Vermicomposting of Water Hyacinth Eichhornia Crassipes (Mart. Solms) Employing Indigenous Earthworm Species

Hemen Deka, Suresh Deka, and C. K. Baruah

Abstract**—**Investigation on vermicomposting of water hyacinth was carried out in laboratory condition in two seasonal trials covering summer and winter period employing the indigenous earthworm species *Perionyx excavatus.* The experiment was conducted in earthen pots using the mixture of water hyacinth (WH) and cowdung (CD) in the ratio of 5:1. The results revealed that earthworm species can efficiently convert the substrate mixture (i.e. WH+CD) into value added material (i.e. vermicompost) that are enrich with plant's available nutrients (N, P, K, Ca, Mg, Fe, Mn, Zn and Cu). Further, there also found to be seasonal influence on the overall vermicomposting process and summer was found to be more productive as compared to the winter.

Keywords**—**Indigenous earthworm, Vermicomposting, Water hyacinth, Seasonal variation

I. INTRODUCTION

WATER hyacinth is the free floating invasive aquatic macrophytes that are known to cause causes severe damage to the aquatic habitat. Literature revealed that the noxious weeds like water hyacinth are resisted to the all physical, chemical, biological as well as hybrid methods that have been applied to eradicate it [1].Large numbers of reports are available regarding utilization of water hyacinth, for example use as paper pulp, poultry/veterinary feed, materials for furniture, carries bags, source of medicinal etc.; however, none of them proved to be economically viable options. The only utilization option of water hyacinth that has been found to be economically viable is the treatment of biodegradable waste waters [2]. However, the quantities of water hyacinth used for this purpose are very low and thus disposal problem of the huge waste biomass of water hyacinth is still remaining as a burning problem.

The role of earthworms in bioconversion of different types of waste materials has been already reported in literature [3]. Even, the technology for bioconversion of water hyacinth into vermicompost has also been already established [4]. However, the reports regarding the use of indigenous earthworm species for vermicomposting of waste biomass of water hyacinth are found to be scanty. Therefore, in the present investigation emphasis has been given for vermibioconversion of waste biomass of water hyacinth by employing a local strain of *Perionyx excavatus* in two seasonal trials covering both summer and winter.

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II. MATERIALS AND METHODS

A. Earthworm Collection and Maintenance of Stock Cultures

The individuals of indigenous *Perionyx excavatus* of different age groups were obtained locally from cowdung dump. The stock cultures of the collected earthworms were maintained in earthen pots using partially decomposed biowaste and cowdung as the feeding materials. The taxonomic identification of the collected earthworm species was further confirmed at Zoological Survey of India, Solan, India before use in the experimental trials.

B. Water Hyacinth and Cowdung

Water hyacinth was harvested from natural wetlands and rinsed thoroughly with tap water in order to remove the mud and other undesirable materials. Fresh urine free cowdung was also collected locally from a livestock farm at Guwahati, Assam, India. The physico-chemical properties of the dry water hyacinth (WH) and cowdung (CD) are presented in the Table 1.

TABLE I
THE PHYSICO-CHEMICAL CHARACTERISTICS OF WH AND CD

Parameters	WH	CD
pH	8.1±0.06	7.01 ± 0.61
Conductivity (mS/ds)	1.5±0.19	0.967 ± 0.14
Ash Content (g/kg)	417±3.6	238.7 ± 2.7
TOC (g/kg)	338±2.1	416 ± 1.8
TKN (g/kg)	9.5±1.3	8.1 ± 0.5
TAP (mg/kg)	5400±2.5	2500 ± 3.0
TK (mg/kg)	9700±2.7	3650 ± 2.1
TCa (mg/kg)	510±2.8	8978 ± 1.7
T Mg (mg/kg)	440±1.9	4669 ± 1.6
Fe (mg/kg)	1640±59	1823.4 ± 1.8
Cu (mg/kg)	2312±28	251.5 ± 1.5
Zn (mg/kg)	640±33	112.6 ± 1.8
C: N ratio	36.0±1.63	51.35 ± 1.75

WH = Water hyacinth; CD = Cowdung; TOC = Total organic carbon; TKN = Total kjeldhal nitrogen; TAP = Total available phosphorus; TK = Total potassium; T Ca = Total calcium; T Mg = Total magnesium.
g/kg = Gram per kilogram; mg/kg = Milligram per kilogram

C. Experimental Setup

The water hyacinth (WH) materials were dried in air, cut into small pieces and mixed with cowdung (CD) on dry weight basis in a ratio of 5:1 for the experiment [5,6]. This mixture (i.e. WH + CD) were predecomposed for 15 days so that it becomes palatable for the earthworms [3]. The vermicomposting experiment was conducted by using earthen pots of 2 L capacity (diameter 15 cm, depth 20 cm). The pots were filled with 1.5 cm thick sterilized soil layer at the bottom as soil is considered as an important supporting material for vermicomposting [5, 6, 7]. The experiment was setup

