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Influence of carbide sludge on microbial diversity and degradation of lignocellulose during in-vessel composting of agricultural waste

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ABSTRACT

Effects of waste carbide sludge (CS) on microbial diversity and degradation of lignocellulosic fractions of mixed agricultural waste was experimented using a 550 L rotary drum composter. Four different trials of varying carbide sludge i.e. trial 1 (0%), trial 2 (1%), trial 3 (2%) and trial 4 (3%) was carried out for the study. The drum was turned every 24 h once to provide proper aeration and mixing of the waste materials for higher degradation and availability of organic matter to the microbial population. Hence with proper combination of waste materials and optimum addition of CS, a maximum of 31.56% reduction in Acid insoluble lignin (AIL), 46.03% of hemicellulose (HC) and 47.54% of cellulose (C) was observed in trial 2. The appropriate addition of CS was considered to increase the overall microbial activity of the composting process in trial 2. However, higher addition of CS in trial 3 and 4 was not effective in terms of higher degradation of volatile solids and also led to loss of organic nitrogen. In addition, it also increased the pH of compost to alkaline conditions and had a major effect on the growth of fungi. Pathogens i.e., *Salmonella*, *Shigella* was completely eliminated at the end of 20 days due to higher temperature and addition of waste carbide sludge in trial 2, 3 and 4 at the end of 20 days.

1. Introduction

In India, about 55 million tones of municipal solid waste (MSW) is generated, which includes 48% of biodegradable waste. The total amount of waste generated is estimated to increase by 5% per year. The higher biodegradable waste is mainly due to the organic fractions of kitchen and yard waste. Landfilling of MSW remains the primary waste disposal strategy in India and it is largely consisted of the organic fractions. When these organic fractions containing high moisture content and biodegradable substrate is landfilled, it produces more leachate thereby causing major environmental pollution (Goodall and Quigley, 1977). In addition, landfilling of these biodegradable wastes will lead to emission of greenhouse gases. The high nutrient content in vegetable waste can be successfully recycled through composting process and applied to agricultural fields as compared to any other process. Composting and anaerobic digestion processes are preferred as sustainable alternative over landfilling, incineration and pyrolysis for disposing these organic wastes (Kulcu and Yaldiz, 2004; Anton et al., 2005).

Composting of organic waste and MSW was carried out with different combinations of various bulking agents such as cattle manure, saw dust and dry leaves for producing quality compost (Singh et al., 2013; Varma and Kalamdhad, 2013; Varma and Kalamdhad, 2014b). However, these bulking agents are rich in lignocellulosic fractions, which contribute to the total organic content of the waste material. Huang et al. (2010) had reported that lignin as the most abundant renewable source on earth and its difficulties during degradation process. Temperature, moisture content and type of lignocellulose majorly governs the degradation rate (Kuhad et al., 1997; Rayner and Bodd, 1988; Varma et al., 2015).

There are many studies on the use of rotary drum composter for composting of organic waste with shorter time period. However, most these studies were focused on the organic matter transformation, stability and maturity of compost (Kalamdhad et al., 2009; Varma and Kalamdhad, 2014a; Varma et al., 2014c). But, there are limited literatures available on the study of lignocellulose degradation during drum composting of agricultural waste and in combination with waste carbide sludge. Hence, the present study focused on the composting of mixed organic waste with varying addition of carbide sludge in four different trials i.e., trial 1 (0%), trial 2 (1%), trial 3 (2%) and trial 4 (3%) respectively. During the study, changes of microbial communities with respect to varying addi-

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Table 1
Initial combination of waste materials.

Treatment	Waste materials					
	Vegetable waste (kg)	Cattle manure (kg)	Saw dust (kg)	Dry leaves (kg)	Total (kg)	Waste Lime Sludge (%)
Trial 1	45	36	9	10	100	0
Trial 2	45	36	9	10	100	1
Trial 3	45	36	9	10	100	2
Trial 4	45	36	9	10	100	3

tion of waste carbide sludge and the degradation of lignocellulosic fractions was studied.

2. Materials and methods

2.1. Feed stock material

Vegetable waste, cow dung, saw dust and dry leaves were used as feed stock materials for preparing the compost. Vegetable waste was collected from Vegetable market, Fancy Bazaar, Guwahati, Assam, India and dry leaves from the Indian Institute of Technology Guwahati campus, Guwahati, India. Cattle manure (Buffalo) was collected from dairy farm and saw dust from the nearby Amingaon village. Prior to composting, the maximum particle size in the mixed waste was restricted to 1 cm in order to provide better aeration and moisture control. The compost was prepared with four different proportions of vegetable waste, cattle manure, sawdust, dried leaves and waste carbide sludge as detailed in Table 1.

