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Evaluation of maturity parameters of vermicomposts prepared from different bio-degradable wastes

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ABSTRACT

Disposal of enormous amounts of wastes generated from various sources is becoming a serious problem in our country. Vermicomposting is an economically viable technology in conversion of wastes into a high quality manure which is a valuable input in organic agriculture. Hence an experiment was carried out to study the changes occurring during vermicomposting of different bio-degradable wastes for assessing the stability & maturity of vermicompost. Four different bio-degradable wastes i.e., Vegetable market waste, Agricultural waste, Kitchen waste and Paddy straw were composted separately using earthworms. Irrespective of wastes, C/N ratio (Ratio of Carbon to Nitrogen) decreased significantly during the process of vermicomposting. Humic acid (HA) production was increased while production of fulvic acid (FA) was decreased during vermicomposting of bio-degradable wastes. It was observed during different time intervals that humic acid levels were high when compared to fulvic acid. Among the different wastes under study, higher and lower values of humic and fulvic acids were recorded in vermicompost prepared out of agricultural waste and paddy straw respectively.

Key words: Vermicompost, Bio-degradable wastes, C/N ratio, Humic acid, Fulvic acid, HA/FA ratio.

INTRODUCTION

One of the major environmental problems our country is facing is management of solid wastes which is quite inappropriate. Great quantity of organic wastes are produced by municipal, agricultural, vegetable and fruit markets, agro-industrial activities and disposal of these wastes is causing economic and environmental problems(Castaldi et al, 2005, Vieyra et al, 2009). But these wastes are rich in organic matter content and mineral elements which could be used to restore soil fertility. In those countries where soil organic matter content is low (Castaldi et al, 2008), composts form an important resource to maintain and restore soil fertility.

Another appropriate technology in management of wastes to produce stable and mature organic matter is the use of earth worms during the process of composting. Vermicomposting is a bio-oxidation and stabilization process of organic materials involving joint action of earthworms and micro organisms where in organic fraction of wastes is converted in to valuable soil amendment called vermicompost. During vermicomposting organic matter is oxidized and stabilized mainly because of increased decomposition and humification (Atiyeh et al, 2002, Romero et al, 2007, Li et al, 2011). Vermicompost results in a high quality humified product which can be used as a soil organic amendment. However the principal requirement for application of compost to agricultural fields is its degree of stability or maturity which implies a stable organic matter content (Castaldi et al, 2008, Tejada et al, 2009) and absence of phytotoxic compounds and plant or animal pathogens. Maturity is associated with plant growth potential or phytotoxicity where as stability is often related to compost's microbial activity. (Bernal et al, 2009). Furthermore, the increasing humification level in organic matter is often associated with the higher agricultural value of final compost or vermicompost (Zhou et al, 2014). A no. of criteria have been considered as maturity indices for composts which include pH, temperature, CEC, dissolved organic carbon, C/N ratio, humification index, enzyme activities etc. (Castaldi et al, 2004, Mondini et al, 2004, Tejada et al, 2009). The C/N ratio is one of the important parameters that determines the extent of composting and degree of compost maturity. Since maturation of compost implies the formation of some humic like substances, the degree of organic matter humification is generally accepted as criterion of maturity. Therefore the present study is undertaken to evaluate changes in organic carbon %, Nitrogen %, C/N ratio, humic acid %, fulvic acid % and HA / FA ratio during vermicomposting of different bio-degradable wastes.

