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ANALYSIS OF FUNCTIONAL GROUPS IN THE VERMICOMPOST OF FRUIT WASTE USING *EUDRILUS EUGENIAE*

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ABSTRACT

Environmental degradation is a major threat confronting the world and the rampant use of chemical fertilizers contributes largely to the deterioration of the environment through depletion of fossil fuels, generation of carbon dioxide and contamination of water resources. Vermicomposting, which involves the composting of organic wastes through earthworm activity, has proven to be successful in processing sewage sludge and solids. The objective of the research is to assess the presence of functional groups in the vermicompost through FTIR analysis and to estimate the degradability of fruit waste into useful manure through vermicomposting. Fruit waste used was banana and papaya in the vermicomposting process by *Eudrilus eugeniae*. Respective controls were maintained devoid of earthworms for a period of 60 days. FTIR Analysis was carried out on the 60th day. The vermicompost of banana waste showed strong peaks for the functional groups amides and amines. The vermicompost of papaya waste showed strong peaks for the functional groups ketone, aldehyde and amides. The results confirm that there is more reduction of aromatic structures, aliphatic and polysaccharides in the vermicompost using *Eudrilus eugeniae*.

KEYWORDS: Vermicomposting, FTIR, Functional groups, Eudrilus eugeniae, fruit waste.

INTRODUCTION

Environmental degradation is a major threat confronting the world and the rampant use of chemical fertilizers contributes largely to the deterioration of the environment through depletion of fossil fuels, generation of carbon dioxide and contamination of water resources. It leads to loss of soil fertility due to imbalanced use of fertilizers that has adversely impacted agricultural productivity and causes soil degradation. Now there is a growing realization that the adoption of ecological and sustainable farming practices can only reverse the declining trend in the global productivity and environment protection (Aveyard, 1988; Wani and Lee, 1992; Waniet *al.*, 1995).

Vermicomposting, which involves the composting of organic wastes through earthworm activity, has proven to be successful in processing sewage sludge and solids from wastewater (Neuhauser*et al.*, 1988; Dominguez *et al.*, 2000), materials from breweries (Butt, 1993), paper waste (Butt, 1993; Elvira *et al.*, 1995), urban residues, food and animal wastes (Allevi*et al*., 1987; Edwards 1988; Elvira *et al.*, 1996) as well as horticultural residues from processed potatoes, dead plants and the mushroom industry (Edwards, 1988).

Benitez *et al.*, (1999) concluded that in the vermicomposting process, inoculated earthworm rich and complex organic substances into stabilized humus-like product maintains aerobic condition in the organic wastes, converts a portion of the organic material into worm biomass and respiration products and expels the remaining partially stabilized product. The potential of some epigeic earthworm to recycle organic waste materials into value-added products is well documented (Kale *et al*., 1982; Elvira*et al*., 1998; Garg and Kaushik, 2005; Garg*et al*., 2006; Suthar, 2006).

Coimbatore is an important industrial city in Tamil Nadu. Urban population of the city has increased from 14.61 lakhs in 2001 to 21.51 lakhs in 2011. Hence, the demand for fresh fruits and vegetables has also increased over the years. Cultivation of fruits and vegetable is picking up in the peri-urban areas of the city due to better demand prediction, easy market access, reduced transportation cost and assured market. Hence, the demand of fruits and vegetable of Coimbatore city is mostly met from the peri-urban areas. Banana is an important fruit commonly present in the food basket of most of the consumers in the city.

The present study primarily deals with the management of different types of fruit waste generated in vegetable markets, fruit shops and Juice outlets using the earthworm *Eudrilus eugeniae*. The performance of the composting process and the quality of the end product is assessed by the combined application of independent methodologies like physical, chemical, microbiological and statistical methods for the determination of its stability as manure. The objective of the research is to assess the presence of functional groups in the vermicompost through FTIR analysis and to estimate the degradability of fruit waste into useful manure through vermicomposting.

