# Vermicomposting of De-Oiled Cake of *Brassica juncea* by *Eisenia foetida*

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**De-oiled cake of *Brassica juncea* is produced in large quantities in India and Worldwide. It has no economic importance. Present experiment is an attempt to convert it in nutrients rich vermicompost through the activities of *Eisenia foetida*. The experiment was laid down with four treatments viz. Control: Buffalo dung + *Eisenia foetida*, $T_1$: Buffalo dung + *Brassica juncea* cake, $T_2$: Buffalo dung + *Brassica juncea* cake + *Eisenia foetida* and $T_3$: *Brassica juncea* cake + *Eisenia foetida*. The experiment was performed in above ground pits made from bricks of size (45×45×21 cm) (l×b×h). Treatments were replicated thrice. Vermicomposting material was analyzed at 0, 30, 60 and 90 days period for its various chemical properties like pH, electrical conductivity, total organic carbon, available phosphorus, potassium, sodium, lignin, cellulose, and hemicellulose and degradation of substrate was confirmed by FTIR spectroscopy. Yield of vermicompost was also recorded at maturity. Results reveal that in 90 days produced vermicompost show slightly alkaline pH, increased values of electrical conductivity, available phosphorus, potassium, sodium; and decreased values for total organic carbon, cellulose and hemicellulose compared to their initial values. This effect of treatments was found significant at 5% level for some parameters.**

**Keywords:** Chemical changes, earthworms, microbial decomposition, vermicompost.

Rapeseed-mustard is an important oil seed crop and grown on 34.19 million hectares area with a production of 63.09 million tons in the world during 2012-13. In India it covered 19.29% acreage area and 11.127% of production in this period (http://www.drmr.res.in/about_rm.html, retrieved on 12/1/2015). The oil seeds contain Glucosinolates. When oil seeds are processed to remove oil these glucosinolates converted into thiocyanates, nitriles, isothiocyanates, epithionitriles etc. by the action of myrosinases. These products are toxic to mammalian species because they interfere with uptake of iodine causing goiter. Its de-oiled cake is commonly used as cattle feed but it is not safe due to above facts. Harmful effects of glucosinolates are reported by many workers (Duncan, 1991; Barrett *et al*., 1997; Papas *et al*., 1979; Fenwick and Cruits, 1980). Therefore we tried a different approach for management of this waste through vermicomposting. Earthworm's gizzard has numerous of enzymes having capacity to rupture a number of complex molecules.

Vermicomposting is a proven technology to convert a variety of plant wastes into a best fertilizer which supports plant growth (Benitez *et al*., 1999; Atiyeh *et al*., 2002). *Eisenia foetida* species of earthworm is widely accepted for vermicomposting of agricultural waste.

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## MATERIALS AND METHODS

In the present experiment we used de-oiled cake of Mustard (*Brassica juncea*), earthworms species *Eisenia foetida* and buffalo dung. Mustard cake was obtained from Kukarvada, Dist: Mehsana and other materials were procured locally from sadra and Randheja village of District Gandhinagar, Gujarat. Before addition to vermicompost pits the cake was chopped into small pieces (about 1 inches long). For vermicomposting pits from bricks were prepared on above ground of our campus. These pits were 45cm long, 45cm wide and 21cm high.

### Treatments

Above materials were mixed in different combinations to obtain four treatments. Control comprises Buffalo dung and *Eisenia foetida* only; Treatment T1 comprises Buffalo dung and *Brassica juncea* cake without earthworms whereas treatment T2 contains earthworms alongwith Buffalo dung and *Brassica juncea* cake. Last treatment T3 contains *Brassica juncea* cake and *Eisenia foetida* alone without dung. To minimize the experimental error all the above treatments were replicated thrice.

### Filling of pits

A total of six kilogram of material was filled in each pit. In pits of control and T3 treatments 6kg buffalo dung and *Brassica juncea* cake were filled alone whereas in T1 and T2 the material was filled in layers. In layered treatments a layer of 3Kg Buffalo dung was kept at bottom of pit followed by one layer of 1Kg mustard cake which was covered by 2Kg of buffalo dung. Fermenting material was kept moist and turned after every seven days. Earthworms in respective pits were added after second turning in the amount of 18g except T1. To prevent moisture loss all pits were covered with gunny bags. The material was analysed at 30, 60 and 90 days of filling to find out the changes in various chemical properties. At maturity (90 days) the Earthworms were removed from pits and samples were analyzed for various parameters along with yield.

