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Conversion of Water Hyacinth (*Eichhornia crassipes*) into Nutrient-Rich Fertilizer by Pit Methods

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ABSTRACT

Among the aquatic weeds, water hyacinth is considered to be the most obnoxious of all aquatic weeds and occupies eighth rank in the world. Water hyacinth caused lot of problems to human beings and animals in many ways. The present study is therefore aimed to develop an appropriate technology for recovery of resources from aquatic weeds by pit methods of composting. Compost was prepared from aquatic weed water hyacinth using three different pit methods namely Indore method, Bangalore method and phospho-compost method. Physical and chemical parameters of the compost were analyzed in the initial and final stage. The physical analyzes of composts showed that electrical conductivity, porosity, water holding capacity and moisture content were increased from initial to final stage in all pit methods especially in Bangalore method. The drastic reduction was noticed in lignin and cellulose level of composts especially in Bangalore compost. All the three compost have recorded higher macro and micro nutrients especially in Bangalore compost from initial to final stage. Among the three composts, Bangalore compost recorded the highest reduction in C: N ratio followed by phospho-compost and Indoor compost. Increased bacterial and fungal counts were observed in Bangalore compost than the Indore and phospho-compost. The generic compositions of bacterial and fungal strains of three composts were revealed that more or less same types of genera were present. In this context we conclude that all the three techniques of composting are best suitable to replenish the *Eichhornia* weed biomass. Water hyacinth based compost used as an organic fertilizer has appropriate macro and micro nutrients and microorganisms that will support the plant growth.

Keywords: Bangalore method, Indore method, phospho-compost method

INTRODUCTION

To increase agricultural production manure plays a vital role. The demand for fertilizers in India increases substantially every year and surpasses domestic production. The excess fertilizer demand is met by imports, but the import of fertilizers is expensive and synthetic in origin (Naika and Gracy 1996). Use of chemical fertilizers had a romantic beginning in the 1960's and in the long run it causes destruction of ecological harmony by the tremendous usage of chemical compounds. The chemicals pose both plants as well as soil to be sick in terms of less nutritive value and diseases affecting living beings (Ghosh 2000). Application of chemicals may also lead to mining of the bio carbon (humus) reservoir in the soil. The increasing cost of fertilizers, growing ecological concern and conservation of energy have in recent times gained considerable interest in the use of organics as sources of plant nutrients as well as to accelerate the activity of microbes in building the soil fertility (Rajkhowa *et al.* 2000; Tiwari *et al.* 2000).

Our natural resources are utilized indiscriminately which in turn has resulted in negative environmental effects such as soil erosion, soil salinity, prolonged water logging and pollution of surface and ground water resources, which threatens our climate and our biological diversity (Yadava and Yadav 1998). Maintenance of soil productivity is achieved by the supply of plant nutrients, control of insects, weeds and other pests (Lampkin 1990; Rajasekaran 1995). Farming practices, which involve heavy application of chemical fertilizers lead to depletion of certain nutrients in soil and accumulation of certain others in excess resulting in nutrient imbalance and in turn it affects the soil productivity. In order to achieve sustainability in agricultural production, organic manure definitely plays a key role because it exerts beneficial effect on the physical, chemical and biological characteristics of the soil (Fox *et al*. 2008). Organic farming is the most desirable way of maintenance of good soil health and stability in production through the use of organic and biological resources. Accumulation of lignocelluloses in large quantities present a disposal problem which in turn produces deterioration of the environment and also loss of potentially valuable materials used in paper manufacture, biomass fuel production, composting, human and animal feed among others (Sanchez 2009).

Water hyacinth is a free floating aquatic weed causing enormous inconveniences in the irrigation and navigation systems of several parts of the world such as India, Africa, Australia, USA and Indonesia (Chandrasingh and Narayana Rao 1977). Water hyacinth is utilized as a helpful plant instead of a disturbing weed. It is used as a fertilizing agent, input to biogas plants, animal feed, etc. (Mukhopadhyay 1980). With the prime objective of safe disposal of water hyacinth in the environment, the present study was initiated to investigate the feasibility of using the water hyacinth beneficially in agriculture through composting by employing three different pit methods.