MATERIALS AND METHODS

The earthworm species, *Eudrilus eugeniae* was obtained from the vermicompost pit of Nirmala College for Women (Autonomous), Coimbatore.

Two different types of fruit waste generated from Pazhamudhir Nilayam, Vegetable market Coimbatore were collected and segregated as banana peel waste and papaya peel waste. The fruit wastes were shredded manually. Cow dung was obtained from a local cowshed and was sun dried and flaked.

The experiment was conducted in square plastic pots measuring 17 ×17 ×17 cm of length, breadth and height respectively. Holes were drilled at the bottom of the pots so as to drain excess water. The pots were filled from bottom up with successive layers of pebbles, coconut husk, cow dung flakes and shredded fruit peels respectively. The fruit waste was mixed with cow dung flakes in the ratio of 1:1. All pots were maintained in triplicates. Water was sprinkled daily on all pots to maintain the moisture content and turned at regular intervals for proper mixing and aeration. The experimental pots were kept under shade and covered with gunny bags to prevent moisture loss. This setup was maintained for 15 days for partial degradation and stabilization. After 15 days, 20 non-clitellated earthworms were introduced into each treatment pots containing banana peel waste and papaya peel waste. The control pots of banana peel waste and papaya peel waste were devoid of earthworms. This setup was also sprinkled with water daily and was monitored for a period of 60 days. On the 60th day of the experimental period, the samples of compost and vermicompost from all experimental units were collected and used for FTIR analysis.

FTIR Analysis

The Fourier transform Infrared (FTIR) analysis of the samples was carried out by FTIR equipment of mark spectrum incorporated with software (Perkin Elmer Instruments version 3.02.01) for the examination of the spectra. For sample analysis, 0.5 g of activated carbon was mixed with about the same amount of potassium bromide (Kbr). The mixture thus obtained was crushed in a mortar to obtain a homogeneous powder which was introduced into a mould to obtain very fine plates. The plates were then introduced in to the spectrophotometer for analysis. The wave number was found to vary between 4000 and 350 cm^{-1}.

RESULTS AND DISCUSSION

The vermicompost of banana waste shows strong peaks for the functional groups amides and amines. Amine group shows N-H stretch while amide group shows N-H stretch and N-H bending in the vermicompost of banana waste (Fig 2 and Table 2).

The vermicompost of papaya waste shows strong peaks for the functional groups ketone, aldehyde and amides. Ketone group shows a, b – unsaturated and aryl ketone. Aldehyde group shows C=O stretch and N-H bending in the vermicompst of papaya waste (Fig 4 and Table 4).

The results confirm that there is more reduction of aromatic structures, aliphatic and polysaccharides in the vermicompost using *Eudrilus eugeniae*. This is associated with organic matter mineralization and it indicates the maturity and stability of the final product when compared to the control (Fig 1 and 3 and Table 1 and 3).

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.

Carboxylic acid present in fruit peel has pharmaceutical properties. It is helpful in curing diseases such as ulcers, jaundice, headache, stomatitis, hemicranias, fever, pain in liver and wounds in cattle as well as in the treatment of edema and rheumatic joint pains (Nair *et al.*, 2013). Besides, carboxylic acid also makes fruit peels suitable for metal adsorption. The major source of carboxylic acid in fruit peel is either pectin or cellulose or lignin (Schiewer and Iqbal, 2010; Schiewer and Patil, 2008) Amines, amides and amino acids are the main groups in fruit peels and owing to their presence fruit peels can be used for protein synthesis. The hydroxyl group in fruit peels plays a vital role in adsorption of anionic impurities such as dyes. Fruit peels does not show any peak between the regions 2220 and 2260 cm^{-1}, which suggests the absence of cyanide groups, confirming that fruit peels studied do not contain any toxic substances (Zou*et al.*, 2012). The amine, amide and amino groups in fruit peels are a good source of nitrogen.