### Analysis of vermicomposting material

The samples at different time intervals were analysed for physico-chemical parameters including pH and electrical conductivity (Richard's, 1945), total organic carbon (Walkely and Black,

**Table 1.** Effect of treatments on yield of vermicompost (kg)

| Treatments | Yield (kg) |
|---|---|
| Control | 1.60[a] |
| $T_1$ | 2.60[b] |
| $T_2$ | 2.25[a,b] |
| $T_3$ | 3.80[c] |
| SEM (±) | 0.33 |
| CD 5% | 0.75 |

Control: Buffalo dung + *Eisenia foetida*; $T_1$: Buffalo dung + *Brassica juncea* cake; $T_2$: Buffalo dung + *Brassica juncea* cake + *Eisenia foetida*; and $T_3$: *Brassica juncea* cake + *Eisenia foetida*

Alphabet [a,b,c] shows significance and non-significance of treatments at 5% level of significance. Treatments with same alphabet are non-significant and with different alphabet aresignificant.

**Table 2.** Effect of treatments on pH, EC, Total organic carbon (TOC) contents at various stages (0, 30, 60 and 90 days) of vermicomposting

| Treatments | pH | | | | EC (dSm$^{-1}$) | | | | TOC (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | 0 | 30 | 60 | 90 | 0 | 30 | 60 | 90 |
| Control | 6.25[a, b] | 6.64[a,b] | 6.90 | 7.46[a] | 0.21 | 0.21 | 0.23[a] | 0.37 | 14.72 | 13.99 | 13.25 | 13.11 |
| $T_1$ | 6.13[a] | 6.33[a] | 6.76 | 7.43[a] | 0.27 | 0.31 | 0.38[b] | 0.47 | 15.24 | 14.36 | 14.01 | 13.95 |
| $T_2$ | 6.33[a,b] | 6.53[a,b] | 6.73 | 7.83[a,b] | 0.26 | 0.28 | 0.33[b] | 0.46 | 15.31 | 14.99 | 13.97 | 12.41 |
| $T_3$ | 6.56[b] | 6.78[b] | 7.10 | 7.96[b] | 0.21 | 0.31 | 0.37[b] | 0.41 | 14.98 | 14.44 | 13.30 | 12.15 |
| SEM(±) | 0.14 | 0.14 | 0.16 | 0.19 | 0.03 | 0.05 | 0.04 | 0.05 | 1.82 | 1.93 | 2.57 | 1.69 |
| CD5% | 0.31 | 0.31 | NS | 0.45 | NS | NS | 0.09 | NS | NS | NS | NS | NS |

Control: Buffalo dung + *Eisenia foetida*; $T_1$: Buffalo dung + *Brassica juncea* cake; $T_2$: Buffalo dung + *Brassica juncea* cake + *Eisenia foetida*; and $T_3$: *Brassica juncea* cake + *Eisenia foetida*

Alphabet [a,b] shows significance and non-significance of treatments at 5% level of significance. Treatments with same alphabet are non-significant and with different alphabet are significant.

1965), nutrients like phosphorus, potassium and sodium (Jackson, 1967), and for cellulose, hemicellulose and lignin content (Thimmaiah, 1999). FTIR (Fourier-Transform Infrared Spectroscopy) analysis was also performed at Center of Excellence, Vapi, Gujarat.

**Statistical analysis**

Completely Randomized Block Design was followed and significance level was find out to check the significance in obtained data at 5% level following procedure described in Gomez and Gomez, (1984).

## RESULTS AND DISCUSSION

**Yield of vermicompost**

During vermicomposting earthworm ingest the substrate, digest it, absorbs nutrients and discard undigested part as castings. If the substrate is easy to digest, contains simple forms, then more nutrients will be absorbed and eventually less part will be discarded with lower yield of product. In present experiment two substrates were used viz. buffalo dung and mustard cake. Compared to mustard cake buffalo dung is easy to degrade because it is a partially degraded product of buffalo so it contains simple forms of compounds which can be digested easily by earthworm's gut flora. Due to this fact we would obtain lesser amount of product in this case. Our results are in tune with this fact and lowest yield is recorded in control treatment containing buffalo dung and earthworms (Table 1). As a portion of buffalo dung is replaced by mustard cake ($T_1$ and $T_2$) yield of vermicompost increased significantly and highest yield was obtained with mustard cake alone ($T_3$) which differs