MATERIAL AND METHODS

The experiment was conducted during November 2014 at Loyola Academy Degree & PG College, Alwal, Secunderabad. The waste materials selected for the study are shown in table 1 :

The different wastes collected were air dried separately after cutting into small pieces. Four different beds (dimensions L x W x H – 15m x 1.5m x 0.6m) were made separately on ground. At the bottom of each bed 4-5 cm layer of coconut coir was placed. The wastes were added layer wise and sprinkled with 10 percent cow dung slurry sufficient to wet the surface. Over this another layer of waste was spread along with cow dung slurry uniformly. This procedure was repeated in similar fashion to complete 200 Kg of raw materials. Then top of the bed was covered with cow dung slurry to prevent exchange of gases. The earthworms *Eisenia foetida* and *Eudrilus eugeniea* were released (@350 worms / m^3) in to the bed after 8-10 days of partial decomposition. The beds were covered with gunny bags to provide darkness to worms, protection from predators, retention of moisture and to maintain stability of temperature. Proper moisture content (40-50%) and suitable temperatures (25-28^oC) were maintained throughout the process of composting by sprinkling water on the gunny bags covering the beds. The samples were collected from each vermicompost bed at the time interval of 15, 30, 45 and 60 days after incubation.

Table 1: The waste materials selected

Vegetable market wastes (VW)	:	Putrified and left over vegetables like cabbage, potato, brinjal, carrot, bendi, cluster beans, ridge gourd, leafy vegetables were collected from vegetable market, Alwal, Secunderabad
Agricultural wastes (AW)	:	Commonly occurring weeds like *Parthenium hysterophorus*, *Portulaca oleracia, Lantana camara, Celosia argentia, Euphorbia hirta, Cynodon dactylon, Cyperus rotundus, Physalis minima* were collected from college farm, Loyola Academy Degree & PG College, Alwal, Secunderabad
Kitchen wastes (KW)	:	Kitchen wastes comprising of cooked food particles, fruit and vegetable peels were collected from hostel messes
Paddy straw (PS)	:	Paddy straw was collected from cattle shed of college farm, Loyola Academy Degree & PG College, Alwal, Secunderabad.

The completion of vermicomposting was indicated by aggregation of earthworms at the bottom of the bed. The waste to vermicompost ratio ranged from 1:0.4 i.e., 40 kg of vermicompost was obtained from 100 kg of raw organic waste material. Mature vermicompost was black, granular, light weight crumbly powder remained at top. When vermicompost became ready, gunny bags covering the beds were removed & sprinkling of water was stopped. vermicomposts were air dried and screened through 2 mm sieve and analyzed for organic carbon, nitrogen, humic and fulvic acids. Organic carbon was determined by using dry combustion method (Jackson, 1973). Nitrogen content (%) in compost samples was determined by kjeldahl digestion and distillation method. Humic and fulvic acids were determined by Tyurin's method (Kononova, 1966).

RESULTS AND DISCUSSION

Organic carbon content C, Nitrogen content N,C/N ratio: Figure-1-3 depicts Changes in organic carbon content C, nitrogen content N, C/N ratio of vermicomposts.