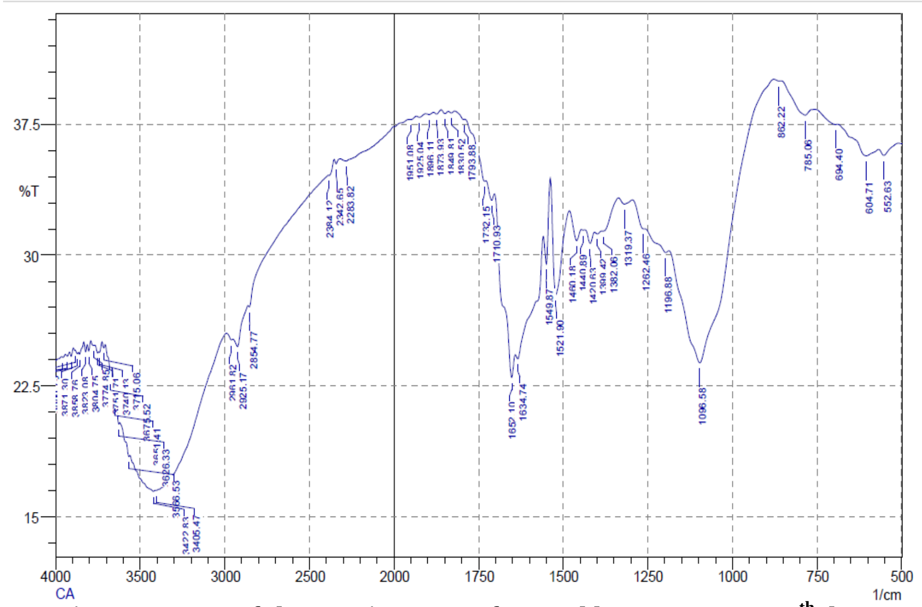

Figure 1: FTIR of the vermicompost of control banana waste - 60th day.

Table 1: IR Absorption Frequencies of Functional Groups in the vermicompost of control banana waste - 60th day.

S. NO.	PEAK	INTENSITY	AREA	FUNCTIONAL GROUPS	TYPE OF VIBRATION
1	552.63	35.72	25.63	Alkyl Halide	C-Br stretch
2	604.7	35.7	52.46	Alkyl Halide	C-cl stretch
3	785.06	38.03	40.54	Alkyl Halide	C-cl stretch
4	1096.58	23.82	158.97	Alcohol Alkyl Halide Amine Ester	C-O stretch C-F stretch C-N stretch C-O stretch
5	1196.88	30.15	36.1	Alkyl Halide Amine Ester	C-F stretch C-N stretch C-O stretch
6	1319.37	32.93	19.47	Alkyl Halide Acid	C-F stretch C-O stretch
7	1420.63	30.68	13.72	Aromatic	C=C stretch
8	1460.18	30.83	16.96	Aromatic	C=C stretch
9	1521.9	27.75	29.01	Aromatic Nitro	C=C stretch N-O stretch
10	1549.87	29.49	9.77	Aromatic Nitro	C=C stretch N-O stretch
11	1634.74	24.05	47.35	Alkane Amide Amide	C=C stretch C=O stretch N-H Bending
12	1652.1	22.9	34.7	Alkane Amide	C=C stretch C=O stretch
13	1710.93	33.15	11.43	Carbonyl Acid Ketone	C=O stretch C=O stretch Acyclic stretch
14	2925.17	24.76	51.65	Alkane Acid Aldehyde	C=H stretch O-H stretch =C-H stretch
15	3405.47	16.51	292.71	Alcohol Amine Amide	O-H stretch, H-bonded N-H stretch N-H stretch
16	3422.83	16.46	113.8	Alcohol Amine Amide	O-H stretch, H-bonded N-H stretch N-H stretch

