

Original Research Article

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## Comparative Assessment of Physicochemical and Biological Quality Characters of Vermicompost from Different Biomass Substrates

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### ABSTRACT

#### Keywords

Physicochemical and biological characters, Vermicompost, Biomass substrate, Water hyacinth, coconut leaf

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In vermicomposting, variation in particle size, palatability and metabolites of solid organic wastes may influence the performance of earthworm as well as quality of its final product. Therefore, the study was taken to characterize the vermicomposts prepared from two different sources i.e. water hyacinth and coconut leaf respectively. Vermicompost of water hyacinth and coconut leaf showed almost similar pH and EC values by Jackson method (1973) but these showed higher in FCO method (1985). CEC value for both vermicompost was 74.20 and 72.60 cmol (+) kg<sup>-1</sup>. The Organic carbon content (23.1%) was recorded in water hyacinth vermicompost while as coconut leaf vermicompost (22.5%). Water holding capacity was much higher (213.90 and 226.2%) as compare to cultivated soil. Available form of N, P, K, S, Zn, Cu, Mn and Fe was found in less content with respect to total K and Na content in both types of vermicompost. Available part of the nutrients was more pronounced in water hyacinth vermicompost than coconut leaf vermicompost while as microbial population was accounted higher in water hyacinth vermicompost than coconut leaf vermicompost respectively. Water hyacinth vermicompost contains higher values of dehydrogenase activity, microbial biomass carbon content as well as urease enzyme activity. Results represented that water hyacinth vermicompost is better in quality than coconut leaf vermicompost with respect to its microbial properties.

### Introduction

In an estimate, the annual total crop residues generated by the world population is projected around 3.8 billion tonnes (Lal, 2005). Around 3 thousand million tonnes of wastes annually produced in India, out of which more than 60% are decomposable (Chauhan *et al.*, 2010). These large quantities of plant residues may serve as potential sources of plant nutrients (Suthar, 2007). These wastes may be recycled

by making manure, compost as well as vermicompost which are the best options for its management (Bhat *et al.*, 2013). Animal wastes also require a route for recycling into valuable end product rather being desecrate and discharge in the environment. Composting by using earthworm which offers the rapid recovery of valuable resources from biodegradable plant and animal wastes to humus-like vermicompost at a very short period of time (Pramanik *et al.*, 2007). A large

area of Southern and eastern India which occupy coconut and a reanut plantation that supplies the huge quantities of coconut leaf biomass per year. Generally, these are burnt in the field and causing pollution to the environment. Large quantity of water hyacinth grows naturally in India under low land areas and stagnant water bodies. Water hyacinth is an aquatic weed which causes economic as well as environmental losses in many countries due to its rapid growth habits. It can obstruct the access to the pumps used for irrigation, causing water resources depletion, and the spreading of mosquitoes and flies which are vectors of a number of diseases (Ding *et al.*, 2001). There are several ways to control water hyacinth like mechanical, biological, and chemical methods. However, it is also used to produce valuable products such as, biogas, compost and vermicompost (Malik, 2007). To turning of these plant residues and animal excreta into a valuable end product i.e. vermicompost will be an option to manage these waste products profitably. However, the organic wastes have different palatability, particle size, metabolites etc. that may influence the growth and performances of earthworms (Suthar, 2007). The substrate and manner of composting dictates the essential properties of the compost like, C/N ratio, available macronutrients (e.g., N, P, K, S) and micronutrients (e.g., Fe, Cu, Zn, Mn, B) for plant and associated micro-flora and fauna (bacteria and fungi). These factors affect the quality of vermicompost. By keeping of this view to understand the variation in quality of vermicompost from different substrates, the study was conducted to evaluate the vermicompost produced from locally grown water hyacinth and coconut leaf biomass respectively.

