Effects of Waste Lime Sludge on Nitrogen Dynamics and Stability of Mixed Organic waste Using Rotary Drum Composter

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ABSTRACT: Feasibility of waste lime sludge (LS) obtained from acetylene gas production industry was studied during co-composting of vegetable waste for enhanced volatile solids reduction. Four different trials were carried out with varying percentage of LS combinations i.e. trial 1, trial 2, trial 3 and trial 4. Increased addition of waste LS raised the levels of pH in the compost, thereby volatizing the nitrogen as ammonia in trial 3 and 4. However, appropriate addition of LS in trial 2 increased the microbial activity and resulted in higher volatile solids reduction (22.1%) which was found double fold increase when compared to trial 1, where 11% VS reduction was observed. Hence, with proper combination of waste materials and addition of LS, a maximum temperature of 66.5 and 61.4° C was observed in trial 1 and 2 respectively. Temperature level above 50° C for more than 4 to 7 days was observed during the process, thus satisfying the regulatory requirements for PFRP (Process to Further Reduce Pathogens). Therefore, the present study concluded that appropriate amount of LS addition increased the organic matter reduction drastically. However in trial 3 and 4, where 2 and 3% addition of LS were not appreciable in terms of proper degradation and stability at the end of composting period.

Key words: Lime sludge, Vegetable waste, Nitrogen dynamics, Volatile solids, Stability

INTRODUCTION

India stands second in the production of Fruits and Vegetables next to China. It contributes about 10 and 14% of Fruits and Vegetables in the world production (Gautam and Guleria, 2007). Indian Agricultural Research Data Book (IAR, 2004) showed that about 150 million tones of fruits and vegetables are produced in India; out of which 50 million tons per annum has been wasted. Owing to rapid urbanization and huge production of organic waste, it poses a major effect on the environment pollution if they are not processed properly. Kulcu and yaldiz (2004) has reported that biogas processes and composting can be preferred as sustainable alternative over land filling, incineration and pyrolysis for disposing these organic wastes. The Municipal Solid Waste (Management & Handling) Rules, 2000 has also recommended composting for the stabilization and processing of biodegradable wastes (MUDGI, 2000).

An *et al.* (2012) has reported that composting can be employed as a safe treatment strategy for solid waste disposal. Composting is the biological decomposition of organic matter forming a stabilized and pathogenic free end product. There are many studies on the use of rotary drum for the composting of vegetable waste, water hyacinth and sewage sludge mixed with cow dung and saw dust (Kalamdhad *et al.*, 2009; Varma and Kalamdhad, 2013; Singh *et al.*, 2013; Varma and Kalamdhad, 2014b). The transformation and mineralization of organic matter during composting is carried out by many microbial communities such as bacteria, fungi and actinomycetes (Zucconi *et al.*, 1987; Davis *et al.*, 1992; Varma and Kalamdhad, 2014a). However these microbial communities are greatly affected by the varying temperature during the process and by the physical properties of waste material being composted. In addition, amendments of alkaline materials as bauxite residue, clay, coal fly ash and lime during co-composting of solid waste has been reported to increase the microbial metabolism and also reduces the availability of heavy metals in compost (Qiao and Ho, 1997; Wong *et al.*, 1997; Fang and Wong, 1999, Singh and Kalamdhad, 2012). However, not much research has been carried out on the application of waste lime sludge on different organic waste combinations for improving the treatment efficiency during composting process.

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In India, about 0.75 million tones of lime sludge is being generated per year during acetylene gas production and expected to increase annually due to very limited utilization of this lime sludge (CPCB, 2006). Therefore, the present study involved the utilization of LS on physico-chemical changes and stability during composting of mixed organic waste, which is more important to be determined before applying compost for land application. A very few literatures are available on the application of waste LS during composting of mixed organic waste. Therefore, the aim of the study was focused on the combination of different organic waste materials i.e., Vegetable waste, cow dung, saw dust and dry leaves (5:4:1) ratio in four different trials by adding different proportions of waste LS; Trial 1 (0%), trial 2 (1%), trial 3 (2%) and trial 4 (3%). Effects of different proportions of waste LS on physico-chemical changes and extent of degradation of organic matter was studied and successfully correlated with the stability of the compost i.e. oxygen uptake rate (OUR) and CO_2 evolution.