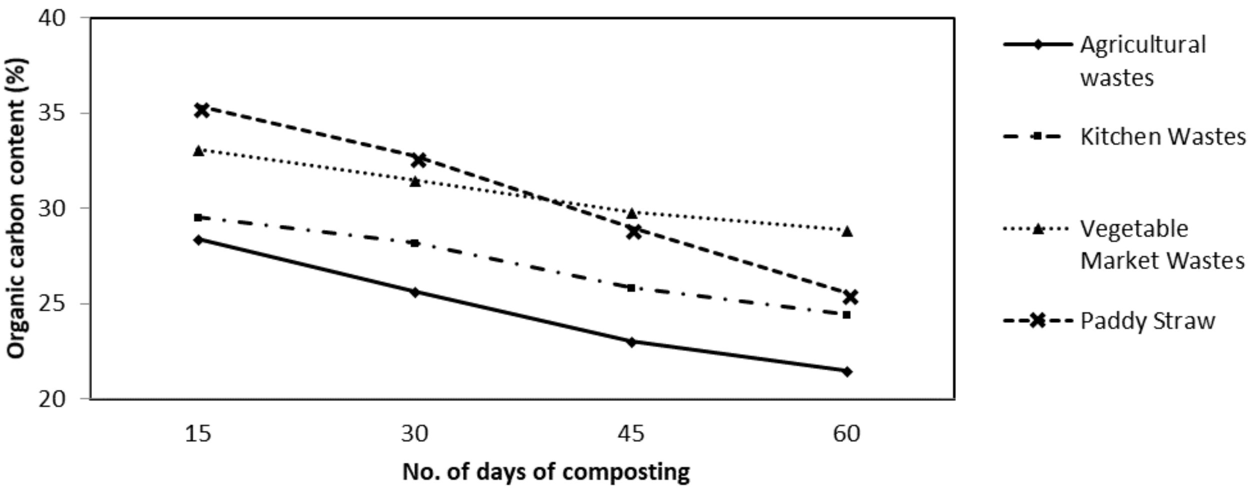

Fig. 1 : Changes in organic carbon content (%) during vermicomposting

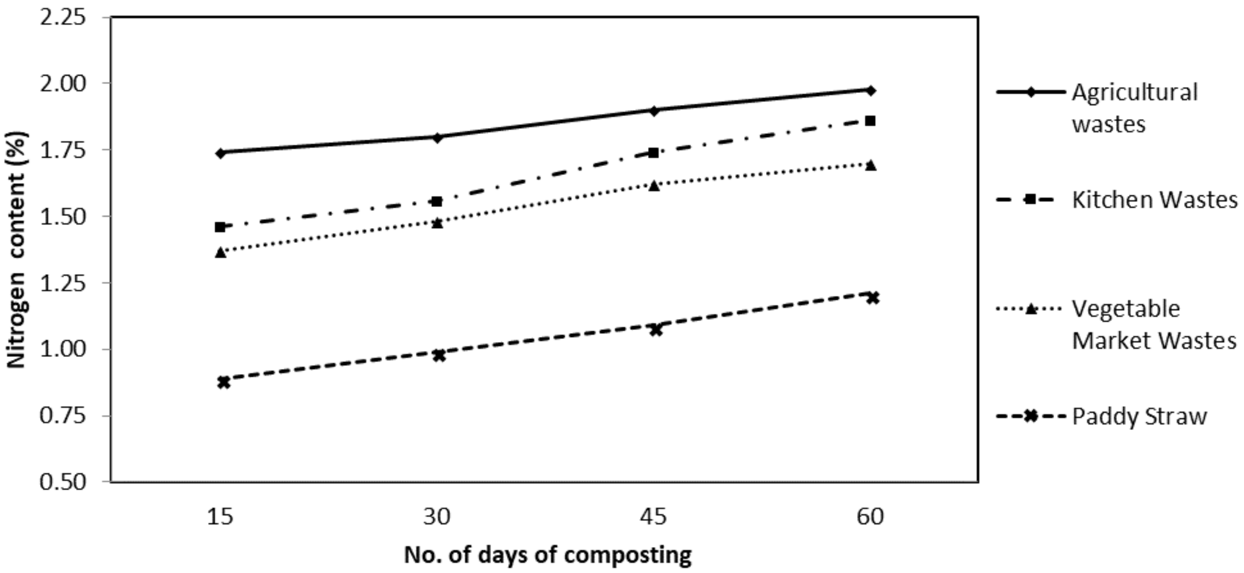

Fig. 2 : Changes in Nitrogen content(%) during vermicomposting

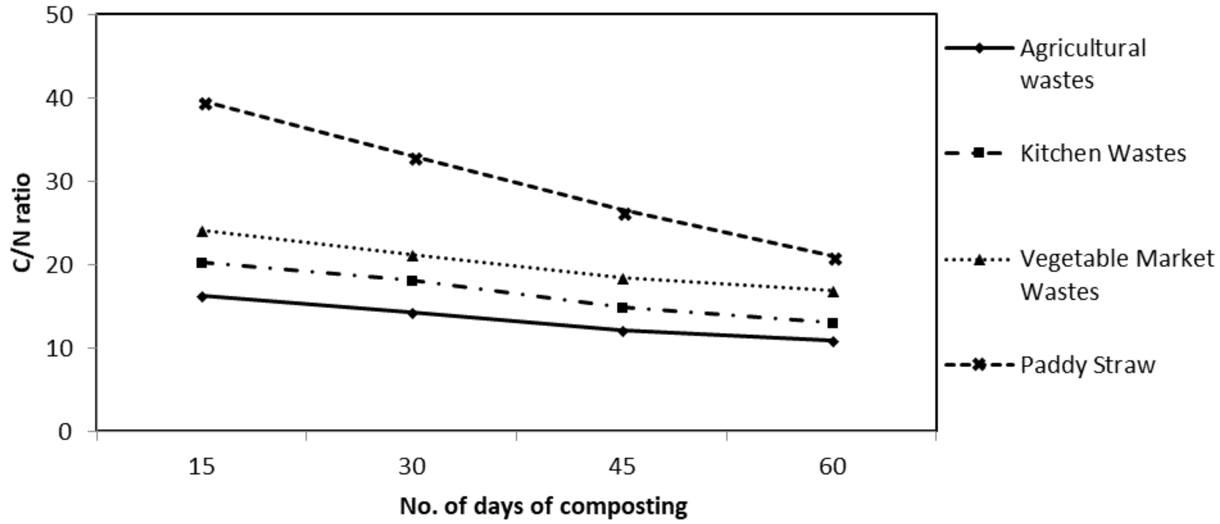

Fig. 3 : Changes in C/N ratio during vermicomposting

Irrespective of the bio-degradable wastes used, organic carbon content decreased during the process of vermicomposting. It varied from 10.86% (AW) to 21.14% (PS). Among these, vermicompost prepared out of AW recorded lowest amount of organic carbon which was due to low carbon content in raw material itself. Earthworms affect the loss of carbon in the form of carbon dioxide through microbial respiration and even through mineralization of organic carbon (Payal et al, 2006, Suthar, 2007, Venkatesh and Eevera, 2008, Zhou et al, 2014, Bhat et al, 2017).

At the end of the experiment, vermicomposts recorded higher total N content. Total N recorded in various vermicomposts was 1.98% (AW), 1.86% (KW), 1.70% (VW) and 1.21% (PS). The increase in nitrogen was due to decomposition of organic matter containing proteins and conversion of ammonical nitrogen to nitrate nitrogen. As the organic matter passes through the gut of earthworms, the material gets digested by enzymatic activity which results in breakdown of proteins and nitrogen containing compounds. (Suthar and Singh, 2008, Zhou et al, 2014, Bhat et al, 2017).

The carbon nitrogen ratio is one of the important parameters that determines the extent of composting and degree of compost maturity. The decrease in organic carbon was observed during vermicomposting. During the process of decomposition, part of carbon was evolved as carbon dioxide and part was assimilated by microbial biomass (Fang et al, 2001, Zhou et al, 2014, Zhang et al, 2015). The N content increased during vermicomposting due to release of nitrogen by earthworms' metabolic products and dead tissues (Araujo et al, 2004, Zhou et al, 2014). The decrease in C/N ratio during vermicomposting was due to respiratory activity of earthworms and microorganisms and increase in nitrogen by mineralization of organic matter and excretion of nitrogenous wastes (Satisha and Devarajan, 2011, Zhou et al, 2014, Zhang et al, 2015). C/N ratio reduced from 34.53 to 16.89 during vermicomposting of cattle dung (Bhat et al, 2017).

Humic acid content, Fulvic acid content, HA/FA ratio:

Figure-4-6 depicts Changes in humic acid content HA, fulvic acid content FA, HA/FA ratio of vermicomposts .

