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# ANALYSIS OF MICRO AND MACRO NUTRIENTS ON VERMICOMPOSTING OF *Eudrilus eugeniae* AND *Eisenia fetida* BY USING INDUSTRIAL TEA WASTE WITH COW DUNG AND KITCHEN WASTE MIXTURE

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**ABSTRACT**

From the present investigation it could be suggested that the underutilized tea waste, cow dung, kitchen waste can also be profitably utilized for the production of nutrient. Further, from the nutrient analysis of the vermicompost it could be deduced that not all the concentrations of TW+CD+KW are equally accepted and processed by *E. eugeniae and E. fetida* as a consequence resulting in differential mineralization rate between the treatment concentrations. The pH, EC, TOC, C:N ratio, macro and micro nutrients in different concentrations of industrial tea waste, cow dung and kitchen waste mixtures. Initial, worm unworked natural compost (control) and vermicompost of *E.eugeniae* and *E.fetida* were analysed. The observation of chemical analysis of the different mixtures of industrial tea waste, cow dung and kitchen waste before vermicomposting revealed N.P.K, ca, mg, Na, Zn, fe, cu & Mn to be more in T4 and T3 treatment than the other treatments (T1 –T2). Hence, it can be concluded that the quality of vermicompost partly depends upon quality of organic wastes used for vermicomposting and partly upon the rate of degradation of organic wastes by the combined effects of earthworm and microbial activities.

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## INTRODUCTION

Vermicomposting is an effective biological process for conversion of organic wastes into a stable end product, where in microbial activity plays an essential role. Increasing civilization and urbanization has led to an increase in the generation of wastes, there by polluting environment from various sources. Disposal and environmental friendly management of these wastes has become a serious global problem. Much attention has been paid in recent years to develop efficient low input technologies to convert nutrient rich organic wastes into value-added products for sustainable land practices (Kale *et al*., 1982; Daniel *et al*., 1999; Padma *et al* 2002; Garg and Kaushik, 2005).

Researchers from various part of the world have contributed to the knowledge of vermicomposting technology and benefits of vermicomposting organic wastes originated from animals, plants, agriculture, agroindustries, plant based industries, urban sewage etc. The research work carried out on vermicomposting of different organic wastes by diverse variety of earthworms compiled by Ranganathan (2006).. The quality and amount of food material influences not only the size of earthworm population but also the species present and their rate of growth and fecundity (Dominguez *et al*.,2000, Chaudhari and Battacharjee 2002). Hendriksen (1990) suggested that C:N ratio and particularly polyphenol concentration are the most important factor determining litter palatability in detrivorus earthworms.

The review of literature indicated that many researchers have analysed the chemical composition of vermicompost or vermicast and reported: reduction in pH, (near neutral pH) (Haimi and Huhta, 1987); narrow down of C:N ratio (Bhawalkar and Bhawalkar, 1993; Suthar, 2006); decrease in C:P ratio (Pore *et al*., 1992); increase in crude protein, amino acids and vitamins (Vimal and Talashilkar, 1983); reduction in organic carbon content (Jambhekar, 1992; Ramalingam, 2001) and increase in the levels of total nitrogen (Lee, 1985; Orozco *et al*., 1995; Gunadi *et al*., 2002; Christy and Ramalingam, 2005); total phosphorus (Satchell and Martin, 1984); total potassium (Pramanik *et al*., 2007); available N, P, K, Ca, Mg, Na and Zn (Edwards and Bohlen, 1996) and available Fe, Cu, Mn and Zn; (Hervas *et al*., 1989) in vermicast.

Hand *et al*., (1988) defined vermicomposting as a low cost technology system for the processing or treatment of organic wastes. The activities of earthworms along with micro organisms have brought out a rapid mineralization process and generation of the nutrients for plant growth. Karmegam (2000) also observed more NPK in the vermicompost than in the control.

The vermicasts have been reported with a higher Base Exchange capacity and are rich in total organic matter, phosphorus, potassium and calcium with a reduced electrical conductivity, large increase in oxidation potential and significant reductions in water-soluble chemicals which constitute possible environmental contaminants. Agricultural waste, horticultural waste, animal waste, silkworm litter, plant biomass (leaf litter), weeds, kitchen waste abiding, foul, acidic, spicy and spoilt food, city refuse after removing non-degradable waste material such as glass, plastic strong rubber and metal can be vermicomposted (Kale, 1995).

