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Maturity indices as an index to evaluate the quality of sulphur enriched municipal solid waste compost using variable byproduct of sulphur

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Abstract

The aim of this study was to assess the maturity indicators of municipal solid waste compost (MSWC) enrichment with different byproduct of (sugar and fertilizer industry) sulphur (S). The concentration of total S (TS), water-soluble S (WSS), HCl extractable S and available S were significantly different in composts prepared through different byproduct of S with MSW. WSS varied from 4.6 to 5.9% of TS after 120 days of the composting period, whereas, available S varied from 14.5 − 8.6% of TS. S enriched MSW compost had lower C/N, C/S ratio and higher nitrification index as well as lower phyto-toxicity, demonstrating that composts are properly matured and stabilised. Highest compost quality index (0.97) was recorded with S1 compost. Arylsulphatase activity significantly increased with compost maturity. Results stated that all S enriched products maintained a superior amount of plant nutrients and quality indices, indicating that S enriched compost could be a possible substitute for expensive fertilizers.

Introduction

Rapid population growth and urbanization have led to produce a huge amount of municipal solid waste (MSW) in developing countries like India, which causes a negative impact on the environment and human health. India produces near about 70 million ton (Mt) MSW per annum and projected to rise about 165 million ton by 2031 and at this pace it would be reached around 436 Mt by 2050 (Planning Commission Report, 2014). MSW generation has increased in India from 100 to 450 g/day/person. MSW produced in the metro- cities of India is commonly disposed of in landfill as open dumping which creates serious environmental problems. MSW management failure leads to severe resources loss and limited waste management approaches (Buia et al., 2020). The pollutants from dumping sites can contaminate the groundwater or it might be taken up by crops grown in nearby fields and may create a negative impact on human health (Meena et al., 2020, Malovanyy et al., 2019, Eriksen et al., 1999). Despite it contains a huge amount of plant nutrients, a very small fraction of MSW is used for composting in India (Dotaniya et al., 2017). An alternative use of large quantities of nutrient-rich organic waste, as well as crop residues through composting and use as low-cost organic fertilizers, should be popularised. However, it draws the attention of scientists and policymakers to minimise food chain contamination and increased carbon input for sustainable agricultural production.

Composting of MSW is a sustainable recycling tool to minimise the environmental and health issues related to landfilling. It is a comparatively sustainable option for diverting MSW from landfills and creating a quality organic fertilizer through composting technology (Neslihan, 2019, Meena et al., 2016b). As far as concerning the plant nutrients in ordinary compost or farmyard manure (FYM) is very low. The limitations of these products, especially S concentration could be improved by inoculating S through gypsum, phosphogypsum and pressmud to enhance the quality of compost.

Sulphur enriched MSW compost is being encouragingly used for sustainable production of oil seeds crops because S is an important component of proteins, vitamins, amino acids, and enzyme. It enhances oil content and quality of oils seeds and it could be a possible alternative in place of costly chemical fertilizers (Wang et al., 2014). Sulphur enriched municipal solid waste compost is increasingly used for reclamation of sodic soils because it reduce their pH as well as improve the solubility of essential plant nutrients (Garcia et al., 2007).

In India, huge amount of pressmud is generated every year, sustainable recycling of this waste is also a serious issue, approximately 3 tons of pressmud cake is generated from each 100 tons of sugarcane crushed. Pressmud is a byproduct of sugar industries and rich in S (Gupta et al., 2011, Dotaniya et al., 2016).

Gypsum is an excellent source of S as well as Ca. but, due to fixed form its availability is limited to plants. S solubility enhanced through composting technology because of several acids released during the decomposition process, act as plant nutrients chelating agent for enhancing uptake from soils.

Phosphogypsum (PG) generation in India is about 11 Mt per annum. PG produced from phosphoric acid industries are presently stacked and very less amount is sold for beneficial use mostly used in cement industry units as an alternative to gypsum ($CaSO_4 \cdot 2H_2O$) as well as chemical amendments for reclamation of alkali soils (Meena et al., 2018). However, management of PG is a serious issue to the environment especially during the rainy season if not cared properly. In order to minimise the impact on the environment, it is need of the day to find sustainable options to manage PG either through composting technology or other means.

A large amount of waste sources of S is available in India and they contain a good amount of S. Solid waste can be managed either through composting or as direct use in agriculture. However, direct application of waste sources of S in the soil is very limited due to less S availability to crop plants. Carrion et al. (2008) reported that addition of S into composting mass to be more effective in reducing the pH during composting period.Composting of the MSW enriched with waste sources of S is an effective technique for producing a value-added product which could be a low-cost input for sustainable agriculture. For most of the composting projects, stress was given on enrichment of major plant nutrients (NPK). However, S is an important plant nutrient especially for oil seed crops which enhances oil content and quality of seed.