**Table 3.** Changes in available phosphorus, available potassium and available sodium at various stages (0, 30, 60 and 90 days) of vermicomposting

| Treatments | Available Phosphorus (%) | | | | Available Potassium (%) | | | | Available Sodium (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | 0 | 30 | 60 | 90 | 0 | 30 | 60 | 90 |
| Control | 0.023[a] | 0.028[a] | 0.033[a] | 0.041[a] | 0.053 | 0.075 | 0.085 | 0.099 | 0.024 | 0.032 | 0.036[a,b] | 0.041[a] |
| $T_1$ | 0.025[a] | 0.029[a] | 0.034[a] | 0.041[a] | 0.054 | 0.066 | 0.079 | 0.098 | 0.022 | 0.027 | 0.031[a] | 0.039[a] |
| $T_2$ | 0.033[a,b] | 0.038[a,b] | 0.048[b] | 0.061[b] | 0.057 | 0.072 | 0.086 | 0.100 | 0.030 | 0.035 | 0.043[b] | 0.059[b] |
| $T_3$ | 0.044[b] | 0.051[b] | 0.061[c] | 0.074[c] | 0.050 | 0.074 | 0.089 | 0.096 | 0.021 | 0.026 | 0.032[a,b] | 0.040[a] |
| SEM(±) | 0.005 | 0.006 | 0.003 | 0.004 | 0.007 | 0.008 | 0.006 | 0.007 | 0.005 | 0.004 | 0.005 | 0.005 |
| CD5% | 0.012 | 0.014 | 0.007 | 0.009 | NS | NS | NS | NS | NS | NS | 0.011 | 0.011 |

Control: Buffalo dung + *Eisenia foetida*; $T_1$: Buffalo dung + *Brassica juncea* cake; $T_2$: Buffalo dung + *Brassica juncea* cake + *Eisenia foetida*; and $T_3$: *Brassica juncea* cake + *Eisenia foetida*

Alphabet [a,b,c] shows significance and non-significance of treatments at 5% level of significance. Treatments with same alphabet are non-significant and with different alphabet are significant.

**Table 4.** Changes in lignin, cellulose and hemicellulose at various stages (0, 30, 60 and 90 days) of vermicomposting

| Treatments | Lignin (%) | | | | Cellulose (μg) | | | | Hemicellulose (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | 0 | 30 | 60 | 90 | 0 | 30 | 60 | 90 |
| Control | 2.71[a] | 3.12[a] | 3.56[a] | 4.25[a] | 26.24[a] | 19.71[a] | 16.01[a] | 14.65[a] | 2.71[a] | 2.10[a] | 1.71[a] | 1.49[a] |
| $T_1$ | 16.32[b] | 20.25[b] | 24.36[b] | 31.25[b] | 25.60[a] | 22.27[b] | 17.95[b] | 15.74[b] | 16.99[b] | 16.12[b] | 15.26[b] | 15.02[b] |
| $T_2$ | 17.74[c] | 22.13[c] | 25.70[c] | 31.25[b] | 31.68[b] | 23.29[c] | 19.55[c] | 14.04[a] | 15.54[c] | 13.69[c] | 11.25[c] | 9.64[c] |
| $T_3$ | 30.02[d] | 36.25[d] | 40.39[d] | 48.36[c] | 33.48[c] | 28.29[d] | 18.30[b] | 12.09[c] | 29.99[d] | 25.63[d] | 26.25[d] | 22.36[d] |
| SEM (±) | 0.39 | 0.54 | 0.27 | 0.74 | 0.65 | 0.30 | 0.41 | 0.45 | 0.38 | 0.42 | 0.33 | 0.45 |
| CD5% | 0.91 | 1.25 | 0.61 | 1.71 | 1.50 | 0.68 | 0.94 | 1.04 | 0.88 | 0.96 | 0.76 | 1.03 |

Control: Buffalo dung + *Eisenia foetida*; $T_1$: Buffalo dung + *Brassica juncea* cake; $T_2$: Buffalo dung + *Brassica juncea* cake + *Eisenia foetida*; and $T_3$: *Brassica juncea* cake + *Eisenia foetida*

Alphabet [a,b,c,d] shows significance and non-significance of treatments at 5% level of significance. Treatments with same alphabet are non-significant and with different alphabet are significant significantly from rest of the treatments (Table 1). Weight loss of vermicomposting material at final stage was also reported by Twana and Fauziah, 2012; Senthilkumar and Kavimani, 2012.