### **Materials and Methods**

The present study was undertaken to characterise the two types of vermicompost

i.e., vermicompost of water hyacinth and of coconut leaf biomass along with a soil sample collected from BAU farm, Sabour. pH and EC were measured by the method described by Jackson (1973) and FCO (1985). Cation exchange capacity was determined by neutral normal ammonium acetate (1N NH<sub>4</sub>OAc) with the help of the method of Schollenberger as described in Black (1965). Organic carbon was determined by wet digestion method of Walkley and Black (1934) as described in Black (1965). Available nitrogen was estimated by alkaline permanganate oxidation method as described by Subbaiah and Asija (1956). Exchangeable NH<sub>4</sub><sup>+</sup> and NO<sub>3</sub><sup>-</sup> nitrogen present in vermicomposts and soil were determined by the method of Kenny and Bremner (1962) as described by Page *et al.*, (1982). Available phosphorus content was estimated by Olsen's method (Olsen *et al.*, 1954). Available potassium and sodium in soil and vermicompost were determined by neutral ammonium acetate (1N) extract using flame photometer (Jackson, 1973). Extraction of available sulphur was done by using 0.15% CaCl<sub>2</sub> as per the method of Williams and Steinbergs (1959) and the extracted sulphur was estimated by turbidimetrically method of Chesnin and Yien (1951) using a spectrophotometer at 420 nm wavelength. Available Fe, Cu, Zn, Mn were estimated by Lindsay and Norvell (1978) method with the help of atomic absorption spectrophotometer.

Total nitrogen present in vermicompost and soil was determined by standard method (Piper, 1966). Total phosphorous of vermicompost and soil was determined by diacid digestion and phosphorus in the digest was estimated by the vanadomolybdate yellow colour method (Page *et al.*, 1982). Total potassium and sodium were determined by using known volume of digest (prepared as in total phosphorus) and estimated by flame photometer (Page *et al.*, 1982). Total sulphur in the digest was estimated by using BaCl<sub>2</sub>

crystal (Tabatabai *et al.*, 1982) with the help of spectrophotometer (420 nm). Total Fe, Cu, Zn, Mn were determined by using known volume of digest (prepared as in total phosphorus) with the help of AAS (Atomic absorption spectrophotometer).

Microbial population like total bacteria, total actinomycetes, total fungi, azotobacter, and phosphorus solubilising bacteria (PSB) were also taken into account by counting colony forming unit (cfu g<sup>-1</sup>) through serial dilution plate technique (Allen, 1960). Microbial biomass carbon was estimated in chloroform fumigation extraction procedure as described by Jenkinson and Powlson (1976) and calculation was made by Vance *et al.*, (1987). Dehydrogenase activity in soil and vermicompost was determined by the spectrophotometer (Klein *et al.*, 1971). Urease enzyme activity in samples was estimated by Tabatabai and Bremner (1972).

## Results and Discussion

### Physico-chemical properties of vermicomposts

Results of physicochemical properties of two different types of vermicompost along with a cultivated soil which are presented in Table 1. Both type of vermicompost showed similar pH values *i.e.* 6.81 (water hyacinth) and 6.92 (coconut leaf) respectively *i.e.*, less than cultivated soil (7.94). pH value determined by FCO method (1985) showed little higher than normal pH method (1:2.5) by Jackson but the magnitude was higher in coconut leaf vermicompost (0.31) than water hyacinth vermicompost (0.22) that may be explained by higher quantities of Na, K content in it which neutralise carboxylic group and other acids after long time shaking (2 hour). Electrical conductivity (EC) value showed similar trend. Highest EC value observed in water hyacinth vermicompost (3.35 dS m<sup>-1</sup>) in FCO method

(1985) whereas coconut leaf vermicompost resulting 2.25 dS m<sup>-1</sup> which is showed in Figure 1 that indicates the presence of little quantities of soluble salts in the vermicompost casts and soluble salt content is more in water hyacinth vermicompost than coconut leaf vermicompost respectively. Irshad *et al.*, (2013) reported that higher EC values in composted manures could be attributed to the release of salts from the manure with the passage of time. Cation exchange capacity of both types vermicompost was about to similar [74.20 and 72.60 cmol (+) kg<sup>-1</sup>]. Organic carbon content in water hyacinth vermicompost was 23.1% and in coconut leaf vermicompost 22.5%. Maximum water holding capacity was much higher (213.90 and 226.20%) than cultivated soil (41.00%).