The finished product should be meet out the quality parameters to guarantee its marketability. A proper selection of composting method is important to provide sustainable recycling of MSW into a quality product. On the other hand, an integration of different parameters or indices

explaining the quality of different waste sources of nutrients utilized for compost preparation provides a clear representation of the nature and composition of compost. It can produce additional erudition and nutrient-enriched product could be applied in more scientifically.

Several parameters have been used to assess the process and stability of the value-added products. Compost stability and maturity are frequently used to describe the rate of decomposition of organic matter during composting process, though they are principally diverse. Maturity is a measurement of the chemical condition of the compost and used to show the presence or absence of phytotoxic effects, which are mainly due to higher levels of ammonia or organic acids (Chen et al., 2019, Moharana and Biswas, 2016). Indiscriminate use of immature compost had a negative effect on germination of seeds, root length, finally clamp down plant growth. However, stability refers to the rate of respiration of compost material.

Conceptually, a material having high amount of biological activity indicates that decomposition of the compost is still going and that product is not ready to use as a soil application (Wu et al., 2000). However, several researches have been investigated that composting of municipal solid waste is sustainable option to recycle the enormous quantities of waste, no studies have reported of different by-product of S enrichment and municipal solid waste composting and their effect on different fractions of S and maturity of compost. Therefore, this research was conducted to address the subsequent objectives (i) to monitor the changes in various fractions of S during the process of composting using different sources of S enrichment with MSW (ii) to study the effect of S enrichment on C/N, C/S ratios, WSC/Org-N and nitrification index and (iii) to assess the phytotoxicity of S enriched composts by using germination index (GI). We hypothesized that inoculation of compost with different waste sources of S along with MSW, would increase various fractions of S and nutrients availability.

Section snippets

Raw materials

The MSW was obtained from Bachamdi dumping site of Bharatpur, Rajasthan and pressmud was collected from Bagpat sugar mill, Uttar Pradesh, India. Gypsum was collected from Bharatpur, Rajasthan. Mustard stover collected from the experimental farm of ICAR-Directorate of Rapeseed-Mustard Research (ICAR-DRMR), Bharatpur, Rajasthan. Pressmud, gypsum and phosphogypsum had 3.7 ± 0.17, 16 ± 0.2 and 15.6 ± 0.76% total S, respectively. Heavy metal (s) concentration in raw material were analysed and were

Changes in different fractions of S

TS content in S enriched composts increased as composting progressed toward maturity (up to 120 days). At the end of the 30 days of composting, TS was ranged from 4.5 to 8.5 g kg^{-1} (Table 1). At 60 days of the composting, the maximum TS was reported under S5 (9.94 g kg^{-1}) followed

by S1 (8.13 g kg^{-1}) and the lowest being with MOW (S0) compost (4.80 g kg^{-1}). TS varied from 12.43 to 5.69 g kg^{-1} at 90 days of the composting period. Significantly higher TS were reported at 120 days of composting

3.1.4.TP, WSP and Olsen P

Data revealed that highest TP was found under S5 (0.83%) followed by S3 (0.72%) at the 30 days of composting [Supplementary file (Table 2)]. At the end of 120 days of composting, significantly higher TP was observed with S5 compost (1.06%) followed by S3 (0.89%) and S2 (0.84%). TP was gradually increased with composting period, irrespective of substrates. This might be due to decomposition and loss of inorganic matter during decomposition of different substrates and little loss of P as leaching

3.1.5.TK, WSK and NH_4OAc-K

TK increased in all composts prepared from different waste sources of S with the progress of decomposition [Supplementary file (Table 2)]. TK content ranged from 0.99 to 0.75% at the 30 days stage of composting. TK gradually increased in all composts as composting period increased, the highest total K was found with S5 (1.53%) and the lowest with S0 (1.19%) at the last stage (120 days) of the composting. Results showed that increased K content in all composts indicates that held sufficient K to

Dehydrogenase (DHA)

DHA is a measure of total microbial activities in compost, and an easy to monitor compost maturity because it refers to a group of endocellular enzymes and catalyze the oxidation of soil organic matter (Forster et al., 1993). DHA had lower activities at the end of 30 days of composting time, due to the less microbial activity during the initial stage of composting (Fig. 3 a). The DHA values varied from 96.3 to 62.6 μTPF g^{-1} compost h^{-1}, significantly higher DHA had observed for S5 compost and

Conclusions

The present study demonstrated that enrichment of different waste sources of sulphur with MSW improved the compost quality in terms of various fractions of S as well as N, P and K in the prepared composts. Results suggested that compost maturity parameters fulfilled the criterion of the threshold values: C/N ratio < 15; WSC/Org-N ratio < 0.55 and GI > 70%. In this study, all the composts prepared from different waste sources of S and municipal solid wastes are well matured and stabilised and

Declaration of Competing Interest

The authors declared that there is no conflict of interest.

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