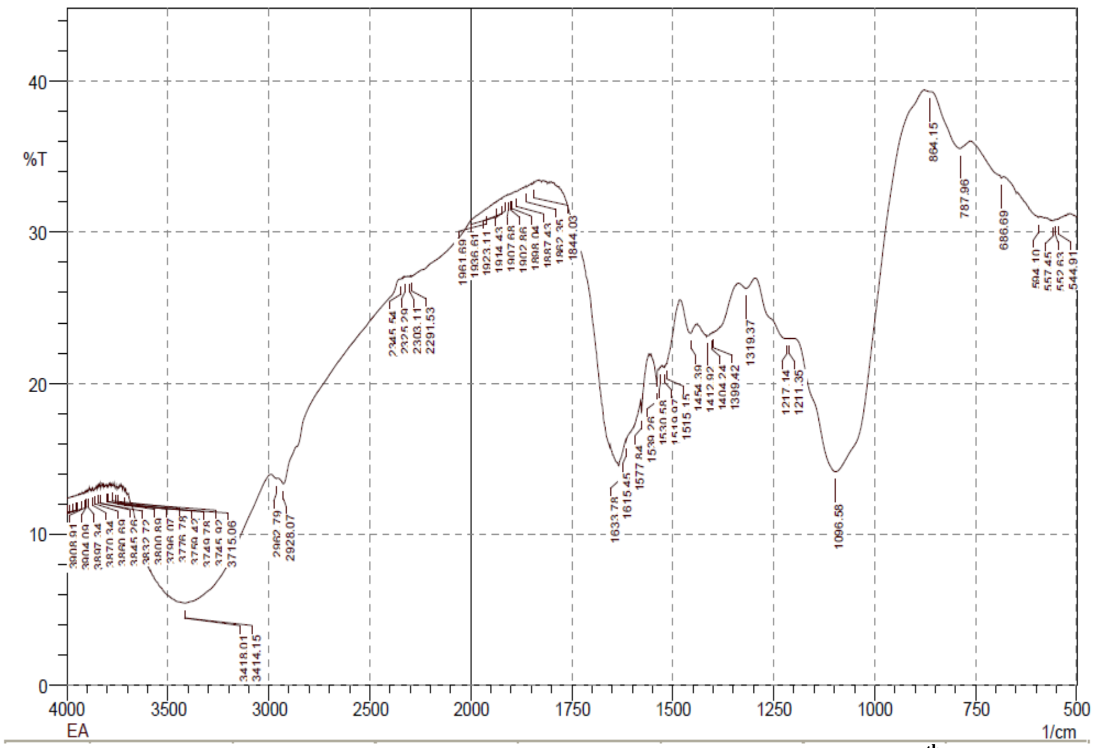

Figure 2: FTIR of the vermicompost of experimental banana waste - 60th day.

Table 2: IR Absorption Frequenciesof Functional Groups in the vermicompost of experimental banana waste - 60th day.

S. NO.	PEAK	INTENSITY	AREA	FUNCTIONAL GROUPS	TYPE OF VIBRATION
1	787.96	35.56	11.189	Alkyl Halide	C-cl stretch
2	1096.58	14.136	208.863	Alcohol Alkyl Halide Amine Ester	C-O stretch C-F stretch C-N stretch C-O stretch
3	1319.37	26.277	23.336	Alkyl Halide	C-F stretch
4	1454.39	23.324	7.864	Alkane	-C-H bending
5	1530.58	21.029	2.605	Nitro Aromatic Amide	N-O stretch C=C stretch N-H bending
6	1633.78	14.523	15.747	Alkene Aromatic Carbonyl Amide	C=C stretch C=C stretch C=O stretch N-H bending
7	2928.07	13.345	414.834	Alkane Acid	C-H stretch O-H stretch
8	2962.79	13.694	25.715	Alkane Acid	C-H stretch O-H stretch
9	3414.15	5.444	457.104	Alcohol Amine Amide	O-H stretch, H-bonded N-H stretch N-H stretch
10	3418.01	5.445	6.095	Alcohol Amine Amide	O-H stretch, H-bonded N-H stretch N-H stretch