The research publication by Elvira *et al*. (1998) on paper mill sludge composting by *Eisenia* andrei revealed a noticeable reduction in organic carbon level, C/N ratio, C/P ratio and an increase in N and P at the end of the experiment. Large amount of humic substance were produced during the vermicomposting and these have been reported to have positive effects on plant growth independent of nutrition (Chen and Ariad, 1990; Atiyeh *et al*., 2002). The vermicomposts have more available nutrients than the organic waste from which they are produced. A comparative study, on the quality of organic matter and heavy metal in different mixtures of paper mill sludge and sewage sludge before and after vermicomposting (E. endrei) reported that a 1:6 mixture of paper mill sludge to sewage sludge was the most effective mixture for increasing the weight of *E.andrei* during the vermicomposting period. vermicomposting of pulp mill sludge mixed with garbage sludge,cowdung, pig slurry and poultry slurry at different ratios showed highest growth and highest mortality of E.andrei in all the mixtures considered (Elvira *et al*.,1998).

Vermicompost process will progress properly by starting the process with a C:N ratio around 25-30 and it will decrease during the process. Carbon reduces because heterotrophic bacteria use organic material as source of electron and carbon is oxidized to $CO_2$ and releases to atmosphere (Tchobanoglous *et al*., 1993). Increasing in number of worms can be effective in maintenance of pH around neutral range. It is important for obtaining vermicompost to be at the standard range of A class's range, 6.5-8.4, (Brinton, 2000). Hence, the aim of the present investigation is to document the stepwise chemical changes during the composting of kitchen waste by an indigenous species of earthworm. Such study is necessary to determine the time of vermistabilization for harvesting of quality compost from a particular type of waste.

## MATERIALS AND METHODS

The exotic earthworm *Eudrilus eugeniae* and *Eisenia fetida* has been selected for the present study. *Eudrilus eugeniae* and *Eisenia fetida* was obtained from the breeding stock maintained in the Department of Tea research foundation (UPASI) of coonoor, Nilgiris, India. The worms were stocked in cement tanks containing urine free, sun dried and powdered cowdung. The cement tanks (with *Eudrilus eugeniae* and *Eisenia fetida* stock) were covered by wooden framed iron mesh and maintained at room temperature (27 ± 2° C) with 60-70% moisture. Once in 15 days the surface layer of used up cowdung was removed and replaced with fresh cowdung.

### Vermicomposting study

To find out the best concentration control (T1) 100 soil,( T2 ) TW 40(g)+CD 20(g) +KW 40(g), (T3) TW 50(g) + CD 10(g) + KW 40(g) (T4) TW 60(g), CD 10(g) KW 30(g). TW + CD + KW feed substrates that can give good quality vermicompost with high level of nutrients, higher microbial population, higher quantity of Teawaste, in the present investigation the vermicomposting studies using *Eudrilus eugeniae* (Kinberg) and *Eisenia fetida* (Savingny) were carried out. Different concentration of TW, CD and KW substrates were prepared following the fermented organic method as described by Bano and Kale, (1987) and Kondo, (2004). For the sake of convenience, the vermicomposting experiments conducted with different concentration of TW, CD and KW mixtures are designated as T1,T2, T3 and T4.

Tea Waste (TW), cow dung (CD) and kitchen waste (KW) were weighed (dry weight) in specific concentration mixed using well water, so as to have 60-70% moisture, transferred to cement tanks (50 x 35 x 30 cm) (4 kg in each tank) and allowed 15 days for predecomposition to facilitate feed acceptance by earthworms (Edwards and Bohlen, 1966). The feed substrates were given three to four times in two weeks time, to enable temperature stabilization and uniform initial degradation of organic matter before introducing the worms as suggested by Kale and Sunitha (1993).

After 15 days, nonclitellated *Eudrilus eugeniae* (Kinberg) and *Eisenia fetida* (Savingny) worms about 10 days old with the total weight of 0.080 gm / kg were introduced into each experimental tank (T1 – T4). For each treatment, a control was also maintained without earthworms. For all treatments and control three replicates were maintained for a period of 90 days. The cement tanks were covered with wooden framed wire mesh and maintained at room temperature 28 □ 2□ C with 60-70% moisture in the vermiculture lab. Once in 15 days up to 90 days, the total weights of the worms were recorded.

**Collection of worm worked and worm unworked compost samples for chemical analysis.**

On 90th day vermicompost from each treatment (worm worked) T1 – T4 and compost from control (worm unworked) were collected, air dried, sieved and stored in polythene bags for pH, EC, N, P, K, OC, and CN ratio analysis. The vermicompost produced from T1 –T4 treatments were used for tea plant growth and yield study.

