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Potential for composting of green phumdi biomass of Loktak lake

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ABSTRACT

Control harvesting of the floating phumdis (combination of different types of weeds and other plant species growing on detritus organic matter) of Loktak lake, Manipur, India is carried out to check their proliferation and protect the precious lake. Composting can be the best alternative for utilization of this huge harvested green phumdi biomass. Studies were carried out on the physico-chemical and biological transformations during agitated pile composting of the harvested biomass with rice husk and cattle manure in different combinations (Trial T1, T2, T3, T4 and T5). The maximum temperature of 46.8 °C during the composting process was monitored in T4 (5 phumdi: 4 cattle manure: 1 rice husk). Highest reductions of volatile solid (VS), soluble biochemical oxygen demand (BOD), CO_2 evolution rate, and oxygen uptake rate (OUR) [20.4, 77.7, 80.6 and 61.7%, respectively] and highest increase of nitrogen [32%] were also observed in T4. Trial T3 (6 phumdi: 3 cattle manure: 1 rice husk) also gave comparable results. Nutrient contents in phumdi compost were higher than other green waste composts. Present study concluded that effective composting of phumdi biomass with appropriate proportion of cattle manure and rice husk is possible.

1. Introduction

An important wetland of North East India is Loktak lake which is situated in the southern part of Manipur valley and the largest natural fresh water lake in the region (Geographical location: 24°25′–24°42′N, 93°46′–93°55′E; Area: 289 km^2). The lake has a unique ecosystem called 'phumdi' – a local word for the floating mats of vegetation mass formed by the proliferation of different types of weeds and other vegetation on the black spongy detritus organic debris at various stages of decomposition and occurring in different sizes and thickness. More than 130 species of plants representing different genera are reported either intermingling in the phumdis or in the clear water zones of the lake (Trisal and Manihar, 2004). The phumdis proliferate rapidly threatening the whole lake ecosystem and deteriorating the overall health of the lake (Santosh and Bidan, 2002; Sanjit et al., 2005). Some of the plants of the lake are desirable since they are temporarily beneficial in reducing agricultural, domestic and industrial pollution or in providing continuous supply of phyto-planktons and helping fish production. Phumdi proliferation is now controlled through harvesting of phumdi biomass. In the process the silt collected and trapped in the roots as well as the inorganic nutrients entering the lake which are assimilated by the phumdi plants are also removed.

There is ample scope for bio-processing of phumdi biomass due to its high organic content (Devi et al., 2002). An economical option for the treatment and disposal of the harvested green phumdi biomass can be through composting of the biomass followed by land application. In composting, the organic components undergo several transformations producing metabolites that may be inhibiting or stimulating plant growth before they mature into compost which is a biologically stabilized and safer matter containing newly formed macromolecules along with non-degradable organic matter together in the form of humic-like substances (Wong et al., 2001). The mineralized form of the product is mostly due to the degradation of easily degradable compounds such as proteins, cellulose and hemi-cellulose that are utilized by microorganisms as carbon and nitrogen sources (Gunnarsson and Petersen, 2007). The biomass load for disposal is reduced in the process and the product which is rich in important plant nutrients such as nitrogen, phosphorous and potassium can be used as a soil conditioner in agricultural applications (Villasenor et al., 2011; Gabhane et al., 2012).

Studies have been undertaken on the composting of aquatic weeds and green wastes, e.g. agitated/periodically turned pile composting of water hyacinth (Singh and Kalamdhad, 2012; Prasad et al., 2013), rotary drum composting of water hyacinth (Singh et al.,

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2012); composting of green waste (Gabhane et al., 2012). So far, there is no relevant literature on any intensive study undertaken on the composting of the harvested green phumdi waste constituted mostly with weeds, other vegetation and detritus organic debris.

The study of phumdi biomass composting requires determination and understanding of the physico-chemical parameters at various stages of the composting process in order to assess the performance and achieve process efficacy. A characteristic of the compost is stability which is important in relation to the compost's field application and potential for odor generation. The stability of composts is related to microbial activity (Eggen and Vethe, 2001) and is the degree to which the organic fractions in composts have been stabilized during the composting process (Gomez et al., 2006). Stable composts contain mainly recalcitrant humus-like matter that has decreased the rate of biological activity (Kalamdhad et al., 2008). Another aspect of compost is maturity which is associated with plant growth and phyto-toxicity (Bernal et al., 1998) and is a key parameter for the proper design and operation of composting facilities, given the harmful effects of immature compost use on plant growth. Also, the phumdi compost cannot be applied for agriculture if the concentrations of the trace elements of the composts exceed the prescribed standards. Therefore, the objectives of the present study is to investigate and compare the organic matter transformation during agitated pile composting of phumdi biomass premixed with cattle manure and rice husk as a bulking agent in different proportions by determining the physico-chemical and biological parameters i/c trace metals and evaluate its stability using respiration tests at different stages of the composting process.

