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Struvite for composting of agricultural wastes with termite mound: Utilizing the unutilized

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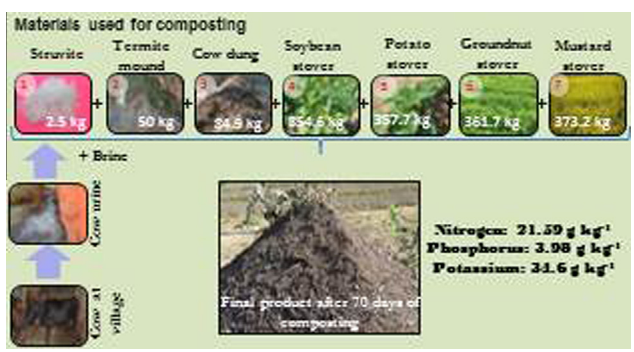
HIGHLIGHTS

- Consequence of struvite application on composting was studied.
- Composting of crop residues with termite mound and struvite is promising one.
- Addition of struvite improves the quality of finished compost.
- Incorporation of struvite significantly improved NPK in finished compost.
- MANOVA reveals the significant difference between control and rest of the composts.

GRAPHICAL ABSTRACT



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ABSTRACT

Although, compost is the store house of different plant nutrients, there is a concern for low amount of major nutrients especially nitrogen content in prepared compost. The present study deals with preparation of compost by using agricultural wastes with struvite ($MgNH_4PO_4{\cdot}6H_2O$) along with termite mound. Among four composting mixtures, 50 kg termite mound and 2.5 kg struvite with crop residues (stover of ground nut: 361.65 kg; soybean: 354.59 kg; potato: 357.67 kg and mustard: 373.19 kg) and cow dung (84.90 kg) formed a good quality compost within 70 days of composting having nitrogen, phosphorus and potassium as 21.59, 3.98 and 34.6 g kg^{-1}, respectively. Multivariate analysis of variance revealed significant differences among the composts. The four composts formed two (pit 1, pit 2 and pit 3, pit 4) different groups. Two principal components expressed more than 97% of the total variability. Hierarchical cluster analysis resulted two homogeneous groups of composts.

1. Introduction

Preparation of compost and its application in agricultural field is an age long practice throughout the world since ancient times. India is an agricultural based developing country and millions of people sustain their lives from the agricultural produces. However, decline trend of farmyard manure (FYM) and competitive uses of cow dung invite amalgamation of several composting materials for preparation of value added compost (Ghosh et al., 2004). In general, application of chemical fertilizers is very common for high yielding crops in India. According to the information provided by the Department of Fertilizers, Ministry of Chemicals &

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Fertilizers, Government of India, the total consumption of urea, diammoniumphosphate (DAP), single superphosphate (SSP) and muriate of potash (MOP) were 31.2, 11.8, 4.7 and 4.3 million metric tons (MMT), respectively in the year 2012–13 and the projected amount for urea, DAP, SSP and MOP will be 32.0, 12.0, 5.1 and 4.5 MMT, respectively for the year 2014–15. These indiscriminate use of chemical fertilizers and consequences of its continuous use is clearly known to the farmers (Nishanth and Biswas, 2008). Furthermore, application of high cost chemical fertilizers invite financial crisis particularly to the small farmers in rural regions of India (Karak and Bhattacharyya, 2011). Therefore, they are switching over to organic cultivation just by using the traditional *age-old composting* technique to obtain optimum return. Furthermore, it has been widely documented that organically produced crops satisfy consumer's choice due to its higher nutritive value as well as it leads to lower environmental problem (Rembiałkowska, 2007). The meta analyse proves that organic crops have higher safety and nutritional value than the conventional crops (Barański et al., 2014). However, there are several drawbacks of using compost as it contains low amount of major nutrients, low density and presence of several heavy metals in it. In turn, this has also been elevated, coupled with cost of production and no immediate cash return. It has been documented that the major source of P for agriculture is rock phosphate and its deposits are non-renewable and are going to be limited in future (Prabhu and Mutnuri, 2014). Struvite ($MgNH_4PO_4{\cdot}6H_2O$, magnesium ammonium phosphate hexahydrate), a slow release fertilizer (0.2 g L^{-1} in water) from cow urine could be a better source of P as well as N (Jeong and Kim, 2001; Jeong and Hwang, 2005; Kim et al., 2009) and which is considered as renewable and substitutable resource. In review Shu et al. (2006) reported that 365 kg struvite application in agricultural field is enough to fertilize 2.6 ha land, which is equivalent to 40 kg P as P_2O_5 ha^{-1} $year^{-1}$ as a phosphatic fertilizer. Prabhu and Mutnuri (2014) reported that in India, 12,176 tonnes of struvite can be prepared per day from cow urine for fertilizer use. Antonini et al. (2012) concluded that struvite induced biomass yields of different crops like wheat, maize etc. comparable to those produced by a commercial fertilizer. For sustainable agricultural development through organic farming could be possible by preparation of value added compost but suitable proportion of raw materials is very much essential. Very recent study reported by Karak et al. (2014a) concluded that termite mound along with the agricultural crop residues and cow dung produced good quality of compost and which has been documented with respect to the several physical and chemical parameters. It is worthwhile to note from our reported study that the prepared compost did not show any toxicity but till there is small amount of N and P (Karak et al., 2014a). While quality and maturity of compost is concerned, carbon/nitrogen (C/N) ratio is widely used as the indicator for compost maturity; however, it may not be a stand-alone parameter to indicate the maturity and should be considered along with the other maturity and stability parameters like temperature profile, pH, EC, NPK, heavy metal contents and germination index (GI) (Guo et al., 2012; Zhou et al., 2014; Karak et al., 2013). Stable and mature compost can increase plant growth but application of unstable and immature compost restrict plant growth as it can fix nitrogen in the soil and restrict plant growth by competing for oxygen in the rhizosphere and releasing toxic substances (Bernal et al., 2009). Therefore, it is of paramount importance to judge the compost maturity and stability through several parameters as a function of various stages of composting as suggested by several literatures. In the present study we screened the suitable proportion of composting raw materials with the advent of new interest in preparation of NPK rich compost by using struvite, termite mound, cow dung and agricultural wastes (e.g. stover of ground nut, soybean, potato and mustard) through several compost stability and maturity parameters. The insightful objective of the present study is to enrich the prepared compost with N and P through addition of struvite with termite mound and agricultural wastes.

