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Short communication

Potential of waste carbide sludge addition on earthworm growth and organic matter degradation during vermicomposting of agricultural wastes

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ABSTRACT

The effect of waste carbide sludge (WCS) with higher Ca content and pH buffering capacity was investigated during vermicomposting of agricultural waste. Agricultural waste mixture was prepared by mixing vegetable waste, cow dung, saw dust in (5:4:1) ratio for a total mass of 2.5 kg. In addition, 0.27 kg of dried leaves was added to all of the trials as bulking agent. Finally, the effect of WCS addition was experimented in five different trials of the same ratio of waste combinations but varying WCS concentration as following: 0.5% WCS was added in trial 1, 1% WCS in trial 2, 1.5% WCS in trial 3, 2% of WCS in trial 1 and 2.5% WCS in trial 5 respectively. Appropriate addition of WCS had no negative effects on the growth of biomass, as considerable increase of earthworm population was observed in WCS added trials as compared to the control. A maximum of 43.7% of total organic carbon reduction was observed in trial 3 when compared to all other trials. Higher biomass growth was observed in WCS added trials as compared to the control experiment proving the possibility of WCS effect on biomass growth. Total metal and micronutrient concentration was observed to increase toward the end of process.

1. Introduction

In India, about 0.75 million tonnes of waste carbide sludge is produced as a by product during acetylene gas production and is estimated to increase further due to limited utilization (CPCB, 2006). In addition, India is also producing 221.4 million metric tonnes of fruits and vegetables and wasting 5.8 to 18% of the total produced fruits and vegetables (CIPHET, 2013). These agricultural wastes with high organic matter and nutrient content can be successfully converted into organic manure by using vermicomposting technology. The final vermicompost can be used as an excellent soil conditioner for plant growth due to its rich nutrient content (Ndegwa and Thompson, 2001). Numerous studies have been reported on the potential use of epigeic earthworm, *Eisenia fetida* for the treatment of domestic and industrial organic waste (Nayak et al., 2013; Ravindran et al., 2015). But the utilization of waste carbide sludge during vermicomposting for the treatment of agricultural waste still remains unproven.

There are only few literatures available on the use of lime for the immobilization of heavy metals and pathogen control during composting (Wong and Selvam, 2009; Singh and Kalamdhad, 2013b). Similarly, waste carbide sludge with 30–40% pure lime is also used during co-composting of water hyacinth and vegetable waste for the reduction of heavy metal availability and higher organic matter reduction (Singh and Kalamdhad, 2013a, 2014; Varma et al., 2015). From all the literatures it has been concluded that due to higher Ca content in lime and waste carbide sludge increases the microbial activity and with buffering capacity it helps in immobilization of heavy metals. There are very few literatures available on the utilization of waste carbide sludge during composting and limited literatures on the utilization of WCS during vermicomposting. Since vermicomposting is a combined microbiological and earthworm process, addition of waste carbide sludge during the process would improve the treatment efficiency as well as the waste load will be minimized. Therefore, the present study focused on the effects of waste carbide sludge addition on the physico-chemical and biological characterization during vermicomposting of agricultural waste mix. The studies were carried out by mixing vegetable waste, cow dung, saw dust and dry leaves altogether and finally by employing *E. fetida* for the degradation study.

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2. Materials and methods

2.1. Feedstock materials

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 dung) 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 less than 1 cm in order to provide better aeration and moisture control. Varma and Kalamdhad (2014b) suggested that mixture of 54 kg vegetable waste, 45 kg cow dung, 9 kg saw dust (5:4:1) and 10 kg of dried leaves of total mass of 100 kg (wet weight) was the best combination for producing stabilized compost within shorter time period using rotary drum (20 days). The combinations of waste materials for vermicomposting of vegetable waste were performed by one of the co-authors and found successful (Khwairakpam and Kalamdhad, 2011). Therefore, the present study was experimented to utilize the WCS during vermicomposting and study the effects on physico-chemical and biological characterization. Waste carbide sludge (WCS) was collected from Assam Air Products Pvt. Ltd., Guwahati, Assam, India. WCS is produced during acetylene gas production by calcium carbide in semisolid condition. Collected WCS contained about 60–70% moisture content and it was dried at 105 °C in oven for 24 h. It was ground and passed from 0.22 mm sieve before application. Therefore, the same combinations were scaled down to 2.5 kg and experimented for the effect of WCS in 5:4:1 ratio. Different proportions of WCS were experimented along with agricultural waste by employing *E. fetida* for 45 days (Table 1).