MATERIALS & METHODS

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 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 and dried leaves. Waste lime sludge is produced as an end product during acetylene gas production by calcium carbide. Therefore, the waste LS was collected and oven dried at 105° C, ground and then passed through 0.2 mm sieve for uniform size before use. Finally, all the waste materials were mixed properly before feeding into the drum. The composition of waste materials and initial characterization of waste LS is given in Table 1 and Table 2, respectively.

Five-hundred gram grab samples were collected manually from six different sources without disturbing the adjacent materials. 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. Temperature was monitored us-

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

Table 2. Initial characterization of waste lime sludge (LS)

S.No	Parameter		Lime Sludge
1.	pH		12.5 ± 0.06
2.	EC (ds/m)		8.5 ± 0.13
3.	Moisture content (%)		55 ± 0.32
4.	Volatile solids (%)		0.62 ± 0.22
5.	Pure Lime (%)		$35 - 40$
6.	Nutrients (mg/kg dry matter)	Na	1.5 ± 0.05
		K	1.2 ± 0.03
		Ca	65650 ± 350
		Mg	4.7 ± 1.27
7.	Heavy metals (mg/kg dry matter)	Fe	3.0 ± 0.06
		Cu	0.66 ± 0.02
		Mn	7.23 ± 0.23
		Zn	2.14 ± 0.43
		Ni	0.2 ± 0.007
		Pb, Cd, Cr	ND*

(mean ± SD*, n = 3)
ND – not detected, *SD – standard deviation.

ing a digital thermometer throughout the composting period. pH and electrical conductivity (EC) of the compost (1:10, w/v waste: water extract) were analyzed as described by (Kalamdhad *et al*., 2009). Volatile solids (VS) were determined by the ignition method (550°C for 2 h in muffle furnace) (BIS, 1982). Total Kjeldahl nitrogen was analyzed using the Kjeldahl method, ammoniacal nitrogen (NH_4-N) using KCl extraction, total and available phosphorus (acid digest) using the stannous chloride method. Analysis of stability parameters such as CO_2 evolution and oxygen uptake rate (OUR) were performed as described in Kalamdhad *et al*. (2008). Biodegradable organic matter was measured as soluble bio-chemical oxygen demand (BOD) (by the dilution method, APHA, 2005) and soluble COD from the supernatant of the blended mixture of 10 g wet sample in 100 mL deionized water. Bacterial population (1:10 w/v waste-water extract) including total coliforms (TC) and fecal coliforms by inoculation of culture tube medias with Lauryl tryptose broth and EC medium using the most probable number (MPN) method (APHA, 2005).

RESULTS & DISCUSSION

Fig. 1 shows the variation in temperature profile of all four different trials during composting, indicating the effects of waste lime sludge (LS) amendment 0, 1, 2 and 3% on the degradation pattern. A gradual increase in temperature was observed in all the four trials during the initial stage of composting. However, as the composting progressed a variation in temperature profile was observed which can be considered due to addition of LS. A maximum temperature of 66.5, 61.8, 55.8 and 51.4°C was observed in trial 1, 2, 3 and 4; thereby started to decrease further. During composting, temperature of 52 to 60°C was considered to maintain the greatest thermophilic activity (Mohee and Mudhoo, 2005). A sudden drop in temperature was

observed in trial 3 and 4 during the second and third day of composting, in which higher amounts of LS was added. But in the case of trial 2, a maximum of 61.8° C temperature was achieved and observed to have prolonged thermophilic temperature above 50°C from day 2 to 7. However in trial 1, even a maximum temperature of 66.5°C was observed, but the thermophilic phase was not continued for more than six days as compared to trial 2. Hence it can be considered that that the prolonged thermophilic stage can be due to the increased metabolic activity of microbes by appropriate addition of LS. Lower addition of LS (1 %) in trial 2, can be considered to provide a buffering capacity against pH drop and with suitable amount of Ca, which would have improved the metabolic activity of the microbes (Kubota and Nakasaki, 1991). Even though higher temperature in compost environment was reported to have a major effect on pathogen control (Petrica *et al*., 2009); addition of lime was also reported to control their population by release of ammonia and higher pH (Wong and Selvam, 2009).