2. Methods

2.1. Preparation of struvite

Fresh cow urine was collected from nine local farmer's homes at Chandrakona block of West Midnapore, West Bengal, India and brine was procured from local market of Digha, West Bengal, India. The ratio of 1:0.5 fresh cow urine and brine was mixed to get struvite crystal at pH 9.0. It was done as this ratio and pH gave best quality struvite as reported by Prabhu and Mutnuri (2014). Cow urine and brine were mixed in 25 L plastic container and stirred for 15 min with bamboo stick by adding 5 N KOH to adjust the pH at 9 to get struvite crystal. The solution was kept for another 2 h and white crystal was separated by decantation. Thereafter, all the nine crystals were subjected to dry in the shade and in the room temperature on a plastic sheet until water was evaporated. Prepared struvite was used for composting.

2.2. Struvite characterization

The morphological features of the prepared nine struvite samples were observed under Scanning Electron Microscope (SEM). The SEM images were recorded on high resolution Quanta 200 FEG SEM, USA. The powdered struvite sample was pasted on a carbon tape and dried overnight under vacuum to ensure complete removal of moisture. Samples were gold sputtered prior to imaging. For chemical analysis, all the prepared struvite were mixed and a composite sample was subjected to analysis.

2.3. Feed stocks, composting procedure and sampling

Composting was done during the month of October, 2014 to December, 2014. Four composting pit mixtures with three replications each were employed for the present investigation. The dry weight (in kg) ratio of the mixtures were: pit 1 (control) – termite mound (TM):stover of ground nut (GN):stover of soybean (SN):stover of potato (PO):stover of mustard (MU):cow dung (CD)::50:361.65:354.59:357.67:373.19:84.90; pit 2 – pit 1 + 1.5 kg struvite (ST); pit 3 – pit 1 + 2.5 kg ST and pit 4 – pit 1 + 3.5 kg struvite (ST). Details of composting pit, composting procedure and set up, turning frequency, sampling and duration of composting were followed as outlined earlier by Karak et al. (2014a).

2.4. Physical and chemical properties of feed stocks and composting samples

All the raw materials and composting mixtures were analyzed for volume reduction, bulk density, pH, electrical conductivity (EC), total organic carbon (TOC), oxidisable carbon (OXC), water-soluble carbon (WSC), cation exchange capacity (CEC), total nitrogen (TN), NH_4^+-N, NO_3^--N, total P, total K, total heavy metals (Cr, Cd, Ni and Pb) and germination index (GI) following the procedure described by FCOI (1989). Duration of composting, methodology of sample collection and protocol for temperature measurement is available at Karak et al. (2014a). The procedures of CEC, OXC, WSC, NH_4^+-N and NO_3^--N were described in our previous report (Karak et al., 2013). The VARIAN atomic absorption spectrophotometer (Model No.: AA 240, Australia) was used to assess Cr, Cd, Ni and Pb in the extracts. The accuracy of heavy metal analysis