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by taking 500 g WH + CD mixture (on dry weight basis) in each pot and no extra feeds were provided during the study. Three replications were setup for statistical analysis of the results. In each earthen pot, 15 individuals (average weight of 8.6–9.2 g) of 40 days old earthworms were introduced from the stock culture. The moisture level in the pots was maintained at 65–70% throughout the study period [8]. To avoid moisture loss and protect the earthworms from other predators the experimental pots were placed on water filled trays and covered with jute sheets. The experiment was conducted both in summer and winter seasons to study the seasonal impact on vermicompost production. The mean ambient temperature during the experimental period was recorded as 29.5 ºC and 20.8 ºC in summer and winter, respectively. The average duration of the experiment was of 105 days. A similar setup was also maintained as control without adding earthworms. The vermicompost was harvested after the appearance of black granular structure on the surface of the composting medium. Vermicompost output percentage as against each seasonal period was calculated on dry weight basis taking generated vermicompost and the raw material used in the experiment.

D. Physico-chemical Analysis

The vermicompost generated in the two seasonal trials were mixed properly for analysis of pH, conductivity, ash content, total organic carbon (TOC), total kjeldhal nitrogen (TKN), available phosphorus (P), total potassium (K), total calcium (Ca), total magnesium (Mg) and heavy metals (Mn, Cu, Fe and Zn). The pH and conductivity value were measured in 1:5 (w/v) water suspensions using digital pH (Elico Li 127) and conductivity meter (Elico CM 180) respectively. The ash content was measured following the method of Nelson and Sommers [9]. Total Organic Carbon was measured by Walkey and Black titration method described by Jackson [10]. Micro Kjeldhal method [10] was used for measuring nitrogen. The C: N value was calculated from the measured values of total organic carbon and nitrogen. Available phosphorus was determined by using the spectrophotometer (Shimadzu UV 1601) following the stannous chloride method [11]. Total sodium and potassium was determined by acid digestion method using flame photometer with standard solution [11]. For analysis of Ca, Mg, Mn, Cu, Zn and Fe samples were digested in microwave digester [Milestone, Ethos 900] and then analysed by Atomic Absorption Spectrophotometer (Shimadzu AA 7000). All the samples were analysed in triplicate and average results were recorded.

E. Statistical Analysis

Paired sample t-test was used to analyse the significant differences in vermicompost production in two seasonal periods. The same test was also used to compare initial bio-waste mixture (WH + CD) as well as compost (without earthworm) and vermicompost generated from this mixture for their different chemical parameters.

III. Results And Discussion

A. Vermicompost production

The vermicompost production efficiency of the species *P. excavatus* varies significantly in two seasonal trials and there was higher output in summer as against the winter (Fig 1). The higher vermicompost production in summer as compared to that in winter season may be due to decreased reproductive and other metabolic activities of the earthworms in winter [5, 6].

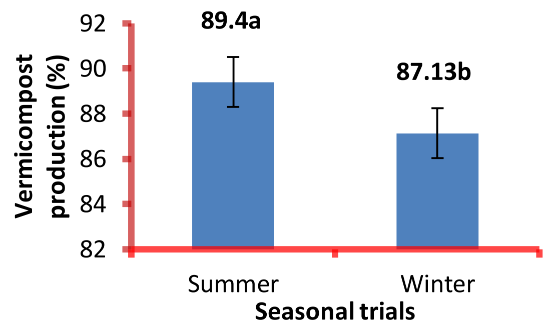

Fig. 1 Vermicompost production by *P.excavatus* in summer and winter seasonal trials (Values with different letters indicate significant differences, Bar indicates Standard Deviation)

B. Physico-chemical composition (pH, EC, TOC, ash content, C/N ratio)

The end product (i.e. so called vermicompost) was found to be differing significantly from compost and initial substrates (WH + CD mixture) in pH, EC, TOC and ash values (Table 2). There was decrease in pH levels in both the vermicompost (7.02±0.4) and compost ((5.3±0.8) as compared to the initial level (8.1±0.6) in biowaste form. The decrease in pH could be due to production of CO_2, ammonia, NO_3^- and organic acids during vermicomposting process [7]. The electrical conductivity (EC) value of the initial substrate material was 1.5±0.19 mS/ds that were decreased up to 0.546±0.6 mS/ds in the vermicompost of *P. excavatus* whereas in case of compost it was of 0.812±1.0 mS/ds (Table 2). Similar observation was also made by previous workers who reported decrease in electrical conductivity in the earthworm processed materials. The initial level of ash content of the substrate was 417±1.6 g kg^{-1} and it increased up to 612±1.8 g kg^{-1} and 593±1.2 g kg^{-1} in the vermicompost samples of *P. excavatus*. The enhanced mineralization of biowaste materials due to composting and vermicomposting may be the reason for higher ash value in the final product [12]. Similarly, total organic carbon (TOC) was lower in the final product (i.e. vermicompost) as well as in compost sample than the initial levels of the biowaste. The present findings reinforce the earlier findings that upto 49% Carbon loss is possible during the vermicomposting process as a result of CO_2 lost due to respiratory activity and consumption of available Carbon by earthworms and microbes [13]. Further, the result reveals a significant decrease in the C/N values after 105 days of composting and vermicomposting. The C/N value of the raw materials was 37.9 which decreased upto 20.4 and 8.05 in compost and vermicompost sample of *P. excavatus* respectively. The present findings corroborated with the previous worker [14] who reported decrease level of C/N value during vermicomposting of *Parthenium* weed.

