has been extensively used to produce vermicompost from different plant residues, city refuse and sewage sludge because of its rapid growth rate, early sexual maturity and extensive reproduction [5&7].reported that *D. veneta, Eudrilus. Eugenia, P. excavates* and *P. hawayana* and *Eisenia foetida* to be the most capable earthworms to breakdown the organic refuse.

These earthworms could adapt relatively well to different types of organic wastes, provided the physical structure, pH and the salt concentration were not above the tolerance level for each earthworm species [18]. The earthworms derive their nourishment from microorganisms that grow upon these materials and at the same time they promote further microbial activity since the faecal material or 'casts ' they produce is more fragmental and microbially active than what was consumed initially [7]. During the process of composting the important plant nutrients in the materials (particularly nitrogen, potassium, phosphorus and calcium) are released and converted through microbial action into forms that are more soluble and bio available to plants. [15] It has been found that earthworms necessarily have to feed on microbes, particularly on fungi for their protein /nitrogen requirement [16].

The present study is therefore aimed at utilizing fruit wastes along with cow dung and soil for the preparation of vermicompost using *Eudrilus eugenia and Eisenia foetida* earthworms and also to monitor the pH, electrical conductivity, Total Organic Carbon (TOC), Total Kjeldahl Nitrogen (TKN), carbon to nitrogen (C:N) ratio along with the bacterial population of the resultant composts. Further it was aimed to subject the vermicompost to Fourier Transform Infrared Spectroscopy (FTIR) analysis in order to interpret the degree of stabilization of the organic matter.

MATERIAL AND METHODS

The cowdung, fruit waste and two different earthworm species were used for the waste degradation process. The different kinds of waste preparation includes **(C1)-**Fruit waste + cow dung + soil (**Control**)(C2)- Fruit waste + cow dung + soil + Earthworm (***Eisenia foetida*** **).(C3) -** Fruit waste + cow dung + soil + Earthworm (***Eudrillus eugenia***).

Three different sets 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 *Eudrilus eugenia* on the quality of vermicompost produced This was studied in terms of various parameters such as pH, EC, moisture content, TOC, TKN, C:N ratio and bacterial population .

COMPOSTING PROCESS EXPERIMENTS

Three plastic containers (diameter 0.14 m and depth 0.12 m) were filled with the feed mixture. The first two containers with feed mixtures were subjected for vermicomposting using *Eisenia foetida* and *Eudrilus eugenia* The optimized initial feed mixture (w/w) ratios used was 500 g fruit waste, 500 g cow dung slurry, and100 g of finely sieved soil. The plastic containers were labelled asC1, C2 and C3. The mixtures were turned over manually everyday for 15 days in order to eliminate volatile substances that are toxic to the earthworms. After 15 days, 50g *Eisenia foetida* earthworms were introduced into the second containers named as C2.About 50g *Eudrilus eugenia* were introduced into the third container named as C3 . The moisture content was maintained at 60–76% throughout the study period by periodic sprinkling of adequate quantities of water. The samples were taken and were analyzed for pH, EC, TKN, TOC, C: N and bacterial count.

CHEMICAL ANALYSES

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 (1). Organic–C analysis of compost extracts were estimated using the [22]. The total nitrogen content of the manure was estimated by the micro Kjeldahl method as per [21].

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.

FOURIER TRANSFORM INFRARED SPECTROSCOPY (FT–IR)

Two milligrams of finely ground compost was mixed with 400mg of KBr and compressed under vacuum for 10 min. The FTIR 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.

RESULTS AND DISCUSSION

VARIATION IN PH, EC AND PHOSPHORUS:

As shown in table 1 there were little changes in the pH of vermicompost when compared to initial values. The pH has increased to alkaline in all the bins namely C1, C2 and C3. (Fig:1) 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 (14), whereas the EC has shown an increase in its value from 313.41 to 413µs/cm in C1, 312.48-354.13 µs/cm in C2 and 306.91- 362.52 µs/cm in C3. (fig: 2) The increase in EC is due to loss of organic matter and release of different mineral salts in available forms such as phosphate, ammonium, potassium ions etc [11].The phosphorus content in the C1, C2 and C3 sample has got increased finally (Fig 3).

VARIATION IN TOC, TOM, TKN, C: N:

There was a marked reduction in the TOC (fig 4) and TOM (fig 5) in the final vermicompost prepared from both fruit waste using *Eisenia foetida* and *Eudrillus eugenia*. This finding has been supported by other workers (10) who reported about 30% reduction in TOC content. It may be due to the microbial respiration. Similar result has been reported by (19).