**Chemical properties**

Data presented in Table 2 and Table 3 reveals that pH, electrical conductivity, total organic carbon, available P, K and Na contents varies with treatments and except organic carbon, contents of all other parameters increased at maturity than that of initial. Further data show that at various stages of analysis the effect of treatments was significant and at some stages it was non-significant. At maturity of vermicompost the effect of treatments was found significant for pH, available phosphorus and sodium. Intestinal calcium secretion and excretion of ammonia by earthworms raise the pH of vermicompost and make it alkaline (Ismail, 1997; Ismail, 2005; Edwards and Bohlen, 1996).

Mineralization of organic substrates like cellulose, hemicellulose, lignin etc. during

**Table 5.** Specific functional group /compound present in control of raw buffalo dung and dung composted with *Eisenia foetida*

| Raw buffalo dung | | Dung composted with *Eisenia foetida* | |
|---|---|---|---|
| Adsorption frequency ($cm^{-1}$) | Functional group or compound | Adsorption frequency ($cm^{-1}$) | Functional group or compound |
| 3420.85 | Moisture | 3397.69 | Heteroaromatic compound containing N-H group |
| 3011.51 | Aromatic C-H structure | | |
| 2933.28 | C-H with methyl and methylene | 2352.87 | $CO_2$ |
| 2226.58 | $CO_2$ | 1049.32 | C-O starching vibration in alcohol and phenol |
| 1487.17 | Aromatic monomer | 829.79 | Aromatic compound region |
| 1423.99 | C-N stretching/-OH bond of carboxyl | | |
| 1296.03 | Phosphate ester | | |
| 1052.37 | Ethanol | | |
| 848.80 | Aromatic carbon compound | | |

**Table 6.** Specific functional group /compound present in control of *Brassica juncea* and *Brassica juncea* composted with *Eisenia foetida*

| Raw *Brassica juncea* | | *Brassica juncea* composted with *Eisenia foetida* | |
|---|---|---|---|
| Adsorption frequency ($cm^{-1}$) | Functional group or compound | Adsorption frequency ($cm^{-1}$) | Functional group or compound |
| 3421.91 | Two N-H group(primary amine and amide) | 3396.59 | Heteroaromatic compound containing N-H group |
| 3009 | Heteroaromatic like pyridine, parazine pyrols, furan | 3007.63 | Heteroaromatic like pyridine, parazine pyrols, furan |
| 2924.11 | C-H with methyl and methylene | 2927.48 | Asymmetric/symmetric stretching of methylene |
| 2352.96 | $CO_2$ | | |
| 1637.94 | C-O,C-N,N-O | 2208.24 | Weak (C=N) stretching bond alkaline molecule, C=C. |
| 1425.55 | C-N stretching | | |
| 1287.52 | Aromatic/ heteromatic carbon | 1420.35 | Aromatic/ heteroaromatic , C-N stretching |
| 848.80 | Aromatic carbon compound | | |
| | | 1036.22 | C-O bond, C-O stretching vibrations in alcohol and phenol |

vermicomposting by the activities of earthworms and other microorganisms of dung releases mineral salts (Gupta and Garg, 2008; Khawairakpam and Bhargava, 2009; Kaviraj and Sharma, 2003) which results into increased values of electrical conductivity (Neuhauser *et al*., 1988). Organic carbon is being utilized by microorganisms as energy source and the respiratory activities of