Irrespective of the bio-degradable wastes used, organic carbon content decreased during the process of vermicomposting. It varied from 10.86% (AW) to 21.14% (PS). Among these, vermicompost prepared out of AW recorded lowest amount of organic carbon which was due to low carbon content in raw material itself. Earthworms affect the loss of carbon in the form of carbon dioxide through microbial respiration and even through mineralization of organic carbon (Payal et al, 2006, Suthar, 2007, Venkatesh and Eevera, 2008, Zhou et al, 2014, Bhat et al, 2017).

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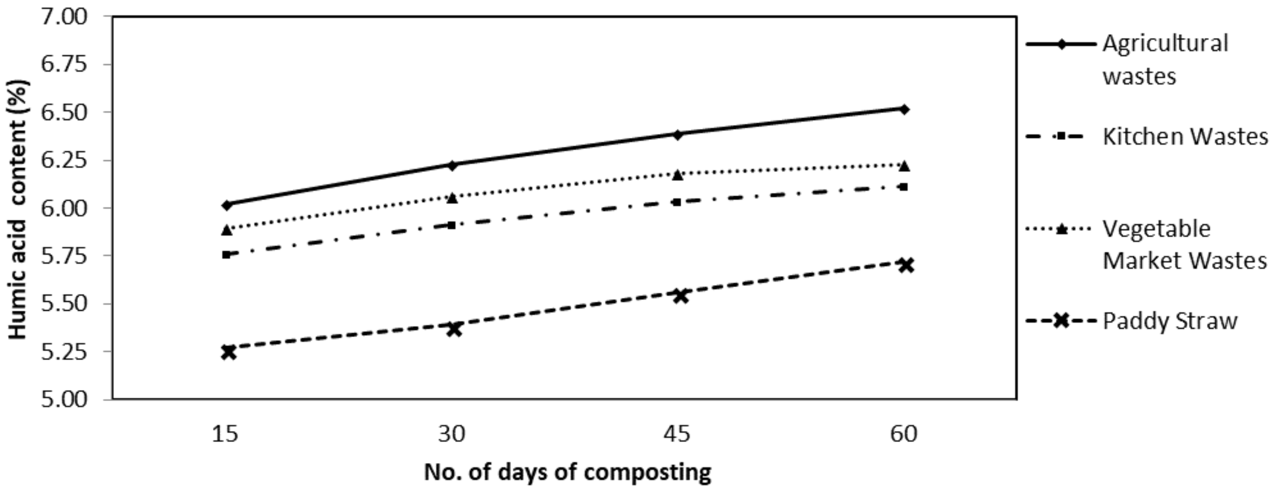