**Determination of pH and Electrical conductivity (EC).**

pH and EC were determined by the method described by ISI Bulletin (1982). 5gram of dry sample was taken in a 100ml beaker and 50ml of distilled water was added. The content was mixed well using a glass rod. After 30min the pH and EC were determined by using digital pH and electrical conductivity meter (Moded-Global DPH500).

**Estimation of total nitrogen, phosphorus, potassium and organic carbon in vermicompost and control compost**

The total nitrogen of compost sample was estimated by Kjeldahl method, as detailed by Tandon (1993). Total phosphorus content of the sample was estimated as per Tandon (1993) by colorimetric method. Total potassium content of the substrate was determined by Flame Photometric method as described by Tandon(1993). Sodium and calcium contents of the samples were determined by following the procedure of Tandon (1993) and the method is similar to that of K estimation. Mg, Zn, Fe, Cu and Mn content were estimated using atomic absorption spectrophotometer (AAS) according to the procedure outlined by Tandon, (1993). The determination of organic carbon was carried out as per the procedure of ISI Bulletin (1982).

**Statistical analysis**

By using computer, mean values ( ) with standard error (SE) were obtained from the data. The statistical significance between treatments was analyzed using one way analysis of variance (ANOVA) with the help of the computer package SYSTAT (Wilkinson, 1986). The critical difference (CD) value was also computed by Q test. A significant difference between any pairs of means that was subjected to ANOVA was indicated by CD value.

## RESULTS

**pH**

The pH level of vermicompost were decreased in all the treatment especially T4 treatments of E.*eugeniae* (4.9 ± 0.01) and E.*fetida* (4.8 ± 0.04) showed significantly ($P<0.05$) decreased pH than T3, T2 and T1 treatments (Table.1,2)

**EC**

The EC of vermicompost obtained from different treatments T1-T4 of E.eugineae and E.*fetida* range from 0.6 ± 0.04 to 1.9 ± 0.04 and from 0.7 ± 0.05 to 1.7 ± 0.05 respectively. EC of T4 and T3 treatments significantly increased than T1-T2 treatmen of both species (table 1,2 ).

**TOC, C:N ratio**

TOC content was reduced in vermicompost of all treatment. Especially T4 treatments in E.*eugeniae* (11.0 ± 0.04) and in E.*fetida* (11.2 ± 0.03) showed significantly ($p<0.05$) reduced TOC contents by the end of vermicomposting than T3, T2 and T1 treatments (table 1,2).

The C:N ratio significantly ($P<0.05$) varied between the treatment T1-T4. The CN ratio of vermicompost was reduced in T4 treatment of E.*eugeniae* (18.1 ± 0.12) and in E.*fetida* (18.0 ±

0.11) The T4 was significantly lower than T3, T2 unworked natural compost (WU) the maximum pH, TOC & CN ratio reduction was observed in vermicompost obtained from T4 treatments minimum in T1 followed by T2 and T3 of both species.

**Macro Nutrient**

The macro nutrients, N,P,K were found to be increased significantly ($P<0.05$) in vermicompost obtained from all the treatments T1-T4 of E.*eugeniae* and E.*fetida* . Among the different treatment T4, T3 treatment showed higher macro nutrient than T2, T1 treatments (table 3,4 ).

**Micro Nutrient**

The micro nutrients (Ca, mg, Na, Zn, Fe, Cu and Mn) of vermicompost produced by E.*eugeniae* and E.*fetida* showed significantly different in all treatments T1-T4. However, the T4 and T3 treatment showed significantly ($P<0.05$) higher level of micro nutrients than T2, T1 treatments (Table 5-8).

In this present analysis the pH, TOC and CN ratio significantly ($P<0.05$) decreased in the all the treatment (T1-T4) on the other hand EC, N, PK and micro nutrients (Ca, mg, Na, Zn, Fe, Cu and Mn) were found to be increased significantly ($P<0.05$) in all treatments. In general, the physico-chemical analysis of vermicompost indicate that among the parameter tested the level of pH, TOC and CN ratio were significantly ($p<0.05$) reduced then that of the values of control and (natural compost) on the other hand the level of EC, N.P.K, Ca, mg, Na, Zn, Fe and Mn were significantly ($P<0.05$) increased than the control. Of the two worms the vermicompost of E.*eugeniae* exihibits more nutrients than E. *fetida* .amounts of vitamins ingested from food are measured in micrograms or milligrams.