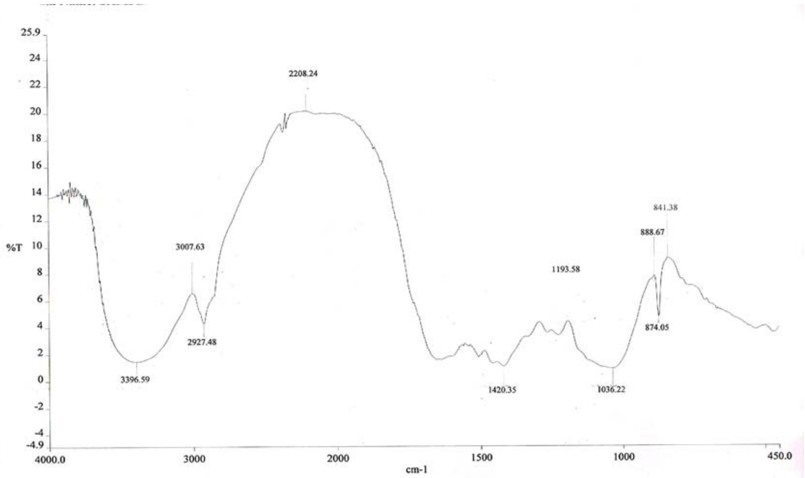
**Table 7.** Specific functional group /compound present in control of *Brassica juncea*+dung and *Brassica juncea* composted with dung

| Control of *Brassica juncea* + dung | | *Composted Brassica juncea* +dung | |
|---|---|---|---|
| Adsorption frequency ($cm^{-1}$) | Functional group or compound | Adsorption frequency ($cm^{1}$) | Functional group or compound |
| 3410.48 | Two N-H group(primary amine and amide) | 3404.52 | Heteroaromatic compound containing N-H group, Two N-H group(primary amine and amide) |
| 3006.49 | Heteroaromatic like pyridine, parazine pyrols, furan | 2925.54 | Asymmetric/symmetric stretching of methylene |
| 2924.32 | Asymmetric/symmetric stretching of methylene | 1054.53 | Quinones |
| 1937.33 | $C=C-CH_2$ | | |
| 1637.09 | C-O,C-N,N-O | 3002.60 | Aromatic C-H stretching |
| 1425.48 | C-N stretching | | |
| 1488.76 | Aromatic/ heteroaromatic compound | 1420, 1485.66 | Aromatic/ heteroaromatic, C-N stretching |
| 848.80 | Aromatic carbon compound | 1296 | C-O,C-N, phosphate ester |
| | | 874.38, 888.58, 841.33 | Interaction between C=S and N, Si-H Bend. |

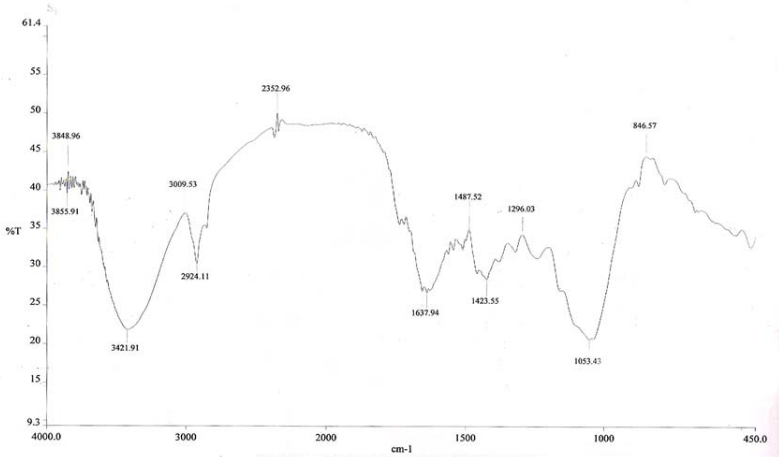
**Table 8.** Specific functional group /compound present in control of dung+ *Brassica juncea* and *Brassica juncea* composted with *Eisenia foetida* +dung

| Control of *Brassica juncea* + dung | | Composted *Brassica juncea* +dung+ *Eisenia foetida* | |
|---|---|---|---|
| Adsorption frequency ($cm^{-1}$) | Functional group or compound | Adsorption frequency ($cm^{-1}$) | Functional group or compound |
| 3410.48 | Two N-H group(primary amine and amide) | 3401.85 | Two N-H group(primary amine and amide) Heteroaromatic compound containing N-H group |
| 3006.49 | Heteroaromatic like pyridine, parazine pyrols, furan | 2925.09 | Asymmetric/symmetric stretching of methylene. |
| 2924.32 | Asymmetric/symmetric stretching of methylene | 2997.91 | C-H with methyl and methylene |
| 1937.33 | $C=C-CH_2$ | | |
| 1637.09 | C-O,C-N,N-O | 2085.70 | C=C,C=N |
| 1425.48 | C-N stretching | | |
| 1488.76 | Aromatic/ heteroaromatic compound | 1654.56 | Quinone |
| 848.80 | Aromatic carbon compound | 1420, 1485.7 | Aromatic / heteroaromatic C-N stretching. |
| | | 1297 | C-C,C-O,C-N, phosphate ester |
| | | 1037 | C-O stretching vibration in alcohol a and phenol |
| | | 832 | C-C,C-O,C-N, furan ring |