Available nitrogen in water hyacinth and coconut leaf vermicompost were 443.40 mg kg<sup>-1</sup> and 417.20 mg kg<sup>-1</sup> (Fig. 2) which contributed to 3.26% and 2.87% of total nitrogen content (1.36% and 1.45%), respectively. Ammonium form of nitrogen content was higher than the nitrate form in both the vermicompost and cultivated soil. Available phosphorus content in water hyacinth and coconut leaf vermicompost were 52.30 mg kg<sup>-1</sup> and 36.32 mg kg<sup>-1</sup> which explained 0.83% and 0.69% of total P (0.63 and 0.52%) content, respectively. Comparatively much higher content of available K found in both vermicompost (1882.33 mg kg<sup>-1</sup> and 2047.00 mg kg<sup>-1</sup>) which was 36.47 and 36.55% of total content of K. Similar trend was found in analysis of Na content. Available sulphur content in water hyacinth as well as coconut leaf vermicompost were 118.62 and 93.43 mg kg<sup>-1</sup> which contributed 4.28 and 4.04% of total S content respectively. Higher content of total N and K was found in coconut leaf vermicompost (Fig. 3) than water hyacinth vermicompost but reverse found for total P, Na and S. Micronutrient contents were much less than

the macronutrient content. Available micronutrient content in water hyacinth as well as coconut leaf vermicompost resulted 1.16 and 1.04 mg kg<sup>-1</sup> for Cu which resulted 0.99 and 1.08% of total content, 4.84 and 6.74 mg kg<sup>-1</sup> for Zn that contributed 9.68 and 8.98% of total Zn content, 21.22 and 17.02 mg kg<sup>-1</sup> for Fe which was 0.67 and 0.84% of total content and 14.42 and 16.72 mg kg<sup>-1</sup> for Mn which explained 6.08 and 4.77% of total Mn. It has been understood from these results that,

available part of nutrients were more pronounced in water hyacinth vermicompost than coconut leaf vermicompost that may be due to higher lignin and cellulose content in coconut leaf that produce more complex humus and make metal humus complex.

The coconut leaf vermicompost content higher amount of total Zn and Mn but lower amount of total Cu in comparison to water hyacinth vermicompost shown in Figure 4.