MATERIALS AND METHODS

The whole plant of aquatic weed *Eichhornia crassipes* about 45 cm in length was collected from the pond site in Mannarkoil village near Ambasamudram and transported to the laboratory for the composting studies. The Water hyacinth samples were chopped into small pieces approximately 10 cm in size. The shredding increased the surface area for microbial degradation. The chopped materials were sun dried to remove excess moisture and also to make the material free of pathogens in the plant biomass and additionally sprayed with cow dung slurry and stored under shade for 15 days.

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Composting techniques

The selected weed was converted into value added biomanure by using three different pit methods of composting employed for this study. They are Indore method, Bangalore method and phospho-compost method. A constant pit size of 1 m × 2 m × 1 m was used for all three methods.

a) Indore method

The Indore method was developed by Howard and Wad in 1931 in Indore (M.P) in India. Hence it is called Indore method of composting. In the present investigation the Indore method was slightly modified. Indore compost pit was filled with separate layers of different materials. Each layer consisted of the following raw materials. The sub-layer 1 with height of 4 to 8 cm was filled with thick dry weeds, the sub-layer 2 with height of 4 cm was filled with cattle dung and third sub-layer with height of 4 cm was filled with thick layer of soil, wood ash and old compost mixture. These three sub layers together made a single layer. The compost pit was filled by six such layers. At intervals of every fifteen days compost pit was mixed well to ensure proper decomposition.

b) Bangalore method

Acharya (1939) had successfully developed the heat fermentation method of manure production which was popularly known as the Bangalore method. Slightly modified method of Acharya (1939) was used in the present study. The weeds (instead of farm wastes) and broiler litter (instead of night soil) were spread in alternate layers of 15 cm and 5 cm height until the pit was filled, with a final layer of weeds on the top. The pit was closed with perforated plastic bags and then it was finally sealed dome shaped with soil to prevent loss of moisture. The materials were turned up and down at every 30 days interval and cow dung slurry was added while mixing.

c) Phospho compost method

Phospho compost method was followed as described by Mishra *et al.* 1984 and Sanyal and Saha 1988. Phospho compost was prepared by mixing weeds, cattle dung, soil and compost in the ratio of 4: 4: 3: 3. In which the rock phosphate is about 70% and the remaining was 30% compostable materials. The moisture was maintained at 60% throughout the period of composting. At an interval of every 15 days the compost materials in the pit was turned upside down to ensure proper decomposition.

Physical parameters

Physical parameters of the compost were analysed in the initial and final stage (Muthuvel and Udaya Soorian 1999).

Chemical parameters

The chemical parameters analysed included lignin (gravimetric method, Ranade *et al.*1980), cellulose (calorimetric method, Updegraff 1969), nitrogen (Kjeldahl method, Tandon 1993), phosphorus (colorimetric method, Tandon 1993), potassium (flame photometric method, Tandon 1993), calcium (titrimetric method, Tandon 1993), magnesium (titrimetric method, Tandon 1993), organic carbon (Tandon 1993), sulphur (turbidimetry method, Tandon 1993), iron (spectrophotometric method, Model CL-27, Jackson 1973), zinc and copper (atomic absorption spectrophotometric method, Tandon 1993) estimated using the following methods.

Microbial population

Bacterial and fungal density and identification analysis were carried out following the method suggested by Allen (1953) and Williams *et al*. (1989).

RESULTS AND DISCUSSION

The proximate composition of the Water hyacinth illustrated in **Table 1**. The results of physical parameters of the initial and final stages of compost prepared by three different pit methods are given in **Fig. 1A** and **1B**. It was observed that the initial pH of composts was acidic and in the final stage of experiment, it reached around seven in all three methods of composts. A similar trend in the change of pH was observed by Cuves *et al*. (1998) for green waste. The decomposition of nitrogenous substitutes resulted in the production of ammonia which might have led to increase the pH value. The physical analyzes of composts showed that electrical conductivity, porosity, water holding capacity and moisture content were increased from initial to final stage in all pit methods especially in Bangalore method. Electrical conductivity is an indicator of concentrations of soluble salts. The increase in electrical conductivity indicated that more soluble minerals are present in available form (Karmegam *et al.* 1997), which can be utilized readily by crop plants.