In trial 1, the initial pH was around 6.7 which was observed the least among all the trials. With higher addition of LS the pH was observed to increase and was in the range of 6.9, 7.1 and 7.6 in trial 2, 3 and 4 respectively. As the composting progressed there was a gradual increase in pH from 6.9 to 8.5 in all the trials and observed high in trial 3 and 4 (Fig. 2a). Finally it was in the range of 7.7, 7.8, 7.3 and 8.5 in trial 1, 2, 3 and 4 respectively at the end of 20 days. The increase in pH may be considered due to the release of ammonia, as the excess amount of organic nitrogen is not utilized by microbes and this might have increased the pH of compost (Rynk *et al*., 1992; Nayak *et al*., 2013). The similar pH increase and decrease during lime treatment of composting was reported by many researchers for different waste materials such as sewage sludge and
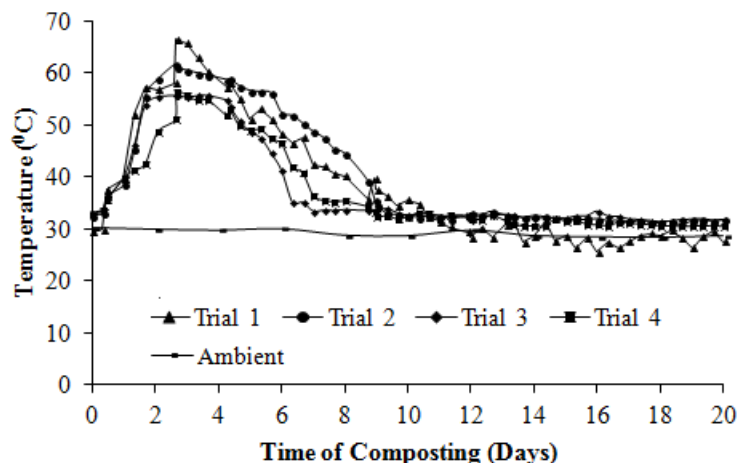

Fig.1. Temperature variation during composting

water hyacinth (Fang and Wong, 1999; Wong and Selvam, 2006; Singh and Kalamdhad, 2013a). The pH of compost has a major effect on the survival of microbial communities with optimum range of 6.0 to 7.5 for bacteria and 5.5 to 8.0 for the growth of fungi (Golueke, 1972). But in the case of trial 4, due to higher amount of LS the pH level increased and thereby leading to volatilization of ammonia. Hence, 1% LS addition was observed optimum for the vegetable waste mixture composting, as higher addition is leading to alkaline pH of the compost.

The EC value of compost reflects the degree of salinity in the composting and its possible phytoxicity effects on the growth of plant. Higher EC in final compost will slow down plant rooting and reduce the transportation of water and nutrients into the plants (Chiang *et al.*, 2007). However in the present study reduction in EC was observed in LS added trials except trial 1. Similar trend of EC in lime amended compost was also monitored by Fang and Wong (1999). The final EC values of the all compost were about 5.18, 2.50, 2.87 and 2.23 dS/m in trial 1, 2, 3 and 4, respectively (Fig. 2b). Richards (1954) has reported that EC values of all lime-amended sludge composts were lower than 3.0 dS/m, which would not affect the growth of slightly salt tolerant plants. Similar such results with final EC value less than 3.0 dS/m was observed in all the three lime amended compost and were also supported by