Fig. 4 : Changes in humic acid (HA) content (%) during vermicomposting

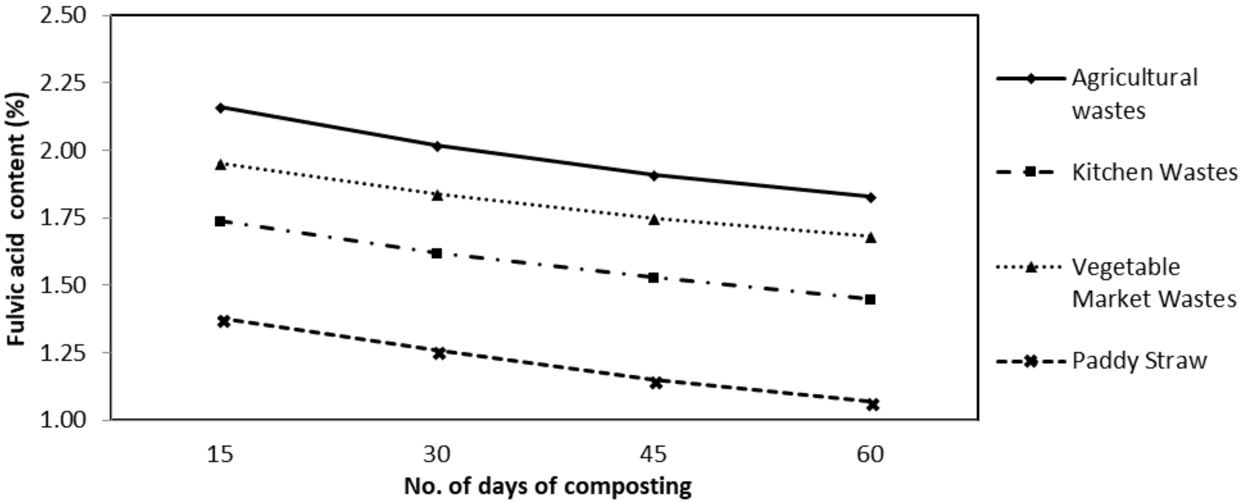

Fig. 5 : Changes in fulvic acid (FA) content(%) during vermicomposting

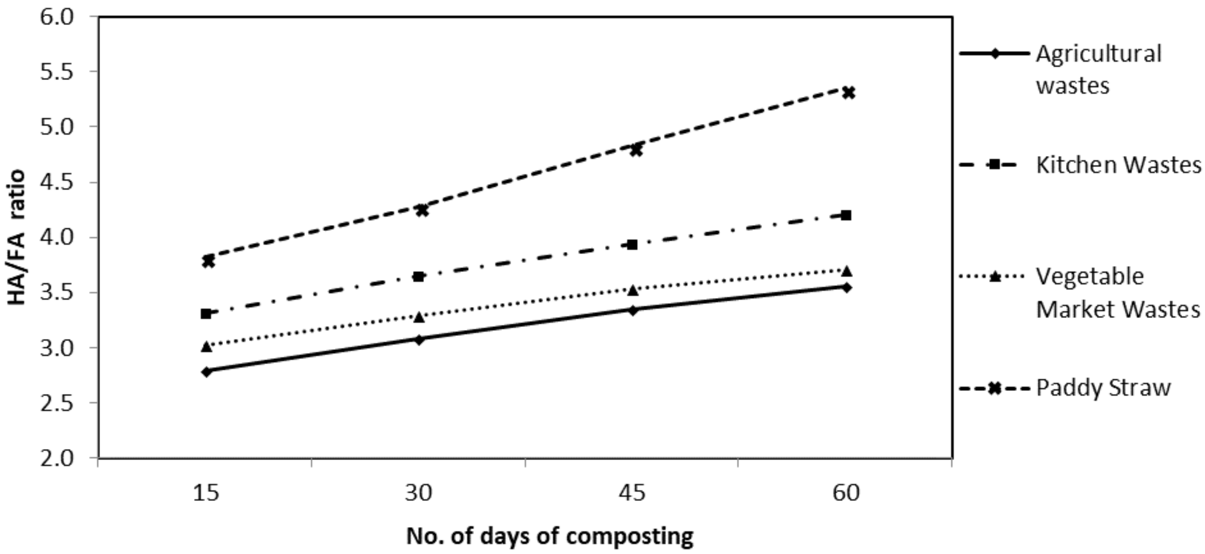

Fig. 6 : Changes in HA/FA ratio during vermicomposting

The increase in nitrogen was due to decomposition of organic matter containing proteins and conversion of ammonical nitrogen to nitrate nitrogen. As the organic matter passes through the gut of earthworms, the material gets digested by enzymatic activity which results in breakdown of proteins and nitrogen

During the process of decomposition, part of carbon was evolved as carbon dioxide and part was assimilated by microbial biomass (Fang et al, 2001, Zhou et al, 2014, Zhang et al, 2015). The N content increased during vermicomposting due to release of nitrogen by earthworms' metabolic products and dead tissues (Araujo et al, 2004, Zhou et al, 2014). The decrease in C/N ratio during vermicomposting was due to respiratory activity of earthworms and microorganisms and increase in nitrogen by mineralization of organic matter and excretion of nitrogenous wastes (Satisha and Devarajan, 2011, Zhou et al, 2014, Zhang et al, 2015). C/N ratio reduced from 34.53 to 16.89 during vermicomposting of cattle dung (Bhat et al, 2017).