## DISCUSSION

**pH**

The earthworm activity significantly contributed towards neutral soil pH conditions through the production of casts. The availability of several plant nutrients and level of other elements depend upon the pH levels of the organic manure. Barois *et al*. (1999) recording of higher pH level in soils in the organic farm site compared to the integrated farm site is likely due to the addition of organic matter and the non use of chemical fertilizers in the former site. Earthworm are very sensitive to pH and in general are neutrophilic in nature (Edwards and Bholen, 1996).The soil quality includes soil reaction (pH),mineral nutrient elements, water content, composition of soil atmosphere and biotic factors. Mature compost when added to soil directly affected almost all of these factors (Marinari *et al*., 2000). The production of NH4 +, CO2 and and T1 (Table 3,4). When compared to control worm organic acids during microbial metabolism in vermicompost may be contributed to the decrease in soil pH (Albanell *et al*., 1988). Falling in the line with this observation it is found that vermicomposting process has reduced the pH from 6.0 to neutral pH in the vermicomposted mixture of industrial teawaste, cow dong and kitchen waste. Most of the other reports on vermicomposting (Garg and Kaushik, 2005; Gunadi and Edwards, 2003) have also reported similar results.

**Electrical Conductivity (EC).**

Soil electrical conductivity (EC) is a measurement that correlates with soil properties that affect crop produc¬tivity, including soil texture, cation exchange capac¬ity (CEC), drainage conditions.The soil analysed with vermicompost had significantly ($p<0.05$) higher EC than the untreated soils. The increased EC during the period of the composting and vermicomposting processes is in consistence with that of earlier workers (Kaviraj and S. Sharma.,2003), which was probably due to the degradation of organic matter releasing minerals such as exchangeable Ca, Mg, K, and P in the available forms, that is, in the form of cations in the vermicompost and compost (Tognetti *et al*.,2005). The soils EC increased with increasing application rate of vermicompost in soil as reported by Atiyeh *et al*.,(2001). The present work associated with previous workers, Lazcano *et al*.,(2008) reported that the EC values ranged between $0.72 \pm 0.02$ ds/m in the vermicompost from different organic waste. The electrical conductivity of vermicompost depends on the raw materials used for vermicompost and their ion concentration [Atiyeh *et al*., 2002]. In the present study the EC has increased in all the worm worked vermicompost (T1-T4) than control. In the present study, EC was increased in the range of $0.6 \pm 0.06$ to $1.9 \pm 0.05$ for different treatments after vermicomposting of both species.

**Total organic corbon (TOC)**

The organic carbon is the main source of energy for plants and animals, the value of organic matter are very important for soil health. The deficiency in organic carbon reduces storage capacity of soil. Nitrogen, phosphorus and sulphur lead to reduction in soil fertility (Kale, 1993). The chemical analysis of vermicompost indicated that during the process of vermicomposting, the level of organic carbon was reduced in the vermicompost obtained from various treatments (T1-T4) when compared to control. The results revealed that during the process of vermicomposting, the level of OC was reduced to a lesser extent. The final product, vermicompost obtained from various treatments, retained the quantity of OC ranging between 26.8%-

**TABLE-1 pH, EC and TOC content of vermicompost of *E.eugeniae* in different concentrations of Industrial tea waste, Cow dung and kitchen waste.**

| Treatment | pH | | | EC (ds/m) | | | TOC (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Initial | WUW | VC | Initial | WUW | VC | Initial | WUW | VC |
| T1 | 6.1±0.03 | 6.0±0.04 | 5.4±0.01[a] | 0.4±0.01 | 0.5±0.01 | 0.6±0.04[a] | 32.0±0.12 | 27.5±0.08 | 26.8±0.07[c] |
| T2 | 6.1±0.03 | 6.0±0.03 | 5.3±0.02[a] | 0.4±0.01 | 0.7±0.04 | 1.1±0.04[ab] | 34.0±0.07 | 24.3±0.05 | 22.4±0.03[b] |
| T3 | 6.0±0.02 | 5.9±0.03 | 5.1±0.01[b] | 0.6±0.02 | 0.9±0.02 | 1.6±0.04[b] | 35.0±0.31 | 22.4±0.07 | 18.1±0.10[a] |
| T4 | 6.0±0.02 | 5.9±0.02 | 4.9±0.01[b] | 0.7±0.02 | 1.1±0.01 | 1.9±0.04[b] | 36.0±0.32 | 20.8±0.03 | 11.0±0.04[a] |