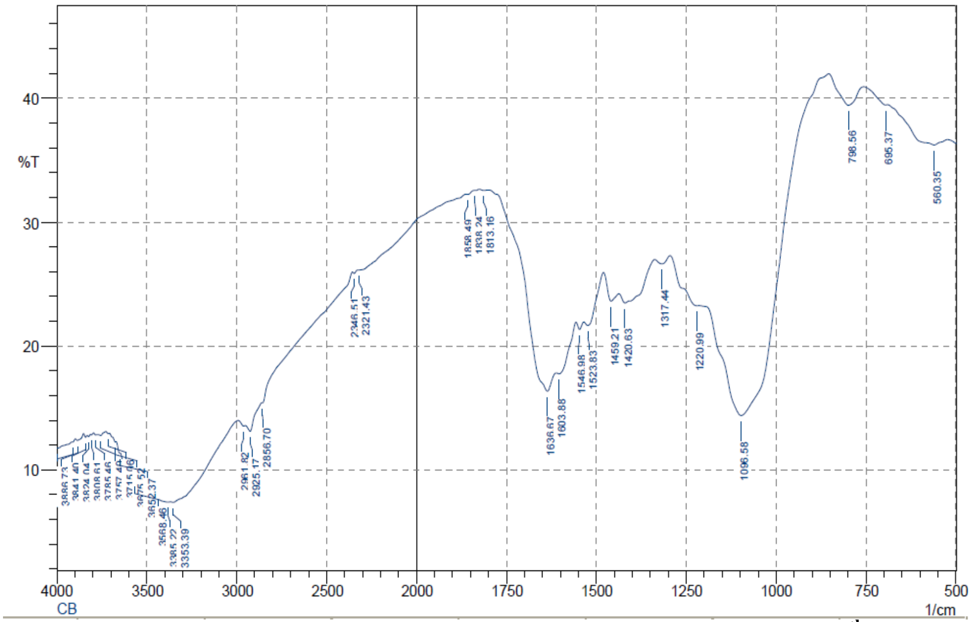

Figure 3: FTIR of the vermicompost of the control papaya waste - 60th day.

Table 3: IR Absorption Frequencies of Functional Groups in the vermicompost of control papaya waste - 60th day.

S. NO.	PEAK	INTENSITY	AREA	FUNCTIONAL GROUPS	TYPE OF VIBRATION
1	798.56	39.437	37.99	Alkene Alkyl Halide	=C-H bending C-cl stretch
2	1096.58	14.394	222.3	Alcohol Ester	C-O stretch C-O stretch
3	1317.44	26.631	24.231	Alkyl Halide Amine Acid	C-F stretch C-N stretch C-O stretch
4	1420.63	23.483	59.964	Alkane Aromatic	C-H bending C=C stretch
5	1459.21	23.633	25.499	Alkane Aromatic	C-H bending C=C stretch
6	1523.83	21.664	34.228	Aromatic Nitro	C=C stretch N-O stretch
7	1546.98	21.343	14.106	Aromatic Nitro	C=C stretch N-O stretch
8	1636.67	16.364	115.773	Alkene	C=C stretch
9	2856.7	15.419	341.083	C=C stretch N-O stretch	C-H stretch O-H stretch
10	2925.17	13.127	76.961	C=C stretch N-O stretch	C-H stretch O-H stretch
11	2961.82	13.536	34.943	C=C stretch N-O stretch	C-H stretch O-H stretch
12	3353.39	7.394	374.604	Alcohol Amine Amide	O-H, stretch H-bonded N-H stretch N-H stretch
13	3385.22	7.407	213.363	Alcohol Amine Amide	O-H, stretch H-bonded N-H stretch N-H stretch