During the process of vermicomposting humic acid production increased while fulvic acid content showed a decreasing trend. The increase in humic acid production varied from 6.02% to 6.52% in AW, 5.89% to 6.23% in VW, 5.76% to 6.11% in KW and 5.27% to 5.72% in PS. Fulvic acid content decreased from 2.16% to 1.83% in AW, 1.95% to 1.68% in VW, 1.74% to 1.45% in KW and 1.38% to 1.07% in PS. The lowest ratio of humic acid to fulvic acid HA/FA ratio 3.56 was observed in AW while it was highest, 5.35 in PS. The increase in humic acid content during vermicomposting of various bio-degradable wastes indicate that high degree of humification of organic matter has taken place. This suggests that during early stage of composting a partial acid co-precipitation of incompletely humified components of organic matter could have occurred because of the dependence of oxidation rate on the chemical nature of the organic compounds. Further, the compost mixtures might have contained the mixture of both humic and non-humic components. Some of these are of aromatic nature (phenolic acids, Benzene carboxylic acids, lignin derived products) and others of aliphatic nature (fatty acids, de-carboxylic acids etc) which are considered to be humic in nature. Non-humic substances such as polysaccharides might have also formed from the beginning of composting. These usually exist in the fulvic acid like fraction bonded to form highly complex polymers of an aliphatic nature with a very low degree of aromaticity (More et al, 1987, Inbar containing compounds. (Suthar and Singh, 2008, Zhou et al, 2014, Bhat et al, 2017).

The carbon nitrogen ratio is one of the important parameters that determines the extent of composting and degree of compost maturity. The decrease in organic carbon was observed during vermicomposting. et al, 1990). Hence as the decomposition proceeded with time, these are converted gradually into humic acids. The high humic acid content in vermicompost implies good quality and maturity of compost (Zachariah and Chhonkar, 2004, Sellami et al, 2008, Tejada et al, 2009, Satisha and Devarajan, 2011). Similar results were reported by Zhang et al, 2015, during vermicomposting of sewage sludge. In terms of fulvic acid this fraction showed a continuous decrease throughout the process of vermicomposting. This noticeable reduction can be explained by the nature of fulvic acid containing easily degradable compounds such as polysaccharides which were exposed firstly to microbial attack. Tejada et al, 2009 during composting of municipal solid waste reported that at the end of composting process fulvic acid decreased by 25.9% of initial value. Sellami et al, 2008 observed that during composting of olive mill wastes for a period of 182 days fulvic acid decreased from 2.632 to 1.082. Zhou et al, 2014, noticed that HA content increased and FA content decreased during co-composting of food waste, saw dust and Chinese medicinal herbal residues. The HA/FA ratio is observed to be a good maturity and stability index. The increase in humic acid to fulvic acid ratio reflects the formation of complex molecules (humic acids) from more simple molecules (fulvic acids) and a diminution in the non-humic components of fulvic acid fraction which are most easily degraded by micro organisms. Shirisha and Rao, 2004, obtained similar increase in HA/FA ratio during incubation of organic residues. Raj and Antill, 2011 showed that HA:FA ratio of all the composts increased significantly with composting time mainly due to pronounced decrease in Fulvic acid production. Similar results were reported by Fourti et al, 2010, Satisha and Devarajan, 2011, Zhou et al, 2014.

CONCLUSION

It can be concluded that C/N ratio, humic acid HA, fulvic acid FA, HA/FA ratio during vermicomposting of various bio-degradable wastes can be of great use in understanding the compost maturity. Among the various wastes under study, vermicompost obtained from agricultural wastes found to contain low C/N ratio, HA/FA ratio while paddy straw recorded high C/N ratio and HA/FA ratio.

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