Whereas the TKN (fig 6) has shown an increase from 0.65%-1.51% for vermicompost prepared from fruit waste using *Eisenia foetida* and from 0.67%-1.54% for vermicompost prepared from vegetable waste using *Eudrillus euginea*. The losses in organic carbon might be responsible for nitrogen addition. This increase has been found to completely depend on the substrates which are being added as fuel to the earthworms with their physical structure and chemical composition. And the increased nitrogen may be due to nitrogenous metabolic products which are returned to soil through casts, urine, macro protein, and earthworm tissue [14].

The C: N (fig 7) ratio has reduced substantially from 21.80 to 11.21 in vermicompost prepared from fruit wastes using *Esienia foetida* and it has reduced from 20.79 to 10.81 in vermicompost prepared from fruit waste using *Eudrillus eugenia*. 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 [17]

Table:1 Characteristics of the Vermicomposting on different weeks of composting with standard error

Components	weeks	TOC %	TKN %	C:N %	TOM %	PH	EC µs/cm	Phosphorous%
Fruit waste (Control) C1	Initial	19.01±0.005	0.65±0.002	23.07±0.005	34.77±0.005	7.7±0.08	313.41±0.005	0.75± 0.002
	1	16.92±0.003	0.68±0.002	20.93±0.005	33.91±0.005	7.7±0.08	314.34±0.005	0.78± 0.005
	2	15.48±0.005	0.68±0.005	19.32±0.002	32.08±0.005	7.8±0.05	320.85±0.005	0.83±0.006
	3	14.06±0.015	0.71±0.005	17.55±0.005	30.23±0.005	7.86±0.002	334.80±0.002	0.88±0.005
	4	13.91±0.005	0.84±0.005	15.30±0.002	29.41±0.005	8.13±0.005	333.16±0.005	0.96±0.002
	5	13.8±0.002	0.97±0.002	14.5±0.005	29.23±0.005	8.33±0.005	342.12±0.005	0.98±0.006
	6	13.62±0.005	1.3±0.002	12.08±0.005	28.73±0.005	8.46±0.005	350.10±0.002	1.01±0.005
Vermicomposting of Fruit waste using *Eisenia foetida* C2	Initial	19.01±0.005	0.65±0.002	21.80±0.002	34.94±0.005	7.86±0.05	312.48±0.005	0.75±0.005
	1	15.48±0.005	0.93±0.005	20.67±0.005	33.23±0.005	7.86±0.05	323.64±0.005	0.78±0.002
	2	15.4±0.005	1.02±0.002	17.48±0.005	32.23±0.005	8.1±0.005	323.64±0.005	0.84±0.005
	3	14.9±0.005	1.12±0.005	15.92±0.01	30.01±0.002	8.23±0.05	325.49±0.002	0.88±0.002
	4	14.34±0.005	1.13±0.005	12.97±0.007	29.41±0.007	8.6±0.28	329.45±0.005	0.96±0.005
	5	13.58±0.01	1.21±0.002	12.06±0.005	29.18±0.005	8.8±0.05	340.62±0.005	0.98±0.005
	6	13.02±0.005	1.51±0.002	11.21±0.005	26.38±0.002	8.5±0.08	354.13±0.005	1.06±0.005
Vermicomposting of Fruit waste using *Eudrillus eugenea* C3	Initial	19.01±0.005	0.67±0.007	20.79±0.002	33.91±0.005	7.66±0.28	306.91±0.005	0.82±0.005
	1	15.38±0.005	0.93±0.007	19.37±0.22	29.18±0.005	7.66±0.28	312.47±0.002	0.84±0.005
	2	15.26±0.005	1.07±0.04	16.68±0.002	26.68±0.005	8.1±0.05	321.78±0.005	0.88±0.002
	3	14.54±0.005	1.14±0.005	15.53±0.005	25.74±0.005	8.43±0.02	324.50±0.002	0.93±0.005
	4	14.23±0.005	1.47±0.002	11.6±0.005	23.98±0.005	8.63±0.02	334.81±0.005	0.95±0.005
	5	13.41±0.005	1.46±0.005	11.52±0.002	23.80±0.002	8.8±0.005	350.62±0.005	1.03±0.005
	6	12.88±0.005	1.54±0.005	10.81±0.002	20.43±0.005	9.26±0.28	362.52±0.002	1.08±0.005

