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Assessing the Effect of Co-composting Technique to Generate Quality Manure Out of Water Hyacinth (*Eichhornia crassipes)*

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An experiment was conducted during 2016-2017 to assess the efficacy of co-composting technique for generating quality manure out of the noxious aquatic weed, water hyacinth (Eichhornia crassipes). Locally available organic substrates viz., crop residues and cow dung were mixed with water hyacinth and co-inoculated with the fungal culture, Pleurotus djamor @ 0.05% and the earth worm, Eudrillus eugineae @ 0.2%. The treatment encompassing water hyacinth + crop residue + cow dung (1:1:1) along with P. djamor and E.eugineae showed higher mean values of total "N" (0.93%), "P" (1.00%), "K" (1.10%) content of manure, germination percentage (100 % each) and vigour index of 13.90 and 12.85, respectively for cluster bean and tomato ; whereas, water hyacinth + crop residues (1:1) without the bio-inoculants recorded higher mean total organic carbon of 40.85 %.

Key words: Compost, Water hyacinth, Co-composting, *Pleurotus djamor, Eudrillus eugineae*

With the advancement in science and technology and increasing urbanization there exists an increased pressure on existing resources. Water is a basic entity on which our entire human life relies on but, currently facing a threat of scarcity. There is a situation that, if there is a chance of third world war surely it will be for water, but on other side the existing/ native water resources are now-a-days adversely affected by variety of aquatic weeds. Water hyacinth (*Eichhornia crassipes*) is the most important world's noxious fresh water plants. It grows over a wide variety of wetland types from lakes, streams, ponds, waterways, ditches and backwater areas covering approximately 2 lakh ha. This weed has attracted significant attention due to its extremely rapid proliferation and congested growth. It affects the riparian population in many negative ways. In many places, the weed poses serious challenges in navigation, irrigation and power generation. It reduces the flow capacity of water thus decreasing the water availability to agriculture. It has been reported that, the flow of water is reduced by approximately 40-95%. The dense mats of these weeds reduce the dissolved oxygen levels in water leading to the death of aquatic life. In addition, it provides habitat conducive for vectors of malaria, causes skin rashes and host agents of amoebic dysentery and typhoid.

The explosive nature of water hyacinth growth and its related problems have called for serious efforts to control its spread. Management strategies include physical, chemical, biological or integrated approaches. As attempts to control the weed have caused high costs and labour requirements, leading to nothing but temporary removal of the water hyacinths. Apart from Tamil Nadu, some of the irrigation and hydroelectric projects in the country like Nagarjuna sagar project in Andhra Pradesh, Tungabhadhra project in Karnataka, Kakki and Iddiki reservoirs in Kerala are suffering from massive growth of aquatic weeds. There is an another perception that aquatic plants have been referred to be originated by inefficient anthropogenic activities which need an hour. Hence, a considerable research effort is needed for getting worth out of waste. Considering the present agricultural scenario which thrust upon the environmental safety and security, the present investigation has been formulated to overcome the foresaid lacuna with the objective of studying the efficacy of composting techniques to generate compost out of water hyacinth.

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Material and Methods

The water hyacinth has been collected from the shallow pond of Lakshmipuram village of Theni district during August 2016 and it has been sun dried for further experimentation to study the efficacy of co-composting techniques of water hyacinth with locally available materials *viz.,* crop residues and cow dung with the supplemental efforts of fungi (microflora) and earthworm (macrofauna). The experiment was laid out in a randomized block design (RBD) replicated four times with treatments including T_1 – water hyacinth + crop residues (1:1), T_2 - water hyacinth + crop residue + cow dung (1:1:1), T_3- water hyacinth + crop residue + cow dung (1:1:1) + *Pleurotus djamor*, T_4 - water hyacinth+ crop residue + cow dung (1:1:1)+ *Eudrilus eugeniae*, T_5- water hyacinth+ crop residue + cow dung (1:1:1) + *P. djamor* + *E. eugeniae*. The dried water hyacinth samples were cut into small pieces and a heap of alternate layers of the listed materials were made upto the height of 1m which accommodates water hyacinth and crop residue on dry weight basis and also cow dung, fungi and earth worms based on the treatments. The moisture content of 65% was maintained by regular watering and turning was given at fortnightly intervals for better aeration and to minimize the composting period.