**Table-2 pH, EC and TOC content of vermicompost of *E.fetida* in different concentrations of Industrial tea waste, Cow dung and kitchen waste.**

| Treatment | pH | | | EC (ds/m) | | | TOC (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Initial | WUW | VC | Initial | WUW | VC | Initial | WUW | VC |
| T1 | 6.1±0.03 | 6.0±0.04 | 5.3±0.02[a] | 0.4±0.01 | 0.5±0.01 | 0.5±0.05[a] | 32.0±0.12 | 27.5±0.08 | 26.9±0.06[c] |
| T2 | 6.1±0.03 | 6.0±0.03 | 5.4±0.04[ab] | 0.4±0.01 | 0.7±0.04 | 0.9±0.06[a] | 34.0±0.07 | 24.3±0.05 | 22.6±0.03[ab] |
| T3 | 6.0±0.02 | 5.9±0.03 | 5.1±0.01[b] | 0.6±0.02 | 0.9±0.02 | 1.4±0.05[b] | 35.0±0.31 | 22.4±0.07 | 18.2±0.11[a] |
| T4 | 6.0±0.02 | 5.9±0.02 | 5.8±0.04[b] | 0.7±0.02 | 1.1±0.01 | 1.7±0.05[b] | 36.0±0.32 | 20.8±0.03 | 11.0±0.05[a] |

**TABLE-3 N, P, K and C:N ration of vermicompost of *E.eugeniae* recorded in different concentrations of Industrial tea waste, cow dung and kitchen waste.**

| Treatment | N | | | P | | | K | | | CN | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Initial | WUW | VC | Initial | WUW | VC | Initial | WUW | VC | Initial | WUW | VC |
| T1 | 1.01±0.02 | 1.80±0.09 | 1.98±0.09$^{a}$ | 0.23±0.01 | 0.56±0.01 | 0.76±0.02$^{a}$ | 0.91±0.07 | 1.11±0.08 | 1.23±0.09$^{a}$ | 29.2±0.17 | 27.8±0.16 | 25.4±0.13$^{c}$ |
| T2 | 1.01±0.03 | 1.87±0.08 | 1.98±0.03$^{a}$ | 0.23±0.02 | 0.83±0.01 | 0.99±0.03$^{ab}$ | 0.92±0.01 | 1.21±0.02 | 1.42±0.03$^{a}$ | 29.2±0.18 | 26.8±0.24 | 24.9±0.27$^{ab}$ |
| T3 | 1.12±0.01 | 2.21±0.05 | 2.34±0.012$^{b}$ | 0.31±0.01 | 1.38±0.03 | 1.47±0.02$^{b}$ | 1.01±0.03 | 1.48±0.04 | 1.94±0.11$^{b}$ | 27.1±0.18 | 24.8±0.17 | 22.3±0.23$^{a}$ |
| T4 | 1.12±0.02 | 2.38±0.014 | 2.43±0.15$^{b}$ | 0.32±0.02 | 1.47±0.04 | 1.56±0.05$^{b}$ | 1.12±0.12 | 1.60±0.10 | 2.10±0.15$^{b}$ | 28.2±0.21 | 21.2±0.13 | 18.1±0.12$^{a}$ |

**TABLE-4 N, P, K and C:N ratio of vermicompost of *E.fetida* recorded in different concentrations of Industrial tea waste, cow dung and kitchen waste.**

| Treatment | N | | | P | | | K | | | C:N | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Initial | WUW | VC | Initial | WUW | VC | Initial | WUW | VC | Initial | WUW | VC |
| T1 | 1.01±0.02 | 1.80±0.09 | 1.95±0.03$^{a}$ | 0.23±0.01 | 0.56±0.01 | 0.73±0.01$^{a}$ | 0.91±0.07 | 1.11±0.08 | 1.21±0.01$^{a}$ | 29.2±0.17 | 27.8±0.16 | 25.2±0.27$^{c}$ |
| T2 | 1.01±0.03 | 1.87±0.08 | 1.96±0.04$^{a}$ | 0.23±0.02 | 0.83±0.01 | 0.96±0.02$^{ab}$ | 0.92±0.01 | 1.21±0.02 | 1.40±0.02$^{ab}$ | 29.2±0.18 | 26.8±0.24 | 24.6±0.02$^{ab}$ |
| T3 | 1.12±0.01 | 2.21±0.05 | 2.28±0.07$^{b}$ | 0.31±0.01 | 1.38±0.03 | 1.41±0.02$^{b}$ | 1.01±0.03 | 1.48±0.04 | 1.84±0.10$^{b}$ | 27.1±0.18 | 24.8±0.17 | 20.0±0.21$^{a}$ |
| T4 | 1.12±0.02 | 2.38±0.014 | 2.39±0.14$^{b}$ | 0.32±0.02 | 1.47±0.04 | 1.52±0.04$^{b}$ | 1.12±0.12 | 1.60±0.10 | 2.03±0.14$^{b}$ | 28.2±0.21 | 21.2±0.13 | 18.0±0.11$^{a}$ |