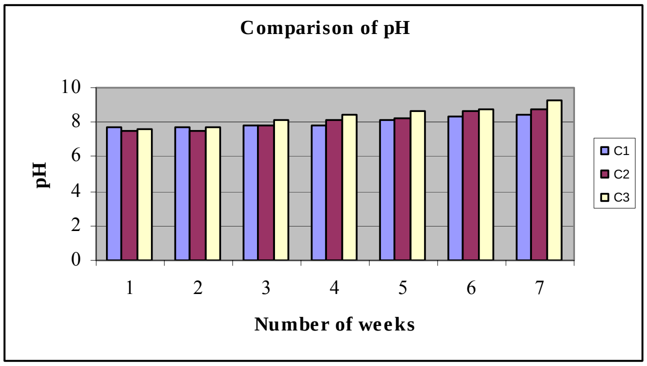

Fig 1: COMPARISON OF pH OF DIFFERENT TYPES OF VERMICOMPOST

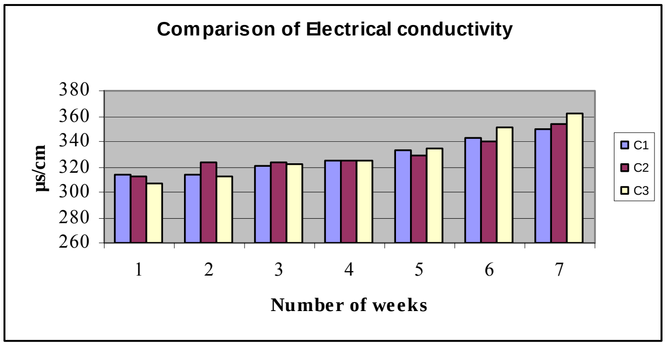

Fig 2: COMPARISON OF ELECTRICAL CONDUCTIVITY OF DIFFERENT TYPES OF VERMICOMPOST

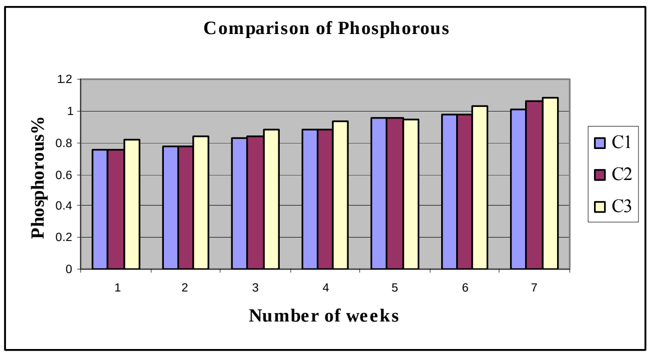

Fig3: COMPARISON OF PHOSPHORUS OF DIFFERENT TYPES OF VERMICOMPOST

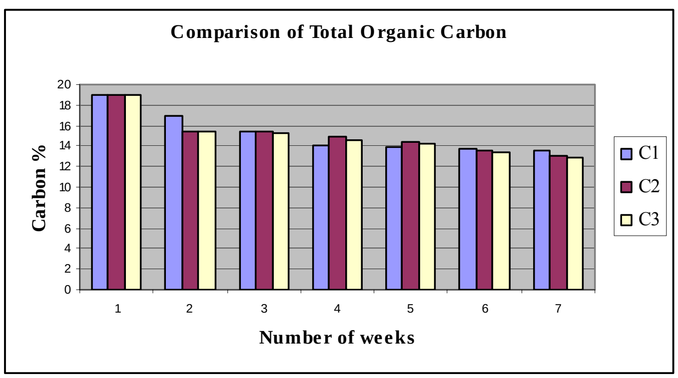

Fig 4 COMPARISON OF TOTAL ORGANIC CARBON OF DIFFERENT TYPES OF VERMICOMPOST

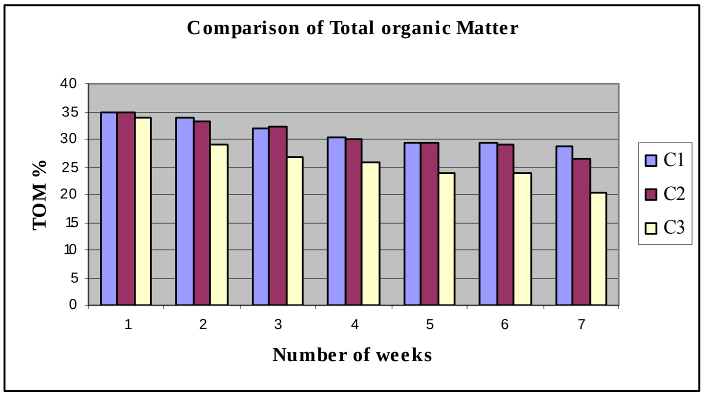

Fig 5 COMPARISON OF TOTAL ORGANIC MATTER OF DIFFERENT TYPES OF VERMICOMPOST

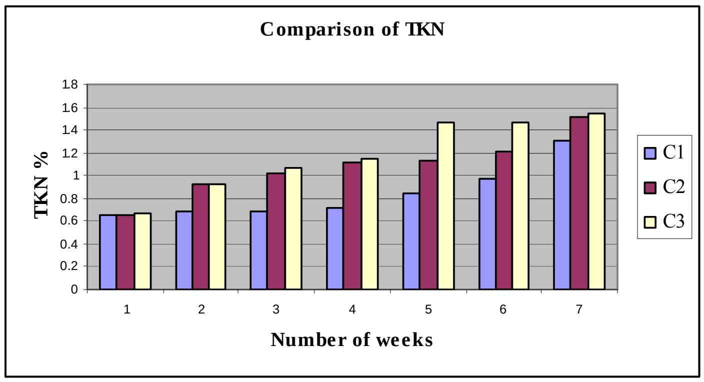

Fig 6 COMPARISON OF TKN OF DIFFERENT TYPES OF VERMICOMPOST

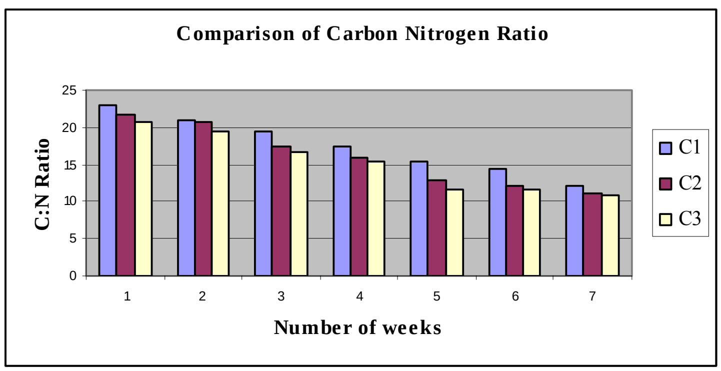

Fig 7 COMPARISON OF C: N RATIO OF DIFFERENT TYPES OF VERMICOMPOST

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 2 and 3.

Table 2 Total Bacterial count of Vermicompost:

S.No	Compost	Total Heterotrophic bacterial population(CFU/ml)	
		Before	After
1.	C1 (control)	THTC	$25X10^{-3}$