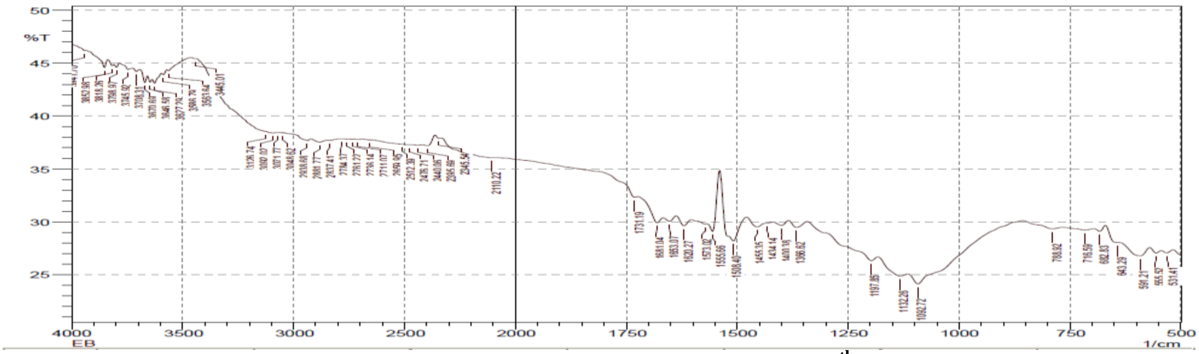

Figure 4: FTIR of the vermicompost of papaya waste on the 60th day of experiment.

Table 4: IR Absorption Frequenciesof Functional Groups in the vermicompost of experimental papaya waste - 60th day.

S. NO.	PEAK	INTENSITY	AREA	FUCTIONAL GROUPS	TYPE OF VIBRATION
1	531.41	27.05	14.73	Alkyl Halide	C-Br stretch
2	555.52	27.04	14.17	Alkyl Halide	C-Br stretch
3	591.21	26.77	38.1	Alkyl Halide	C-Br stretch
4	682.83	29.1	13.37	Alkene	=C-H bending
5	1092.72	24.12	146.19	Alcohol Alkyl Halide Amine Ester Ether	C-O stretch C-F stretch C-N stretch C-O stretch C-O stretch
6	1197.85	26.32	87.58	Alcohol Alkyl Halide Amine Ester Ether	C-O stretch C-F stretch C-N stretch C-O stretch C-O stretch
7	1366.62	29.46	21.85	Alkane Alkyl Halide Nitro	C-H bending C-F stretch N-O stretch
8	1400.38	29.66	18.24	Alkane Alkyl Halide Aromatic	C-H bending C-F stretch C=C stretch
9	1455.35	29.51	21.8	Alkane Alkyl Halide Aromatic	C-H bending C-F stretch C=C stretch
10	1508.4	28.18	21.14	Aromatic Nitro Amide	C=C stretch N-O stretch N-H bending
11	1555.66	29.09	13.82	Aromatic Nitro Amide	C=C stretch N-O stretch N-H bending
12	1620.27	29.62	17.65	Alkene	C=C stretch
13	1681.04	29.9	28.41	Carbonyl Amide Ketone	C=O stretch C=O stretch a, b unsaturated stretch; aryl ketone stretch
14	1731.19	32.31	169.15	Carbonyl Aldehyde	C=O stretch C=O stretch
15	2881.77	37.52	30.69	Alkane Acid	C-H stretch O-H stretch
16	2938.68	37.68	50.56	Alkane Acid	C-H stretch O-H stretch
17	3646.58	43.21	7.34	Alcohol	O-H stretch free
18	3670.69	43.18	12.8	Alcohol	O-H stretch free

CONCLUSION

The present study concludes that the two types of fruit wastes utilized namely banana waste and papaya waste, can be degraded efficiently through vermicomposting using *Eudrilus eugeniae* than normal composting process. It is also interesting to note that papaya waste was degraded more efficiently than banana waste with higher macronutrient content. The most effective use of earthworms are organic waste management and supplement of readily available plant nutrients and demands credit as it maintains and improves soil health.

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