2.2. Composting experiment design

2.2.1. Rotary drum composter

A manually operated batch scale rotary drum composter of 550 L capacity was designed and utilized during the present study. The drum composter was 1.022 m in length and 0.76 m in diameter, fabricated by a 4-mm-thick metal sheet. The drum composter was rotated manually once in every 24 h once for the complete mixing of the waste materials. The details of the composter design are given elsewhere (Varma and Kalamdhad, 2014a).

2.3. Physico-chemical analysis

500 g of each grab samples was collected from six different locations manually without disturbing the adjacent materials. Finally all the grab samples were mixed thoroughly to make a homogenized sample. Temperature was monitored using a digital thermometer throughout the composting period. pH of the compost (1:10, w/v waste: water extract) was analyzed as described by (Kalamdhad et al., 2009). Volatile solids were determined by loss ignition method (on dry mass basis) at 550 °C for 2 h (APHA, 2005).

2.4. Lignocellulose analysis

Lignin was determined in 0.3 g (dry weight) portions of each sample using National renewable energy laboratory (NREL) procedure (Templeton and Ehrman, 1995; Ehrman, 1996). Cellulose was obtained by using the method adopted by Updegraff (1969) and hemicellulose was determined from the difference between neutral detergent fibre (NDF) and acid detergent fibre (ADF) using method provided by Goering and van Soest (1970). All the results reported are the means of three replicates. The statistical significance of differences between all replicated samples was determined using the SPSS 17.0 system for the three different trials.

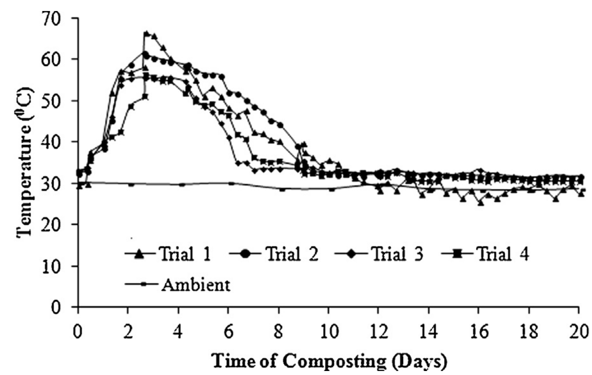

Fig. 1. Temperature pattern during composting.

2.5. Sample preparation for microbial analysis

Microbial count was carried out by adding 10 g of waste or compost into 90 mL of sterile distilled water containing 0.85% (w/v) sterile sodium chloride solution in 250 mL Erlenmeyer flasks (Ryckeboer et al., 2003).

2.6. Culture media for microbial analysis

Mesophilic bacteria and spore forming bacteria were enumerated using Nutrient agar medium (Varma and Kalamdhad, 2014a). Actinomycete isolation agar was used for the enumeration of Actinomycetes. ISP medium No. 4 was used for enumeration of streptomycetes. Fungal growth is inhibited by adding 0.2 g L^{-1} cycloheximide (Ryckeboer et al., 2003). Cycloheximide (0.2 g L^{-1}) was added to inhibit fungal growth. Rose Bengal chloramphenicol agar was used for enumeration of fungus. Salmonella and Shigella isolates were enumerated by using SS Agar (Salmonella Shigella Agar).

3. Results and discussions

3.1. Changes in physicochemical parameters

3.1.1. Temperature

The degradation pattern during composting can be directly viewed as rise in temperature. Fig. 1 shows such rise in temperature for four different trials with different pattern during the process. A maximum of 66.5 °C was observed in trial 1 due to different combination of waste materials without CS addition. However with varying amounts of carbide sludge, a maximum of 61.8, 55.8 and 51.4 °C was achieved in trial 2, 3 and 4 respectively. Even though highest temperature was observed in trial 1, 1% addition of carbide sludge in trial 2 was observed to have prolonged thermophilic phase. The prolonged thermophilic phase can be considered due to increased metabolic activity of microbial population by the addition of carbide sludge. The Ca content of carbide sludge is considered to increase the metabolic activity of microbes during composting and thereby increasing the decomposition process (Varma et al., 2015).