The chemical composition of *Eichhornia* sp. compost prepared by pit methods were studied in relation to composting are indicated in **Fig. 2A** and **2B**. The drastic reduction was noticed in lignin and cellulose level of composts especially in Bangalore compost. The extra cellular enzyme

Table 1 Physico-chemical characteristics of the *Eichhornia* plant.

Parameters	
pH	5.8
ECmS/cm	0.38
Lignin (%)	30.6
Cellulose (%)	26.7
N%	1.16
P%	0.094
K%	0.68

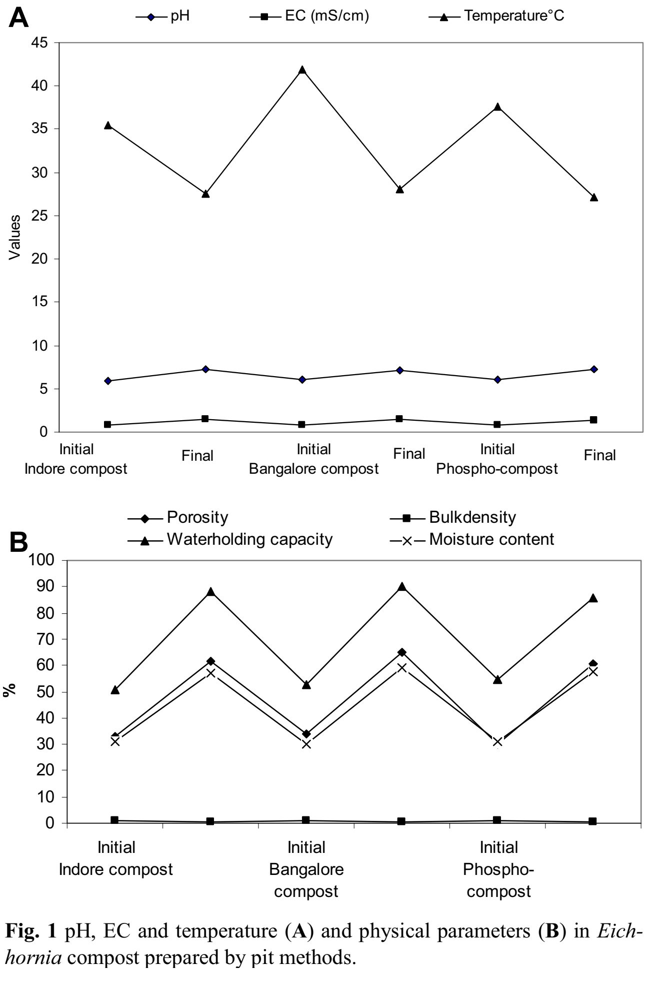

Fig. 1 pH, EC and temperature (**A**) and physical parameters (**B**) in *Eichhornia* compost prepared by pit methods.