To investigate the compost stabilizing characteristic of water hyacinth, the physico- chemical parameters were analysed with 20 days interval with standard procedures outlined by Jackson, 1973 (pH, Electrical Conductivity, Total potassium) , Piper, 1966 (Total Kjeldahl Nitrogen), Pemberton, 1945 (Total phosphorus). Apart from this, germination tests were also conducted to compare the efficiency of the compost. The data obtained from different experiments were statistically analysed using AGRES software through factorial ANOVA for randomized block design to find out the effects of various treatments and Least Significant Difference (LSD) was applied for comparing the treatment means. Analysis of variance was calculated as suggested by Panse and Sukhatme (1967).

Results and Discussion

To study the compost stabilizing characteristic, the physico-chemical parameters like pH, total organic carbon (TOC), Total Kjeldahl Nitrogen (TKN), Total phosphorus (TP), Total potassium (TK) and carbon

Table 1. Characteristics of substrates used for composting

Parameters	Water hyacinth	Cow dung	Crop residues
pH	7.2	8.8	7.4
Total organic carbon (%)	40.2	39.4	43.2
Total Kjeldahl N (%)	0.91	0.55	0.22
Total phosphorous (%)	0.88	0.52	0.49
Total Potassium (%)	0.81	0.51	1.74
C:N ratio	44.18	71.64	196.36

and nitrogen ratio (C: N) were analyzed for all the substrates (water hyacinth, cow dung and crop residue) using standard protocols, so that the nutritive value of each substrate could be evaluated and

Table 2. Changes in EC of compost during composting

	EC (dSm^{-1})				
	Sampling days				
Trts	**Initial**	**20**	**40**	**60**	**Mean**
T_1	0.86	0.92	1.65	1.17	1.15
T_2	0.82	0.90	1.45	1.30	1.12
T_3	0.94	1.21	1.50	1.41	1.27
T_4	0.86	0.98	1.30	1.25	1.10
T_5	0.74	1.30	1.75	1.51	1.33
Mean	0.84	1.06	1.53	1.33	
		SEd		CD (0.05)	
D		0.008		0.016	
T		0.007		0.014	
D x T		0.016		0.032	

compared. The details of the parameters evaluated have been shown in Table1. The determination of chemical parameters of the initial feed revealed that water hyacinth possessed higher total nitrogen (0.91%) and phosphorus (0.88%), whereas crop residues recorded higher total K (1.74%) and C:N ratio (196.36). Studies of Batham *et al.*(2014) revealed that while co-composting with materials of high C:N ratio, cow dung will be highly useful to narrow down the ratio. Hence, the crop residue forms the bulking agent of the compost. Relatively low C:N ratio of water hyacinth showed that it was nutrient rich substrate essential for the feedstock to be decomposed.

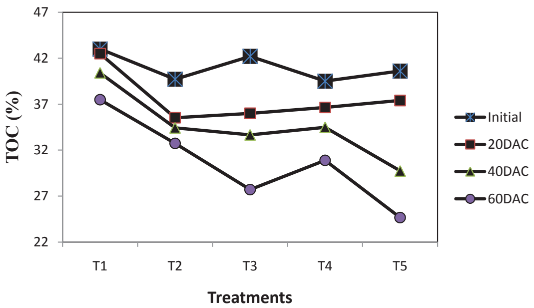

Fig. 1. Changes in Total organic carbon (%) during composting

Changes in the chemical characteristics, stability and maturity of the composting mixture with time were studied by collecting and analyzing the samples at different times. The electrical conductivity (EC) of the