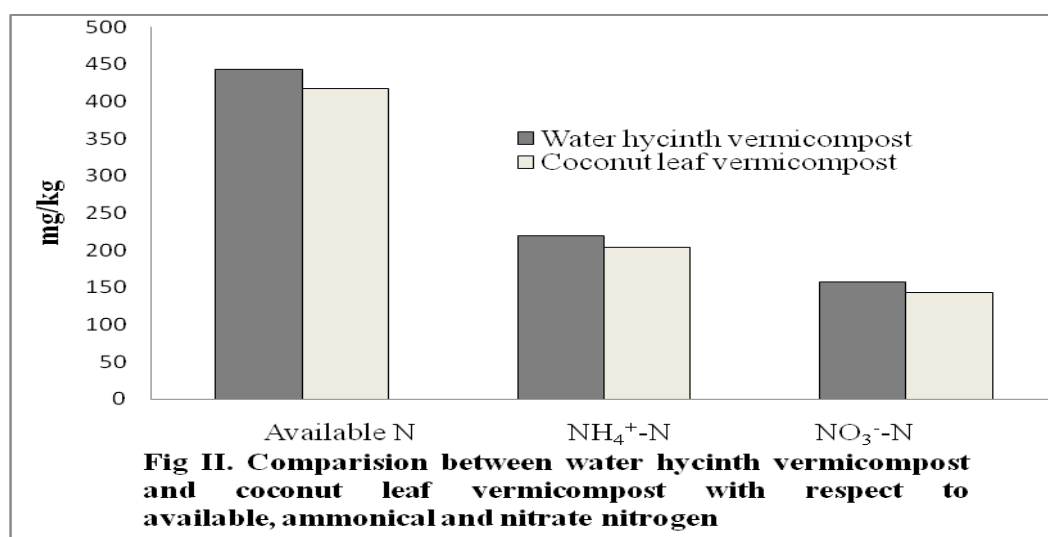
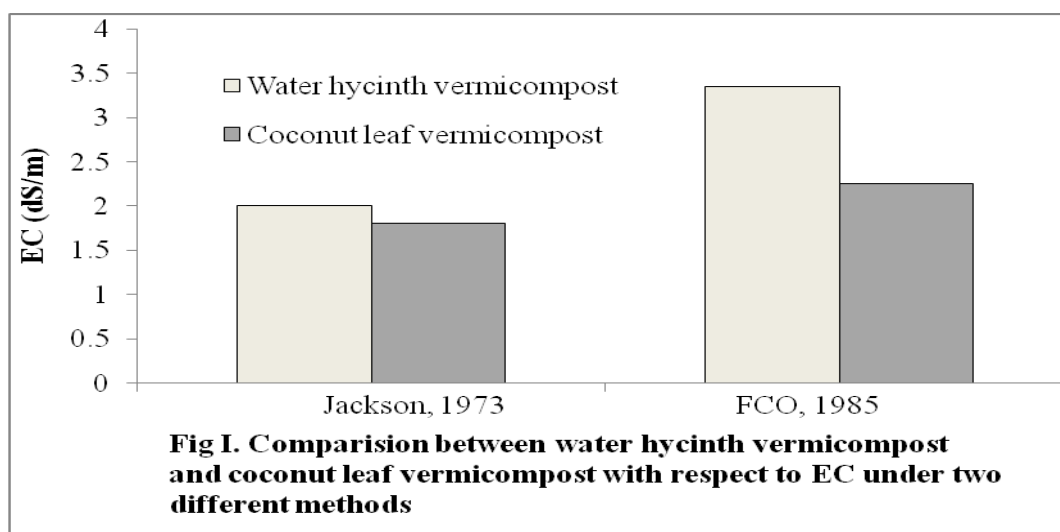
**Table.1** Physicochemical characteristics of vermicompost among two different substrates (water hyacinth and coconut leaf) and cultivated soil