2.	C2	THTC	$70X10^{-3}$
3.	C3	THTC	50X10?^{3}

Table 3: Biochemical test result for the Identification of heterotrophic bacteria:

S.No	Isolated colonies	Shape	Gram staining	Motility	Indole	MR	VP	TSI	Citrate	Oxidase	Catalase	Urease	Name of the genus
1.	C1	rod	Gram negative	-ve	-ve	-ve	+ve	-ve	-ve	-ve	+ve	+ve	***Klebsciella***
2.	C1	rod	Gram negative	+ve	-ve	-ve	+ve	-ve	-ve	-ve	+ve	+ve	***Micrococcus***
3.	C2	rod	Gram negative	+ve	-ve	-ve	-ve	-ve	+ve	+ve	+ve	-ve	***Pseudomonas***
4.	C3	rod	Gram negative	+ve	-ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	***Enterobacter***
5.	C3	rod	Gram negative	+ve	-ve	-ve	+ve	-ve	+ve	-ve	+ve	+ve	***Enterobacter***
6.	C2	rod	Gram negative	+ve	-ve	-ve	-ve	-ve	+ve	+ve	+ve	-ve	***Pseudomonas***

FTIR Spectras of the Vermicomposts:The FTIR spectra of the control and vermicompost samples with *Eisenia foetida* and *Eudrillus Eugenia* are compared (Fig 8 to 11).

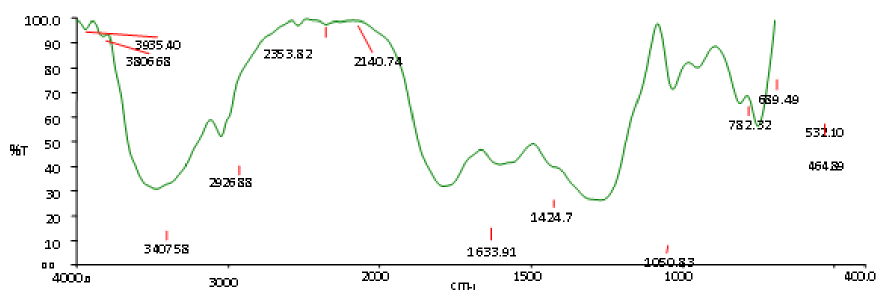

Fig: 8 FTIR Spectrum of C1 (initial)