2.2. Earthworms (*E. fetida*) culture and experimental set-up

Earthworm species *E. fetida* were collected from the Central Plantation Crops Research Institute (CPCRI), Indian Council of Agricultural Research, Regional Station, Kahikuchi, Guwahati, India. For developing the cultures, Perspex bin sizes 450 × 300 × 450 mm were fabricated in the laboratory and the earthworms were cultured in the partially degraded cow dung. For aeration and drainage purpose 16 holes of 10 mm diameter were drilled along the longer sides and 16 at the bottom respectively.

The experiments were conducted in duplicate in bamboo containers (reactors) of curved shaped (radius 2100 mm and depth 140 mm). The reactor was designed for a total weight of 2.77 kg for 45 days based on worm mass added. Initially, the bedding was prepared using chopped hay (about 50 mm), banana pulp (chopped about 50 mm), and tree leaves all were partially degraded and watered to keep it moist. A part of waste materials was added onto the bedding materials and the earthworms were introduced in the center of the materials. Finally, the remaining waste material was added and the reactors were covered with gunny bags to prevent moisture loss. A total of 180 adult earthworm's were added which was calculated according to the weight of the feedstock added and the number of days for experimentation, based on the literature suggested; earthworms can consume materials half of their body weight per day under favorable conditions (Haimi and Huhta, 1986; Khwairakpam and Bhargava, 2009). The moisture level was maintained about 60–70% throughout the study period by periodic sprinkling of adequate quantity of tap (potable) water. The mixtures were turned manually every 15 days in order to provide proper aeration to earthworms and 200 g of homogenized samples were collected on 0, 15, 30, and 45th day of the process and the moisture was measured by drying the sample at 105 °C. It was found that the moisture was in the range of 60–70% and if needed water was added on that day of sampling. Since the temperature is maintained at 25 °C by placing hot and cool blowers, the evaporation of water was minimal as per the observations during the study.

2.3. Physico-chemical and stability analysis

The sampling from the vermicomposting reactors was done manually on 0, 15, 30 and 45th day. Finally all the grab samples were mixed thoroughly to make a homogenized sample. Triplicate samples were collected and stored at 4 °C for subsequent analysis. pH and electrical conductivity (EC) of the compost (1:10 w/v waste:water extract). Volatile solids (VS) were determined by the ignition method (550 °C for 2 h in muffle furnace) (BIS, 1982). The total organic carbon was calculated from volatile solids (Mohee et al., 2008). Total Kjeldahl nitrogen was analyzed using the Kjeldahl method, ammoniacal nitrogen (NH_4-N) using KCl extraction, and total and available phosphorus (acid digest) using the stannous chloride method. Stability parameter CO_2 evolution was performed as described in Kalamdhad et al. (2008). Bacterial population (1:10 w/v waste:water extract) including total coliforms (TC) and fecal coliforms (FC) was measured by inoculating with culture tube medias with Lauryl tryptose broth and EC medium respectively using the Most Probable Number (MPN) method (APHA, 2005). Biodegradable organic matter was measured as soluble bio-chemical oxygen demand (BOD) and soluble chemical oxygen demand (COD) from the supernatant of the blended mixture of 10 g wet sample in 100 mL deionized water (APHA, 2005). The lime concentration in waste carbide sludge was calculated by the hydrochloric acid titration method (ASTM C25, 2000).

3. Results and discussion

3.1. Physico-chemical analysis

3.1.1. pH and electrical conductivity (EC)

pH variation during vermicomposting is highly dependent on the waste materials used for the degradation process. The shift in pH toward acidic and alkaline conditions during the process can be considered due to the production of organic acids and ammonia depending on the raw materials and the degradation pattern. But in the present study the pH was observed to increase till the end of process. The initial pH value was in the range of 6.9, 7.2, 7.4, 7.5 and

Table 1
Initial combination of waste materials.

Experiment	Waste materials					
	Vegetable waste (kg)	Cattle manure (kg)	Saw dust (kg)	Dry leaves (kg)	WCS (%)	Earthworm (initial count)
Trial 1	1.25	1	0.25	0.27	0.5	*Eisenia fetida* (180)
Trial 2	1.25	1	0.25	0.27	1.0	*Eisenia fetida* (180)
Trial 3	1.25	1	0.25	0.27	1.5	*Eisenia fetida* (180)
Trial 4	1.25	1	0.25	0.27	2.0	*Eisenia fetida* (180)
Trial 5	1.25	1	0.25	0.27	0	*Eisenia fetida* (180)