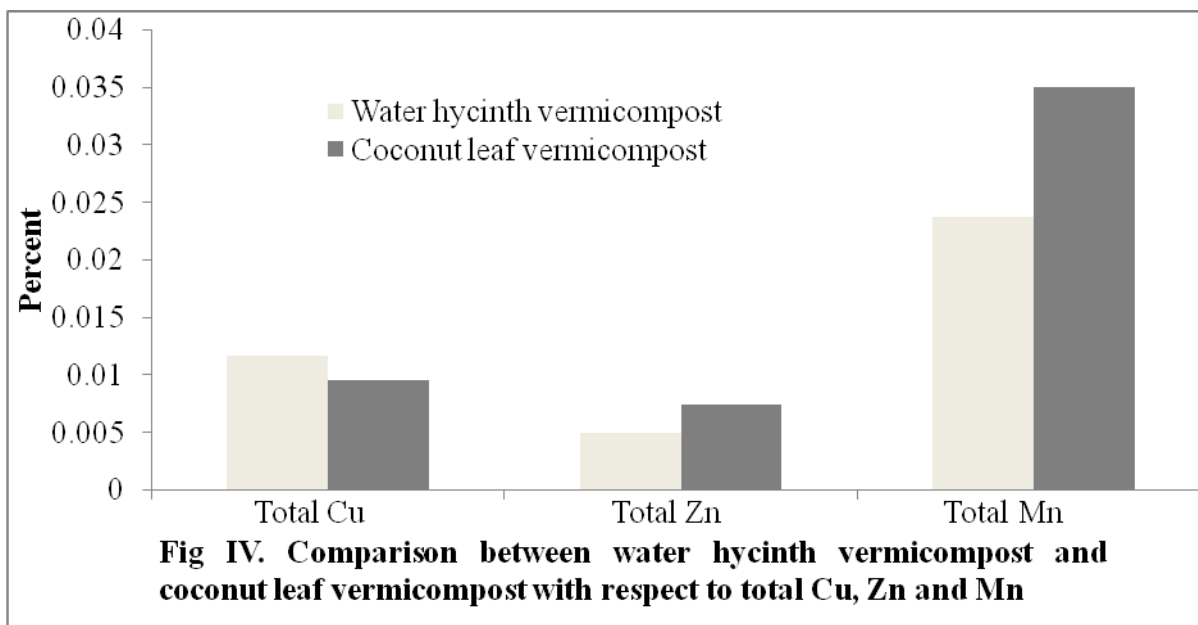
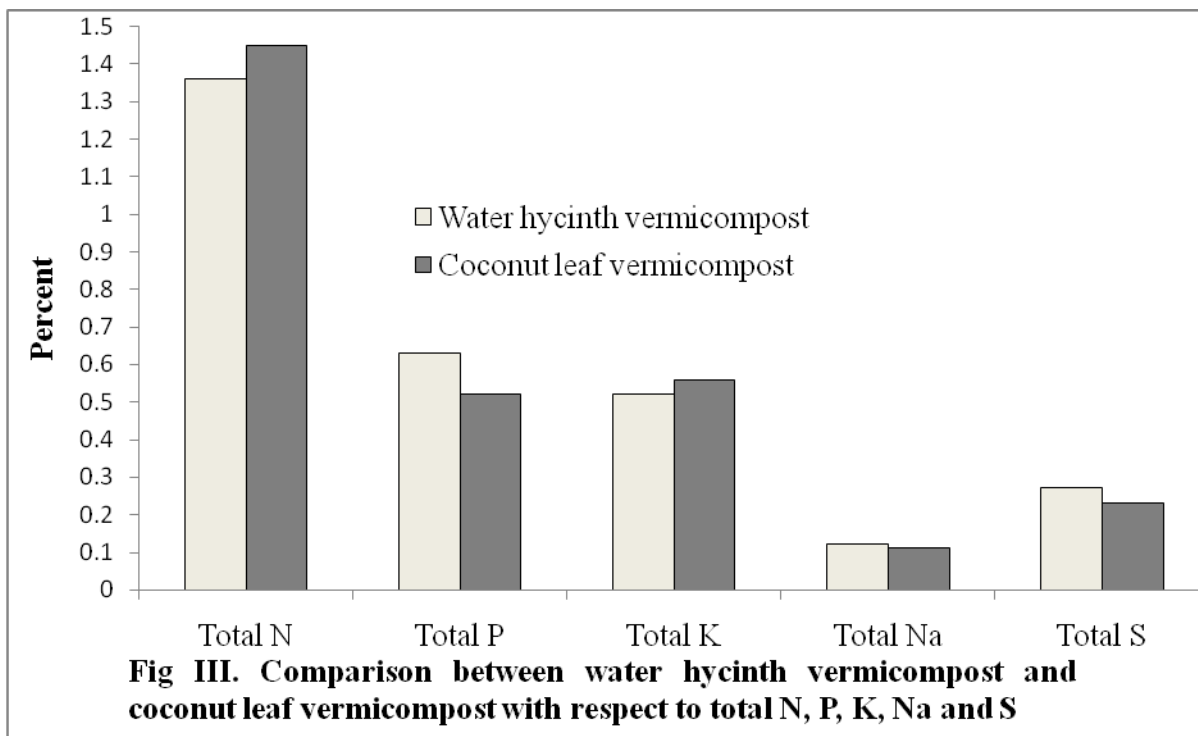
Characteristics	Vermicompost (water hyacinth)	Vermicompost (coconut leaf)	Cultivated soil
pH (1:2.5)	6.81	6.92	7.94
pH (FCO, 1985)	7.03	7.23	-
EC (1:2.5) (dS m <sup>-1</sup> )	2.00	1.80	0.20
EC (FCO, 1985) (dS m <sup>-1</sup> )	3.35	2.25	-
CEC [cmol(+)kg <sup>-1</sup> ]	74.20	72.60	8.60
Organic carbon (%)	23.10	22.50	0.67
Max. Water Holding Capacity (%)	213.90	226.20	41.00
<b>Available macro and micro nutrients</b>			
Available N (mg kg <sup>-1</sup> )	443.40 (3.26%)*	417.20 (2.87%)	98.28 (13.5%)
NH <sub>4</sub> <sup>+</sup> -N (mg kg <sup>-1</sup> )	219.30 (1.61%)	204.40 (0.98%)	18.16 (2.48%)
NO <sub>3</sub> <sup>-</sup> -N (mg kg <sup>-1</sup> )	157.60 (1.15%)	142.80 (0.98%)	7.60 (1.04%)
Available P (mg kg <sup>-1</sup> )	52.30(0.83%)	36.32 (0.69%)	11.42 (0.51%)
Available K (mg kg <sup>-1</sup> )	1882.33(36.47%)	2047.00(36.55%)	97.20(3.70%)
Available Na (mg kg <sup>-1</sup> )	406.00(33.27%)	489.7544.52%)	164.90(4.02%)
Available S (mg kg <sup>-1</sup> )	118.62(4.28%)	93.43(4.04%)	18.40(1.18%)
Available Cu (mg kg <sup>-1</sup> )	1.16(0.99%)	1.04(1.08%)	1.37(9.78%)
Available Zn (mg kg <sup>-1</sup> )	4.84(9.68%)	6.74(8.98%)	1.02(4.43%)
Available Fe (mg kg <sup>-1</sup> )	21.22(0.67%)	17.02(0.84%)	39.47(0.63%)
Available Mn (mg kg <sup>-1</sup> )	14.42(6.08%)	16.72(4.77%)	20.20(6.43%)
<b>Total content of macro and micro nutrients</b>			
Total N (%)	1.36	1.45	0.073
Total P (%)	0.63	0.52	0.22
Total K (%)	0.52	0.56	0.26
Total Na (%)	0.12	0.11	0.41
Total S (%)	0.27	0.23	0.15
Total Cu (%)	0.0117	0.0096	0.0014
Total Zn (%)	0.0050	0.0075	0.0023
Total Fe (%)	0.3167	0.2022	0.6246
Total Mn (%)	0.0237	0.0350	0.0314