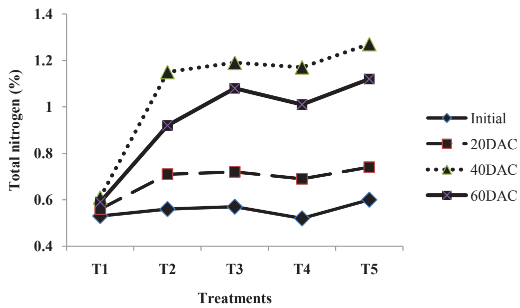

Fig. 2. Changes in total N content during composting

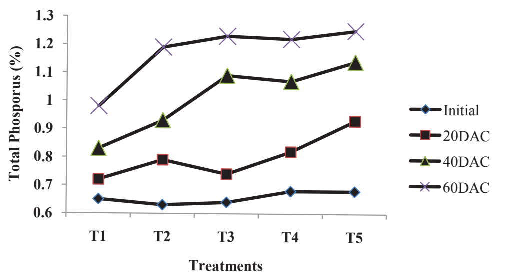

Fig. 3. Changes in total P content during composting

sample was measured using 1:2.5 ratio of sample to distilled water and the mixture was allowed to equilibrate for 30 minutes with occasional stirring with a glass rod. The details about the changes in pH and

EC of compost during composting are furnished in Table 2. Electrical conductivity is the measure of the soluble salt content of compost. The salt content of compost is due to the presence of sodium, chloride, potassium, nitrate, sulphate and ammonia salts (Brinton, 2003).

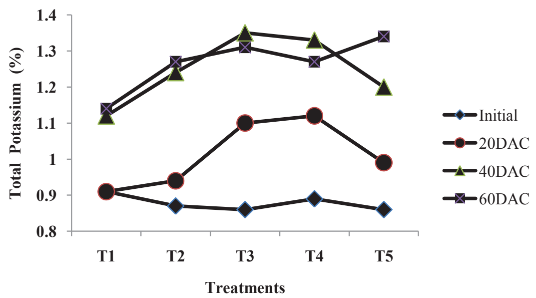

Fig. 4. Changes in total "K" content during composting

The electrical conductivity of compost samples varied from 0.74 to 0.94, 0.90 to 1.30, 1.30 to 1.75 and 1.17 to 1.51 dSm^{-1} during initial, 20, 40 and 60 days old compost samples, respectively. Among the treatments, T_5 with water hyacinth + crop residue+ cow dung (1:1:1) + *P. djamor* + *E. eugeniae* recorded higher EC followed by T_3 with water hyacinth + crop residue+ cow dung (1:1:1) + *P.djamor.* Among the stages, 40 days old compost recorded higher EC, which might be due to high initial microbial activity and mineralization (Campell *et al.,* 1997). But in later stages, as the humification process proceeds, the humic fractions may become complexed with the soluble salts in turn decreasing the amount of mobile free ions (Rao *et al.,* 2007).

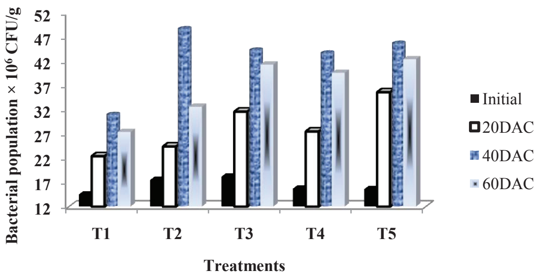

Fig. 5. Changes in bacterial population during composting

The degree of decomposition of organic matter during composting process has often been used to define compost maturity and stabilized organic matter and is characteristic feature of mature composts. In the present investigation, the total organic carbon varied from 39.50 to 43.0 %, 35.52 to 42.50 %, 29.74 to 40.40% and 24.66 to 37.48% during initial, 20, 40 and 60 days old compost samples, respectively. The total organic carbon content was found to be reduced in all the degradation stages of compost samples (Fig.1). Carbon serves as a primary energy source for the microbial growth (Venkatesh and Eevera, 2008) and OC decreases as the decomposition proceeds (Mondhini *et al.,* 2006). Among the treatments, T_5 with water hyacinth + crop residue+ cow dung (1:1:1) + *P.djamor* + *E. eugeniae* recorded minimum TOC, which might be due to the effective role of degraders (microflora and macro fauna). During the decomposition process, there won't be any addition of nitrogen to the substrate, but carbon content decreases due the oxidation of carbon. Part of the carbon in the decomposing residues evolved as CO_2 and a part was assimilated by the microbial biomass (Cabrera *et al.,* 2005). The results were found to be consonance with the findings of several authors (Theradimani and Marimuthu*.,* 1991) and Nallathambi and Marimuthu, 1993) who reported that *Pleurotus spp* were highly efficient in reducing the organic carbon content.