**TABLE-5 Calcium, Magnesium and Sodium. content of vermicompost of *E.eugeniae* using industrial tea waste, cow dung and kitchen waste in different concentrations.**

| Treatment | Calcium (%) | | | Magnesium (%) | | | Sodium (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Initial | WUW | VC | Initial | WUW | VC | Initial | WUW | VC |
| T1 | 0.21±0.01 | 0.35±0.02 | 2.01±0.12[a] | 0.10±0.02 | 0.20±0.03 | 0.60±0.01[a] | 0.08±0.02 | 0.12±0.02 | 0.22±0.02[a] |
| T2 | 0.21±0.02 | 0.56±0.03 | 2.25±0.21[ab] | 0.10±0.01 | 0.34±0.01 | 0.68±0.03[a] | 0.08±0.03 | 0.14±0.03 | 0.25±0.06[ab] |
| T3 | 0.31±0.01 | 0.89±0.03 | 2.60±0.15[b] | 0.15±0.02 | 0.46±0.02 | 0.79±0.03[b] | 0.10±0.01 | 0.18±0.01 | 0.29±0.05[b] |
| T4 | 0.31±0.03 | 1.01±0.05 | 3.12±0.18[b] | 0.15±0.02 | 0.63±0.03 | 0.95±0.04[b] | 0.11±0.02 | 0.20±0.01 | 0.35±0.05[b] |

**TABLE-6 Calcium, Magnesium and Sodium. content of vermicompost of *E.fetida* using industrial tea waste, cow dung and kitchen waste in different concentrations.**

| Treatment | Calcium (%) | | | Magnesium (%) | | | Sodium (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Initial | WUW | VC | Initial | WUW | VC | Initial | WUW | VC |
| T1 | 0.21±0.01 | 0.35±0.02[a] | 1.96±0.2[a] | 0.10±0.02 | 0.20±0.03[a] | 0.50±0.02[a] | 0.08±0.02 | 0.12±0.02[a] | 0.18±0.03[a] |
| T2 | 0.21±0.02 | 0.56±0.03[a] | 2.20±0.25[a] | 0.10±0.01 | 0.34±0.01[ab] | 0.58±0.03[ab] | 0.08±0.03 | 0.14±0.03[a] | 0.20±0.04[a] |
| T3 | 0.31±0.01 | 0.89±0.03[b] | 2.53±0.13[b] | 0.15±0.02 | 0.46±0.02[b] | 0.69±0.03[b] | 0.10±0.01 | 0.18±0.01[b] | 0.22±0.03[b] |
| T4 | 0.31±0.03 | 1.01±0.05[b] | 2.96±0.17[b] | 0.15±0.02 | 0.63±0.03[b] | 0.85±0.02[b] | 0.11±0.02 | 0.20±0.01[b] | 0.33±0.04[b] |

**TABLE-7 Zinc, Iron, Copper and Manganese content of vermicompost produced by *E.eugeniae* using industrial Tea waste, Cow dung and Kitchen waste**

| Treatment | Zinc (PPM) | | | Iron (PPM) | | | Copper (PPM) | | | Manganese (PPM) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Initial | WUW | VC | Initial | WUW | VC | Initial | WUW | VC | Initial | WUW | VC |
| T1 | 120±1.10 | 163±1.52 | 230±4.37[a] | 290±2.21 | 310±2.35 | 372±3.24[a] | 20±0.12 | 27±0.15 | 58±0.67[a] | 288±7.21 | 314±8.15 | 357±6.81[a] |
| T2 | 120±1.11 | 178±1.87 | 256±4.51[a] | 290±1.22 | 317±4.21 | 378±3.57[a] | 20±0.12 | 29±0.15 | 60±0.71[ab] | 288±7.28 | 316±9.63 | 361±6.21[ab] |
| T3 | 130±1.12 | 184±3.11 | 269±7.21[b] | 311±3.12 | 321±6.15 | 392±5.17[b] | 22±0.12 | 31±0.17 | 63±0.27[b] | 290±8.11 | 321±5.27 | 375±11.09[b] |
| T4 | 131±1.12 | 190±3.23 | 289±4.21[b] | 311±3.12 | 335±6.95 | 398±5.51[b] | 23±0.11 | 33±0.23 | 69±0.87[b] | 291±8.12 | 322±6.31 | 398±11.09[b] |