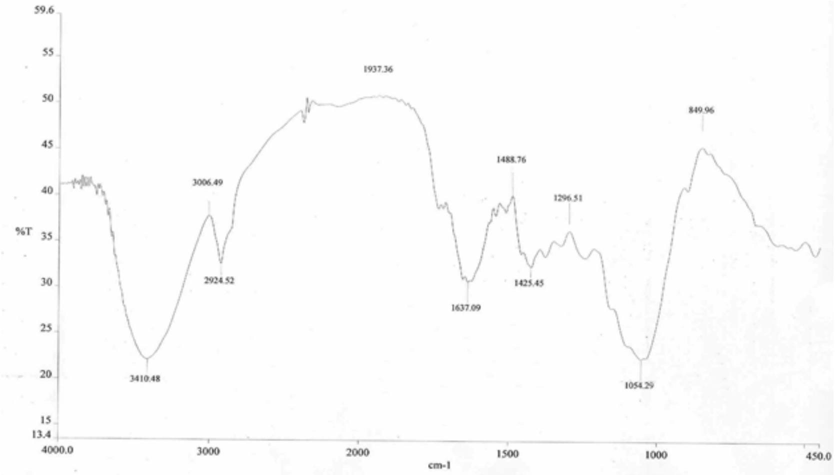
Graph No. : 4.1 FT- IR analysis of Buffalo dung only



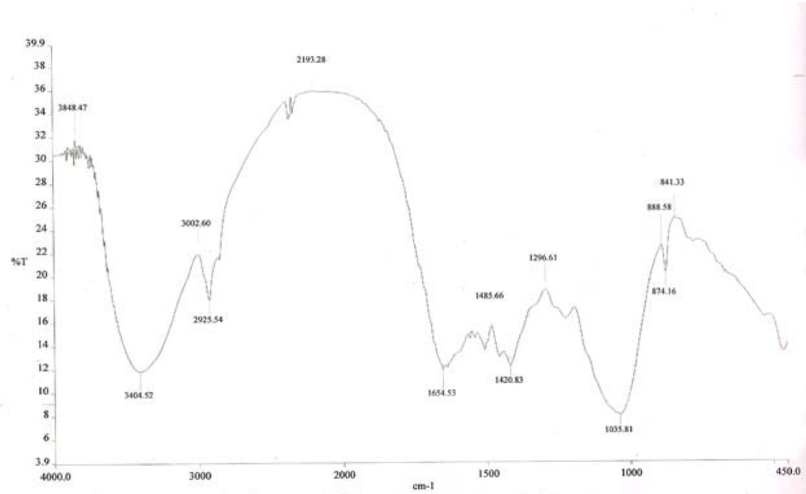
Graph No. : 4.3 FT- IR analysis of *Brassica juncea + Eisenia foetida*



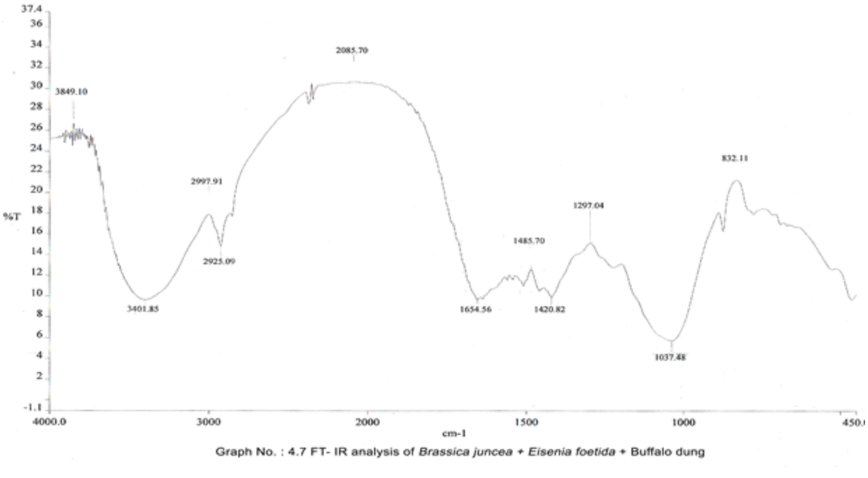
Graph No. : 4.4 FT- IR analysis of *Brassica juncea only*