TABLE II
THE PHYSICO-CHEMICAL PROPERTIES OF THE EARTHWORM PROCESSED WASTE MATERIAL

Parameters	Initial	Compost	Vermicompost
pH	8.1±0.6a	5.3±0.8b	7.02±0.4c
Conductivity (mS/ds)	1.5±0.19a	0.812±1.0b	0.546±0.6d
Ash content (g/kg)	417±1.6a	481±1.8b	612±1.8d
TOC (g/kg)	338±2.1a	289±2.0b	186.1±1.3d
C/N ratio	37.9a	20.4b	8.05c

Mean value± SD, Values in the same row followed by different letters within the same row indicates significant differences.

C. Macronutrient composition

The macronutrient composition of the biowaste material, compost and vermicompost are presented in the Table 3. The vermicompost samples showed higher levels of macronutrients as compared to the compost and biowaste material. There was 2.6 fold increases in TKN level in the vermicomposted material of *P. excavatus* as against 1.5 fold increase in compost sample than the initial value of the biowaste material. The enhanced levels of nitrogen are already reported in literature which may be due to loss of organic carbon and mineralization of organic matter during bioconversion process [15]. Similarly, compost recorded 1.2 fold increase in available P whereas in case of vermicompost sample it was found to be 1.7 fold as compared to the initial level. The present findings are similar with the earlier workers [16] that reports increase in available P due to mineralization of phosphorus in biowaste material. The total K increase was 2.2 fold in vermicompost sample as against 1.5 fold of compost sample. The present findings is an agreement with the earlier work of [17] who reported seven fold increase in TK content in the vermicompost. Similarly, there was 4.4 fold increases in Ca level as against 2.2 fold increase in Mg content. The compost sample recorded 1.5 fold increases in Ca level as against 1.1 fold increase of Mg value. It has been suggested that activity of earthworms drives the mineralization process efficiently and transforms a large proportion of Ca and Mg from bind to free form that may enhance the composition of the elements in the final product [18].

TABLE III
MACRONUTRIENTS COMPOSITION OF THE SUBSTRATE MATERIALS AND END PRODUCTS

Parameters	Initial	Compost	Vermicompost
TKN (g/kg)	8.9±0.5a	14.1±0.4b	23.1±0.8d
TP (mg/kg)	5102±13.9a	6100±18.6b	8000±142d
TK (mg/kg)	9.2±2.1a	14.3±0.3b	20.2±2.2c
TCa (mg/kg)	502±2.6a	772±3.8b	2304±4.2c
TMg (mg/kg)	428±2.9a	480±3.7b	509±4.6d

Mean value± SD, Values in the same row followed by different letters are statistically different TKN = Total kjeldhal nitrogen; TAP = Total available phosphorus; TK = Total potassium; T Ca = Total calcium; T Mg = Total magnesium.

D. Micronutrients composition (Fe, Cu, Zn and Mn)

The compost as well as vermicomposted materials of P. excavatus and E. eugeniae showed significant variation in micronutrient composition as compared to the initial levels of the bio-waste (Table 4). There was a significant enhancement in the concentration of all the trace elements in control (compost). Similarly vermicompost samples also showed higher level of all the micronutrients except Zn. The higher concentration of micronutrients in the vermicompost as compared to compost may be due to mineralization of partially digested worm faecal by detritus communities for example bacteria and fungi [19]. Again, decreased level of Zn in the vermicompost samples may be due to selective absorption of the elements by the earthworm's body tissue.

TABLE IV
MICRONUTRIENTS COMPOSITION OF THE SUBSTRATE MATERIALS AND END PRODUCTS

Parameters	Initial	Compost	Vermicompost
Fe (mg/kg)	1623±3.4a	1905±4.2b	2305±4.1d
Cu (mg/kg)	306±2.3a	389±3.9b	64.8±1.6d
Zn (mg/kg)	2613±2.7a	2647.3±3.3b	187.7±2.7d
Mn (mg/kg)	524.6±2.2a	567.7±3.7b	1321±4.3d

Mean value± SD, Values in the same row followed by different letters are statistically different.

IV. CONCLUSION

The mixture of water hyacinth and cowdung can be converted into vermicompost by employing the earthworm species P. excavatus and E. eugeniae. The end products i.e. so called vermicompost of both the species were found to be more homogeneous, nutrient rich and stabilized than the initial biowaste mixture as well as traditional compost. Nevertheless, the indigenous earthworm species showed better efficiency in terms of vermicast generation in both the seasonal trial summer and winter.

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