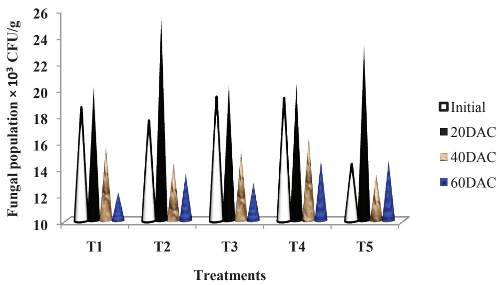

Fig. 6. Changes in fungal population during composting

During composting process, microorganisms oxidize organic matter and release essential minerals for plants such as nitrogen, phosphorus, and sulfur. Changes in total nutrient content during composting process are presented in Fig. 2, 3 and 4. Nitrogen is an important nutrient for composting process since it determines the microbial population. The total N content in the present research varied from 0.52 to 0.60, 0.56 to 0.74, 0.61 to 1.27 and 0.59 to 1.12% during initial, 20, 40 and 60 days old compost samples, respectively. Comparing the composting stages, there was a significant increase in TKN as procession of composting process, which might be due to the breakdown of the proteins.

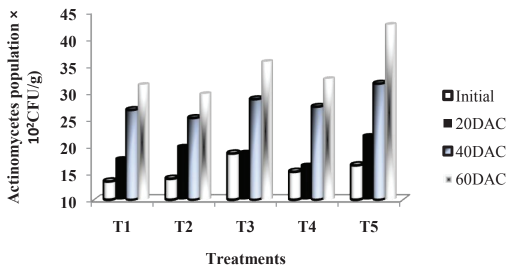

Fig. 7. Changes in actinomycetes population during composting

Among the treatments, T_5 with water hyacinth + crop residue+ cow dung (1:1:1) + *P. djamor* + *E.eugeniae* showed higher TKN which might be due to vibrant role of organisms. Similar results were reported by Suthar (2007), who reported that earthworms enhanced the nitrogen levels of the substrate during digestion in their gut adding their nitrogenous excretory products, mucus, body fluid and enzymes in composting process. In addition, Therdimani and Marimuthu (1991) opinioned that increase in nitrogen content during decomposition might be due to lignolytic activity of *Pleurotus* spp.

Phosphorous is also an important nutrient for plant growth. In the present investigation, the total phosphorous concentration varied from 0.63 to 0.68, 0.72 to 0.93, 0.83 to 1.14 and 0.98 to 1.25 during initial, 20, 40 and 60 days old compost samples, respectively. The total P was higher in the compost harvested at the end of the experiment compared to that of the initial substrate, but water solubility of phosphorous decreases with humification (Elango *et al.,* 2009). Among the treatments, T_5 with water hyacinth + crop residue+ cow dung (1:1:1) + *P.djamor* + *E.eugeniae* showed higher total potassium compared to other treatmental combinations. In addition, this increase might be due to the earthworm gut enzyme phosphatases and "P" solubilizing microorganism present in worm casts, which is in consonance with the findings of Suthar and Singh (2008). The potassium concentration varies from 0.86 to 0.91, 0.91 to 1.21, 1.12 to 1.45 and 1.14 to 1.34% during initial, 20, 40 and 60 days old compost samples, respectively. This might be buttressed due to the production of acids by the microorganisms and enhanced mineralization rate through increased microbial activity during the composting process.