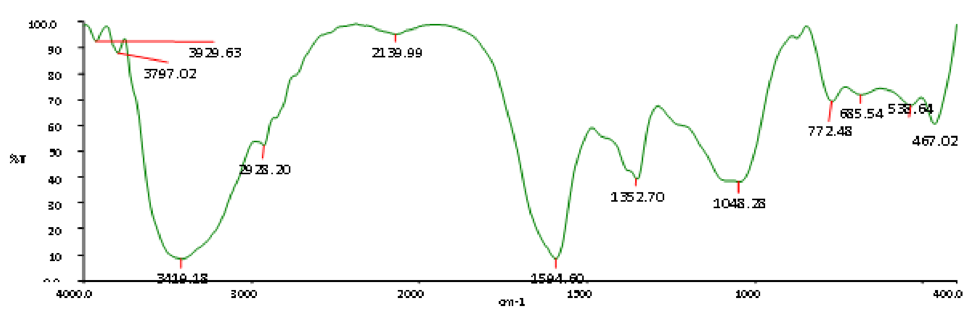

Fig: 9 FTIR Spectrum of C1 (final)

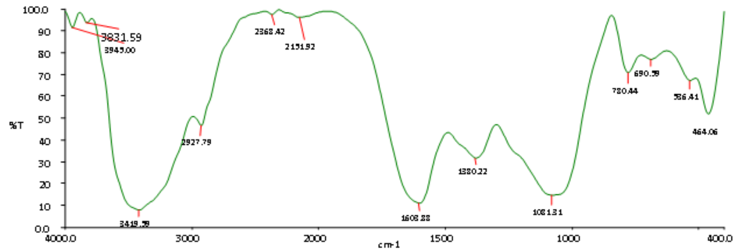

Fig: 10 FTIR Spectrum of C2 (final)

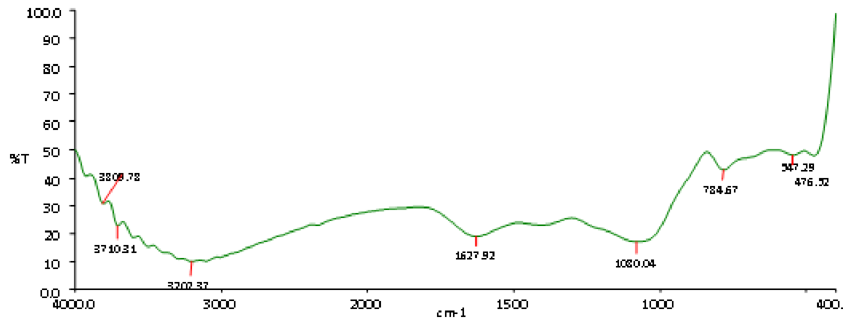

Fig: 11 FTIR Spectrum of C3 (final)

While comparing C1 and C2 sample, the hydrogen bond due to –OH stretch was observed at 3935.40 and the appearance of new peaks in the region of 3831.59 at C2 indicates that there are some chemical changes in –OH stretch. There is increase in the intensity of peaks from 3407.58 to 3419.18 which may be due to C-H bonds and OH groups. The appearance of new band at 2353.82 and 1352.70 may be due to formation of CH_2 and CH_3 acid group. Further there is an increase in the intensity of peaks from 2926.88 to 2928.20 which may be due to aliphatic C-H stretching. And the appearance of new peaks at 1594.60 indicates the formation of amides. Further there is a decrease in the intensity of peaks from 1050.83-1048.28 which indicates the formation of OH ions. While comparing the C1 and C3 sample the decrease in the intensity of peaks around 3710.31 and 3202.37 indicate the degradation in OH stretches and C-H groups. The increase in the intensity of peaks from 1050.83 to 1080.04 indicates the formation of OH groups.
The results confirm that there is more reduction of aromatic structures, aliphatic and polysaccharides in the Vermicompost using *Eudrillus eugenia* than the Vermicompost using *Eisenia foetida*. This is associated to organic matter mineralization and it indicates the maturity and stability of the final product when compared to the control.

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 prepared from fruit wastes using *Eisenia foetida* than the *E. Eugenia* This study thus demonstrates the role of earthworms and microbial population which could facilitate rapid decomposition and the rate of mineralization of wastes (organic matter). The FTIR analysis clearly confirms the higher degree of degradation, since the spectra of the final compound has clearly depicted the presence of amide groups in the vermicompost samples prepared from fruit wastes.

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