\* Value in the parenthesis indicates percent of total content.

**Table.2** Biological characteristics of vermicompost of two different substrate (water hyacinth and coconut leaf) and cultivated soil

Characteristics	Vermicompost (water hyacinth)	Vermicompost (coconut leaf)	Cultivated Soil
Bacteria (x 10 <sup>6</sup> CFU g <sup>-1</sup> dry soil)	71.70	47.40	32.60
Fungi (x 10 <sup>4</sup> CFU g <sup>-1</sup> dry soil)	23.60	17.40	12.40
Actinomycetes(x 10 <sup>6</sup> CFU g <sup>-1</sup> dry soil)	15.40	15.00	8.40
Azotobacter(x 10 <sup>6</sup> CFU g <sup>-1</sup> dry soil)	12.30	8.40	6.30
PSB(x 10 <sup>6</sup> CFU g <sup>-1</sup> dry soil)	13.60	7.30	4.00
Dehydrogenase Activity (µg TPF h <sup>-1</sup> g <sup>-1</sup> dry soil)	87.55	59.06	19.79
Microbial Biomass Carbon (mg kg <sup>-1</sup> )	560.12	440.44	272.20
Urease Enzyme (µg NH <sub>4</sub> <sup>+</sup> released g <sup>-1</sup> soil 0.02M Urea <sup>-1</sup> 2hr <sup>-1</sup> )	50.40	95.20	15.24