Table 3. Effect of different composts on the germination percentage and vigour index

Treatments	Tomato				Cluster bean			
	Length of seedlings (cm)		Germination (%)	Vigour index	Length of seedlings (cm)		Germination (%)	Vigour index
	Root	Shoot			Root	Shoot		
T_1	1.32	4.60	90	5.32	1.02	5.73	90	6.07
T_2	1.67	5.74	92	6.81	1.74	5.8	92	6.94
T_3	3.01	9.00	98	11.76	2.90	8.0	98	10.68
T_4	2.17	6.23	95	7.98	2.90	5.37	95	7.86
T_5	3.50	10.14	100	13.90	3.05	9.8	100	12.85
Mean	2.33	7.14	95.00	9.15	2.32	6.94	95.00	8.88
SEd	0.038	0.133	1.475	0.147	0.033	0.095	1.569	0.122
CD (0.05)	0.084	0.290	3.213	0.320	0.072	0.206	3.419	0.266

In order to evaluate the process and the quality of the end product, better knowledge of the microbial community dynamics is needed. Compost stability is strongly related to microbial activities during the composting process; therefore, several authors have suggested that microbiological parameters can serve as indicators of compost maturity (Eiland *et al.,* 2001; Tiquia, 2005). Knowledge about the micro-organisms present in composts, their coexistence and the ways they replace each other during the different stages of the biological degradation process should help to ensure a high quality of the final compost.

Among the treatments, T_5 with water hyacinth + crop residue+ cow dung (1:1:1) + *P.djamor* + *E.eugeniae* recorded higher microbial activity which picturizes the availability of nutrients compared to other treatments (Fig. 5, 6 &7). The bacterial count varied from 14.5 X 10^6 to 42.4 X 10^6 CFU/g. The decrease of bacterial diversity in the composting mass could be due to the high temperature (Fang and Wong 2000) and the bacterial viable counts were more for 10, 20, 30, 40 days composted samples compared to 60 days old samples.

The fungal population varied from 14.3 X 10^3 to 19.6 X 10^3 CFU/g. The fungal population increases till 20 days and after that there was a decline. Similar results were reported by Hegarty *et al.* (1999). The population of actinomycetes varied from 13.4 X 10^2 to 42.6 X 10^2 CFU/g. The actinomycetes count increases as the composting stage increases which shows the ability of actinobacteria to degrade lignocelluloses, which were last to degrade symbolizing their presence during the later stages of composting. This is in consonance with the findings of Steger *et al.* (2007).

Seed germination and plant growth bioassays are the most common techniques used to evaluate compost phytotoxicity (Kapanen and Itavaara, 2001). The evaluation of compost toxicity by chemical characterization and biological testing is extremely important for screening the suitability of compost for land application. In the present study, it was observed that the compost from all the treatments has no inhibitory effect on germination of tomato and cluster bean seeds.

The results showed that T_5 with water hyacinth + crop residue+ cow dung (1:1:1) + *P.djamor* + *E.eugeniae* showed higher length of seedlings (root + shoot), germination percentage (100%) and vigour index followed by T_3 with water hyacinth + crop residue+ cow dung (1:1:1) + *P. djamor* (Table 3). This shows that the compost derived from water hyacinth in all the combinations were free from heavy metals, ammonia, salts and low molecular weight organic acids (Batham *et al.,* 2014). Further, it was concluded that water hyacinth enhances nutritive value of final compost and if blended in appropriate quantity with other farm wastes could it accelerate the degradation process.

Conclusion

The present investigation revealed that co-composting of water hyacinth + crop residues + cow dung in the ratio of 1:1:1 with the supplementation of *P.djamor* + *E.eugeniae* could yield the manure of higher nutrient content. Adding this, the manure obtained from this co-composting technique mediates optimal physicochemical characters towards the growth of crops like cluster bean and tomato. Hence, it can be recommended to co-compost water hyacinth, crop residues and cow dung in supplementation with *P.djamor* + *E. eugeniae* for getting quality manure in this era of skyrocketing price of fertilizers and to keep the growth of the noxious weed, water hyacinth in check.

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