**TABLE-8 Zinc, Iron, Copper and Manganese content of vermicompost produced by *E.fedita* using industrial Tea waste, Cow dung and Kitchen waste.**

| Treatment | Zinc (PPM) | | | Iron (PPM) | | | Copper (PPM) | | | Manganese (PPM) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Initial | WUW | VC | Initial | WUW | VC | Initial | WUW | VC | Initial | WUW | VC |
| T1 | 120±1.10 | 163±1.52 | 201±3.21[a] | 290±2.21 | 310±2.35 | 350±4.53[a] | 20±0.12 | 27±0.15 | 42±0.52[a] | 288±7.21 | 314±8.15 | 341±7.21[a] |
| T2 | 120±1.11 | 178±1.87 | 203±6.12[a] | 290±1.22 | 317±4.21 | 369±8.32[a] | 20±0.12 | 29±0.15 | 44±0.69[ab] | 288±7.28 | 316±9.63 | 351±5.31[a] |
| T3 | 130±1.12 | 184±3.11 | 229±6.35[b] | 311±3.12 | 321±6.15 | 372±4.87[b] | 22±0.12 | 31±0.17 | 48±0.68[b] | 290±8.11 | 321±5.27 | 357±9.26[b] |
| T4 | 131±1.12 | 190±3.23 | 244±6.26[b] | 311±3.12 | 335±6.95 | 388±8.32[b] | 23±0.11 | 33±0.23 | 52±0.75[c] | 291±8.12 | 322±6.31 | 378±12.11[b] |

T1: Soil alone, T2: TW 40% + CD 20% + KW 40%, T3: TW 50% + CD 10% + KW 40% and T4: TW60% + CD 10% + CD 10% + KW 30%.
WUW: worm unworked natural compost, VC: vermicompost Mean value followed by different letter is statistically different. ANNOVA: Duncan's multiple-ransed test ($P<0.05$).

28.5%. Many earlier investigators had reported and confirmed the reduction of OC content in organic wastes after vermicomposted into vermicompost (Satchell, and Martin 1984; Ramalingam and Thilagar, 2000; Karmegam and Daniel, 2000; Ramalingam and Ranganathan, 2001 and Loh *et al*., 2005; Suthar, 2006). The observed reduction in the level of OC in the present study falls in line with the earlier reported results. Drop in the level of OC due to combined action of earthworm and microbes during vermicomposting revealed that earthworm accelerate the decomposition of organic matter.

At the same time, the maintenance of high level of OC in the vermicompost represents an important source of organic carbon for carbon depleted soil. Organic matter encourages the formation of topsoil and soil aggregates in the surface soil horizon (Bardy, 1988). So it can be concluded that OC in the vermicompost form the main source of energy both for soil organisms and plants and is helpful in the formation of topsoil and soil aggregates.

**C:N ratio**

The significant reduction (-22% to -50%) (T1-T4) and narrow range of C:N ratio below 20:1 in the present study reflected the efficient worm activity, leading to accelerated the rate of organic matter decomposition, and mineralization there by resulting in nutrient rich good quality vermicompost, particularly from the treatments T3 and T4. The observed significant reduction in the levels of C:N ratios in the vermicompost obtained from treatments, T1-T4 were in accordance with the work of Mba (1983) who found that in E.*eugeniae* worked cassava feel compost C:N ratio decreased whereas total nitrogen increased. Many researchers had reported narrowing down of C:N ratio in the vermicompost produced from different types of organic wastes (Karmegam and Daniel, 2000; Bhattacharjee, 2002; Christy and Ramalingam, 2005; Pramanik *et al*., 2007).

The reduction in carbon and lowering of C:N ratio in the worm worked compost could be achieved on one hand by the combustion of carbon during worm respiration and worm gut microbial utilization (Edwards and Bohlen, 1996; Chaudhuri *et al*., 2000) and on the other hand an increase in the level of nitrogen due to loss of dry matter (OC) as CO2, as well as water loss by evaporation during microbial mineralization of organic matter (Syers *et al*., 1979) coupled with the addition of worm's nitrogenous wastes through excretion and mucus secretion (Curry *et al*., 1995). The decrease in C:N ratio over time might also be attributed to increase in the earthworm population which led to rapid decrease in organic carbon due to enhanced oxidation of the organic matter (Nedgewa and Thompson, 2000). So, from the present investigation it can be concluded that the reduction in C:N ratios of vermicompost indicated enhanced biodegradation process of the organic matter in the TW + CD + KW substrates. Further, reduction in C:N ratios of vermicompost are the indices for the effective biodegradation of organic wastes such as TW, CD etc., and production of good quality compost during the vermicomposting process.