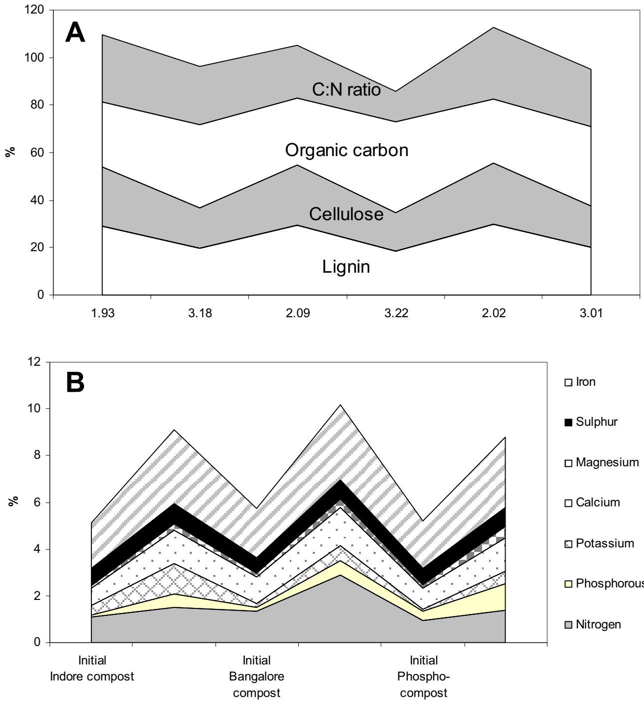

Fig. 2 Chemical (**A**) and physical (**B**) composition of *Eichhornia* composts prepared by the pit methods.

ligninase was capable of degrading a variety of chemical bonds which could be attributed for lignin and cellulose reduction (Kelley 1988). The same events might have happened in the present experiment also. All the three compost have recorded higher nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, copper and organic carbon content. The enrichment of composts as a means of increasing the contents of nitrogen, phosphorous and potassium has been engaging the attention of scientists (Gaur 1992; Fox *et al*. 2008). The enhancement in the concentration of these nutrients was due to the mineralization of native carbon of wastes accompanied by a reduction in the total volume of the wastes under ideal conditions of decomposition (Thilagavathi 1992). It was interesting to note that the Bangalore compost recorded higher increase in nitrogen, calcium, iron, copper, zinc and organic carbon from initial to final stage. In Indore compost the potassium content was increased than other composts because of the addition of wood ash (source of potassium). In phospho-compost, phosphorus content was more than other composts. Among the tree composts, Bangalore compost recorded the highest reduction in C: N ratio followed by phospho-compost and Indore compost. A similar reduction in C: N ratio was reported by Senapati *et al.* (1980) and Mba (1983).

The microbial density of bacteria and fungi and their generic composition in the three different composts utilizing *Eichhornia* as a base are shown in **Table 2**. Increased bacterial and fungal counts were observed in Bangalore compost than the Indore and phospho-compost. The generic compositions of bacterial and fungal strains of three composts were revealed that more or less same types of genera were present in all three types of composts. Tracey (1951) had suggested that cellulolytic organisms might have been selectively increased during composting and is observed in the present study. The present investigation was carried out to make *Eichhornia* compost adopting three different pit methods of composting namely Indore method, Bangalore method and phospho-compost method. The composting duration of Indore, Bangalore and phospho compost methods were sixty, hundred and seventy five days respectively. We conclude that all the three techniques of composting are best suitable to replenish the *Eichhorina* weed biomass.

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Table 2 Total viable bacterial, fungal counts and their generic composition present in *Eichhornia* composts.

Source	Bacterial density CFU/gm	Fungal density CFU/gm	Generic composition	
			Bacteria	fungi
Indore compost	5.60×10^6	6.66×10^3	*Bacillus* sp., *Staphylococcus* sp., *Pseudomonas* sp., *Micrococcus* sp.	*Aspergillus flavus*, *Fusarium roseum*, *Rhizopus nigricans*, *Mucor spinescens*, *Fusidium* sp.
Bangalore compost	9.66×10^6	8.90×10^3	*Micrococcus* sp., *Bacillus* sp., *Staphylococcus* sp., *Pseudomonas* sp	*Fusarium roseum*, *Aspergillus flavus*, *Rhizopus nigricans*, *Aspergillus fumigatus*, *Mucor* sp., *Absidia ramosa*
Phospho compost	2.76×10^6	5.63×10^3	*Bacillus* sp., *Staphylococcus* sp., *Pseudomonas* sp., *Aeromonas* sp.	*Fusarium culmorum*, *Mucor* sp., *Chaetomium globosum*, *Aspergillus flavus*, *Rhizopus* sp.

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