Graph No. : 4.5 FT- IR analysis of *Brassica juncea* + Buffalo dung




Graph No. : 4.6 FT- IR analysis of *Brassica juncea* + Buffalo dung (mature)




Graph No. : 4.7 FT- IR analysis of *Brassica juncea* + *Eisenia foetida* + Buffalo dung earthworms and microorganisms may results in reduced amount of organic carbon in final product (Curry *et al*., 1995).

**Available phosphorus, potassium and sodium**

Microbial mineralization of organic phosphorus and activities of earthworms gut phosphatase resulted in increased amount of available phosphorus in product (Tripathi and Bharadwaj, 2004; Lee, 1992). Acid production is claimed during microbial degradation (Premuzic *et al*., 1998) which causes solubilization of bound phosphorus, sodium and potassium. Mineralization, transformation and mobilization of nutrients from unavailable forms to plant available forms is being supported by a number of workers (Suthar, 2007; Adi and Noor, 2009; Lazcana *et al*., 2008; Sen and Chandra, 2009; Ghosh *et al*., 1999). Solubilization of insoluble potassium due to acid production (Adi and Noor, 2009) and increased amount of potassium in vermicompost due to higher mineralization rate of microbial activity is being well documented (Delgado *et al*., 1995; Benitez *et al*., 1999; Kaviraj and Sharma, 2003; Suthar, 2007).

**Lignin, hemicellulose, cellulose**

Cellulosic material present in substrates are decomposed by microorganisms and earthworms by secreting extracellular enzymes (Sinsabaugh *et al*., 1992). Digestion of cellulose due to cellulolytic activity in the gut of earthworms and cellulose loss in product is well documented (Lattaud *et al*., 1997a; Lattaud *et al*., 1997b; Scheu, 1993; Urba´sek and Piz¡l, 1991; Vinceslas-Akpa and Loquet, 1997; Zhang *et al*, 2000; Zhang *et al*, 1993). Results of present investigation are in line with above workers and showed significant decrease in amount of cellulose and hemicellulose at maturity of vermicompost compared to their initial contents (Table 4).

**FTIR (Fourier Transform Infrared Spectrometer)**

To prove the degradation of substrate during vermicomposting FTIR data were obtained for a wave number range of 4000-450 $cm^{-1}$.and presented in Fig 1-7 and details of corresponding groups present is given in Tables 5-8. When Infra-red radiation is passed through sample, a portion is absorbed by the sample and remaining is transmitted. This absorption and transmittance spectrum over a wide range of wave number creates a molecular fingerprinting because each molecule gives peak at a specific wave number. Obtained peaks are than compared with spectra library of pure substances or components (Smidt and Schwanninger, 2005). Use of FTIR is very common to describe composting process (Huang *et al*., 2006, Smidt *et al*., 2005; Tseng *et al*., 1996). A close examination of FTIR data obtained for Buffalo dung compared with buffalo dung + *Eisenia foetida* (T-5, Fig.1-2); *Brassica juncea* compared to *Brassica juncea* + *Eisenia foetida* (T-6, Fig. 3-4); *Brassica juncea* + dung compared with *Composted Brassica juncea* +dung (T-7 and Fig. 5-6) and Composted *Brassica juncea* +dung+ *Eisenia foetida* (T-8, Fig. 7) clearly reveal that they are different in presence of compounds or groups which show that during vermicomposting some groups or compounds are lost and some are newly formed, hence degradation occurs.

## CONCLUSION

Results of present investigation clearly direct that de-oiled cake of *Brassica juncea* can be successfully converted into nutrient rich vermicompost through the activities of *Eisenia foetida* species of earthworms. In 90 days, biomass, total organic carbon, cellulose, and hemicellulose are reduced by 36.67 to 73.33%, 8.46 to 18.94%, 38.52 to 63.89%, and 11.59 to 45.02%; whereas available phosphorus, potassium and sodium are increased by 64 to 84.85%, 75.44 to 92.00%, and 70.83 to 96.67% respectively. Further the FTIR data confirm the degradation process.

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