**Nitrogen, phosphorus, potassium (N,P,K.)**

The significantly increased levels of NPK in the vermicompost obtained from the treatments T1-T4, specifically in T3 and T4 over control indicated effective decomposition of organic wastes (TW + CD+KW) by the combined action of earthworm and microbes. The increased levels of NPK in the vermicompost were in conformity with the results of earlier workers. Edwards *et al*. (1985) stated that by the combined action of worms and microorganisms on the waste materials most of the NPK, Mg were converted into available form. Kale (1994) reported a significant increase in available NPK in worm worked cowdung and sheep dung. Tiwari *et al*. (1989) have recorded higher value of organic carbon, NPK in the cast than in the top soil samples. Suthar, (2006) reported that the C:N ratio was reduced and also N, P, K contents were increased during vermicomposting process. Haimi and Huhta (1990) and Haimi and Boucelman (1991) have demonstrated that the feeding activity of worm significantly enhanced mineralization of macronutrients of brich litter. Jambhekar (1992) noticed considerable increase in available N, P, and K in the worm worked wastes than that of the original wastes. Ramalingam (1997) reported a significant increase in the level of N, P, K, Ca and Mg in *E. eugeniae* and *E. fetida* worked vermicompost.

Balamurgan and Vijayalakshmi (2004), indicated increased level of N, P, K in composted pressmud and coir waste using microbes and earthworm *E.eugeniae*. Karmegam and Daniel (2000) reported a significant hike in the level of N, P, K in E.*fetida* worked leaf litters. Ramalingam and Thilagar (2000) reported increased levels of N, P, K, Ca and Mg and other micronutrients in the sugarcane trash compost produced by P. excavatus. Ramalingam and Ranganathan (2001) reported significant increase in the levels of N, P, K, Ca, Mg and other micronutrients in the vermicomposted pressmud by the action of *E.eugeniae*.

The presence of large number of microflora in the vermicomposting of the earthworms might play an important role in increasing P and K content by acid production for solubilisation of insoluble P and K during organic matter decomposition as reported by Sharma (2003). Significant rise in nitrogen (N) content during vermicomposting process compared to control is probably contributed by earthworms through excretion of NH4+ (ammonia), secretion of mucus and addition of nitrogen by microbes. Rise in the levels of phosphorus and potassium content during vermicomposting is probably due to the mineralization, solubilisation and mobilization of phosphorus and potassium, because of bacterial and earthworm activity.

Suthar (2006) investigation support the hypothesis that earthworm can enhance the mineralization of P, K during their inoculation in waste system. In the present study, the significantly increased levels of NPK in the vermicompost generated from TW+CD+KW substrates (T1-T4) and also in other treatments could be due to the combined action of microorganisms and *Eudrils eugeniae* and *E. fetida* which increased the mineralization of organic matter when it passes through the gut. Microbial and enzyme activity also contributes to increase the mineral nutrients in the vermicasts through nitrification, phosphate solubilization and mineralization (Edwards and Bohlen, 1996; Ranganathan and Vinotha, 1998). Parthasarathi and Ranganathan (2000) found the enzyme activities involved in mineralization enhanced during the passage of organic matter through the gut of earthworms. Thus, vermicompost obtained from TW60%+CD10%+KW40% (T4) as well as TW50%+CD10%+KW40% (T3) mixtures evidenced with increased level of NPK and drastically reduced C:N ratios and hence can be considered as good quality vermicompost.

## CONCLUSSION

From the nutrient analysis of the vermicompost it could be deduced that not all the concentrations of TW+CD+KW are equally accepted and processed by *E. eugeniae* and *E. fetida* as a consequence resulting in differential mineralization rate between the treatment concentrations. Hence, it can be concluded that the quality of vermicompost partly depends upon quality of organic wastes used for vermicomposting and partly upon the rate of degradation of organic wastes by the combined effects of earthworm activities. The present study proved beyond doubt that TW, CD and KW are served as best raw material for the production of nutrients and microbial rich organic manure. Hence, from the present investigation T4- (TW60% + CD10% + KW30%) feed mixtures can be recommended for vermiculture and vermicomposting and production of organic manure in an ecofriendly way.

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