2. Materials and methods

2.1. Feedstock materials

The floating phumdi was collected from the Loktak lake near Thanga village, Bishnupur district, Manipur, India. The large floating phumdis were cut into pieces weighing approximately 7–10 kg with long sickles, loaded on the local rowing boats and brought to the lakeside by boatmen. The collected biomass was then brought to the composting shed of Manipur Pollution Control Board, Imphal, Manipur, India. Cattle manure and rice husks were obtained from Central Agriculture University, Imphal, India. The phumdi materials were prepared for composting through cutting/shredding (maximum size restricted to 10 mm to provide better aeration and moisture control) and uniform premixing with cattle manure and rice husk in five different proportions detailed in Table 1.

2.2. Agitated pile composting

The prepared five different waste combinations of composting materials were formed into five trapezoidal piles [minimum length (L) 210 cm, minimum base width (W) 35 cm, minimum height (H) 250 cm and top width (T) 10 cm with length to base width (L/W) ratio 6] as shown in Fig. 1 (Singh and Kalamdhad, 2012; Prasad et al., 2013). The five piles containing 150 kg of composting materials were manually turned once on 3rd, 6th, 9th, 12th, 15th, 18th, 21st, 24th, 27th and 30th days. The composting piles were monitored for only 30 days.

2.3. Sampling and analysis of physico-chemical and biological parameters of samples

Samplings for analysis were carried out by a compost sampler when the pile was formed (i.e. on 0 day) and after every turning. Grab samples were collected from five different locations mainly from the mid and end portions of the piles to make 1 kg and thoroughly mixed to form a homogenous sample. Samples in triplicates were stored immediately at 4 °C for a maximum of 2 days for biological analysis. After biological analysis, remaining sub-samples were immediately air dried at 105 °C in oven, ground to pass through 0.2 mm sieve and stored for analysis of the physico-chemical parameters.

Temperature was monitored on mid portion of the pile using a digital thermometer. Moisture content was determined by weight loss of the wet compost sample (105 °C for 24 h) using the gravimetric method (BIS, 1982). 10 g of the sub-sample was shaken with 100 mL distilled water in a horizontal shaker for 2 h and kept for half an hour for settling down the solids. The pH of the supernatant was measured using a pH meter after calibration and correction for temperature (BIS, 1982). Electrical Conductivity (EC) of the filtrate of the above mixture (using Watman filter paper No. 42) was measured using a conductivity meter. Volatile solids (VS) and Ash content were determined by the ignition method (550 °C for 2 h in muffle furnace) (BIS, 1982). Total nitrogen was analyzed using the Kjeldahl method, ammonical nitrogen (NH_4–N) using KCl extraction, total and available phosphorus (acid digest) using the stannous chloride method. The Flame Photometer (Systronic 128) was used for analysis of sodium (Na), potassium (K) and calcium (Ca) concentration whereas Atomic Absorption Spectrometer (Varian Spectra 55B) was used for analysis of magnesium (Mg), zinc (Zn), copper (Cu), manganese (Mn), iron (Fe), nickel (Ni), lead (Pb), cadmium (Cd) and chromium (Cr) concentration after digestion of 0.2 g dry sample with 10 mL mixture of $5H_2SO_4$ and $1HClO_4$ in block digestion system (Pelican Equipments Chennai – India) for 2 h at 300 °C (APHA, 2005).

Biodegradable organic matter was measured as soluble biochemical oxygen demand (BOD) (by the dilution method, APHA, 2005) from the supernatant of the blended mixture of 10 g wet sample in 100 mL deionized water. The oxygen uptake rate (OUR) and CO_2 evolution rate were determined as described in Kalamdhad et al. (2008). For OUR, a dissolved oxygen (DO) probe was inserted below 5–7 cm of the surface of a liquid suspension of compost [8 g of wet sample in 500 mL of distilled water added with $CaCl_2$, $MgSO_4$, $FeCl_3$ and phosphate buffer at pH 7.2 made up according to the standard methods for BOD test procedures (APHA, 2005) and incubated at room temperature (24 ± 2 °C)] contained in an airtight flask. The suspension was continuously stirred by means of a magnetic stirrer and the decrease in DO concentration was measured continuously till it reaches zero to determine OUR in mg O_2/g VS/day. For determination of CO_2 evolution rate, 20 g of wet sample was kept with 10 g oven dried soda lime in separate beakers inside an airtight 500 mL container for 24 h. The CO_2 evolution rate is determined from the difference in the initial weight and final weight of soda lime.

The results reported are the means of three replicates. Analysis of variance (ANOVA) for each parameter was made on the results of all five trials using Statistica software to determine any significant difference of the parameters among the five different trials.

3. Results and discussion

3.1. Initial characteristics

The initial characteristics of the composting materials and the proportion of the materials of the five trials are shown in Table 1. The initial moisture contents were high in phumdi biomass (88.8%) and cattle manure (86.4%) but low in rice husk (9.6%). The high moisture displaces the air available in the pore spaces of the composting materials and the addition of rice husk which is a carbonaceous and fibrous material with low moisture content as a