**Biological characteristics of vermicomposts**

Microbial population like bacteria, actinomycetes, fungi, azotobacter and phosphate solubilising bacteria were counted and presented in Table 2. Total bacteria accounted for fresh vermicompost of water hyacinth and of coconut leaf were  $71.70 \times 10^6$

and  $47.40 \times 10^6$  cfu  $g^{-1}$  dry soil whereas fungi accounted for  $23.60 \times 10^4$  and  $17.40 \times 10^4$  cfu  $g^{-1}$  dry soil, respectively. Population of actinomycetes were  $15.40 \times 10^6$  and  $15.00 \times 10^6$  cfu  $g^{-1}$  dry soil. Population of azotobacter and phosphate solubilising bacteria were  $12.30 \times 10^6$  and  $13.60 \times 10^6$  cfu  $g^{-1}$  dry soil in water hyacinth vermicompost as well as 8.00

$\times 10^6$  and  $7.30 \times 10^6$  cfu  $g^{-1}$  dry soil. These results represented that water hyacinth vermicompost are better than coconut vermicompost with respect to microbial population present.

Dehydrogenase activity of water hyacinth vermicompost ( $87.55 \mu\text{m TPF h}^{-1} g^{-1}$  dry soil) was more than coconut leaf vermicompost ( $59.06 \mu\text{m TPF h}^{-1} g^{-1}$  dry soil) whereas in (Table II) cultivated soil it was too low ( $19.79 \mu\text{m TPF h}^{-1} g^{-1}$  dry soil). Romaniuk *et al.*, (2011) reported that most of the carbon present on the organic amendments includes partially decomposed material that could be easily used as an energy source by soil microorganisms, resulting in higher respirations rates. Dehydrogenase activity in soils reflects the overall metabolic activity of microorganisms present in particular soils (Dick, 1994). Higher activity in water hyacinth vermicompost reflects that metabolic activity of microorganisms were higher in comparison to coconut leaf vermicompost; the probable reason being the quality of substrate as represented by higher C content (23.10%). Das *et al.*, (2016) reported that vermicompost prepared from water hyacinth waste was recorded in higher respiration rate than other vermicompost that might be due to higher mineralization rate and lowest C/N ratio than other vermicompost. The same reason can be cited for higher microbial biomass carbon. Microbial biomass carbon (MBC) content was  $560.12 \text{ mg kg}^{-1}$  in water hyacinth vermicompost and  $440.44 \text{ mg kg}^{-1}$  in coconut leaf vermicompost while  $272.20 \text{ mg kg}^{-1}$  was in cultivated soil. Microbial biomass carbon is considered as the active fraction of carbon (1-5% of total carbon). Higher microbial population as well as higher carbon content of the water hyacinth vermicompost are responsible for higher MBC. Microbes utilises carbon from the organic substrate and locked them up in their protoplasm which is generally released upon cell death. MBC data

reveals that vermicompost of water hyacinth was far better in quality than the vermicompost of coconut leaf. Activity of urease enzyme *i.e.* production capacity of ammonia was more pronounced in coconut leaf vermicompost ( $95.20 \mu\text{g NH}_4^+$  released  $g^{-1}$  soil  $0.02M \text{ urea}^{-1} 2\text{hr}^{-1}$ ) than water hyacinth vermicompost ( $50.40 \mu\text{g NH}_4^+$  released  $g^{-1}$  soil  $0.02M \text{ urea}^{-1} 2\text{hr}^{-1}$ ). This could be of immense importance in managing nitrogen and have impact on their release over the time. Das *et al.*, (2016) also reported similar that urease activity in vermicompost varied depending on the organic wastes used.

From the results of this experiment, it may be inferred that vermicomposts produced separately from different biomass substrate are different in quality with respect to nutrient contents. Microbiological characteristics also differ with changes of substrate for vermicomposting. Vermicompost produced from water hyacinth is better in quality than the vermicompost of coconut leaf with respect to its physicochemical and microbiological characteristics.

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