the various literature (Fang and Wong, 1999; Singh and Kalamdhad, 2013b). Moisture loss during the composting process can be viewed as an indicator of decomposition (Kalamdhad and Kazmi, 2009). Due to the addition of LS and high biodegradable organic matter of vegetable waste, rapid increase in temperature was observed in all the trials within few hours of the composting process. Addition of LS during composting process was reported to increase the metabolic activity without any negative effects on microbial community (Fang and Wong, 1999; Gabhane *et al.*, 2012). The reports were supported by the trial 2 results, where 1% lime was added. However, in the case of trial 3 and 4, there was not much appreciable loss of moisture content. The reason might be due to the addition of excess amount of LS, which had resulted in higher pH thereby causing ammonia release, since ammonium ions start to become unstable in the compost and is released as ammonia gas. In addition, the temperature profiles of trial 3 and 4 were also in accordance with the release of moisture content during the process. Fig. 3a shows the loss of moisture content during composting process. The moisture content was observed to reduce from 67.9, 74.6, 68.5 and 65.8% to 57.5, 66.9, 67.6 and 62.6% in trial 1, 2, 3 and 4, respectively. Hence higher reduction of moisture content (10.3%) was observed in trial 2 when compared to all other trials due to appropriate amount of LS addition.
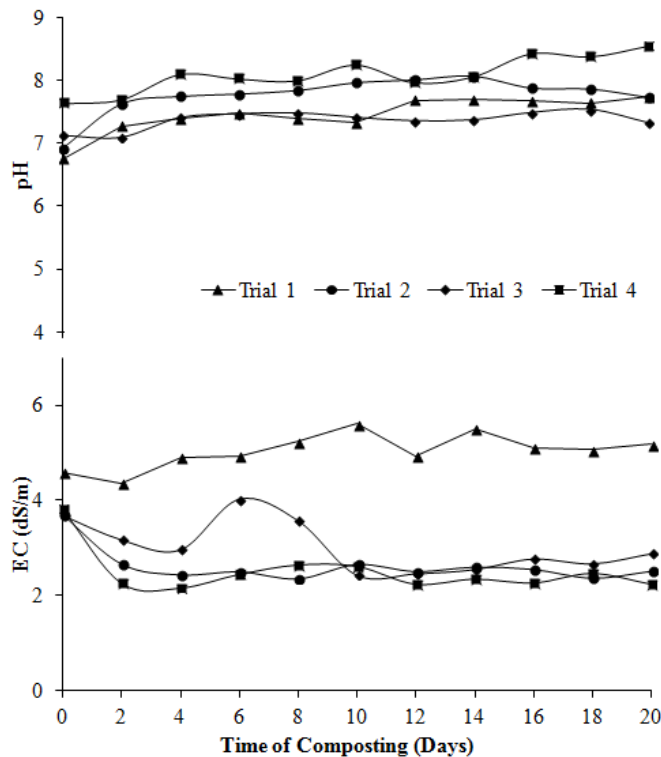

Fig. 2. Changes in (a) pH and (b) EC during composting

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Fig. 3b shows the reduction in volatile solids (VS) in all the four trials. The VS was observed to be in the range of 73.77, 57.9, 52.2 and 51.2% initially and finally reduced to 65.34, 45.1, 44.4 and 38.1% in trial 1, 2, 3 and 4 respectively at the end of 20 days. The VS reduction was in the range of 11.4, 22.3, 24.9 and 25.6% in trial 1, 2, 3 and 4. Even though VS reduction was observed high in trial 3 and 4 as compared to other two trials, the quality of compost with respect to pH, nitrogen and stability were not appreciable. The reason might be due to higher addition of LS, alkaline hydrolysis of organic matter might have occurred instead of proper degradation, thereby leading to higher VS reduction, with alkaline pH and loss of organic nitrogen at the end of composting period. Therefore, trial 2 can be considered the best trial with 1% addition of LS for higher degradation of vegetable waste mixture. A maximum of 22.1% of VS reduction was observed in trial 2 as compared to trial 1, where only 11.4% reduction was observed.

Total organic carbon (TOC) is useful for estimating the age and physical properties of the compost. CO_2 is emitted from the composting mass as a metabolic end product during composting process. Thus, the organic carbon content decreases as the decomposition proceeds (Kalamdhad *et al.*, 2009). Similar reports were observed in the present study with decrease in TOC as the composting progressed. Fig. 3c explains the significant reduction in TOC in all the four trials. Initially the amount of TOC was in the range of 40.9, 32.1, 31.1

and 31.3% and finally reduced to 36.3, 25, 24.6 and 21.1% in trial 1, 2, 3 and 4, respectively. Even though higher temperatures were not observed in trial 3 and 4, considerable amount of TOC reduction was observed in comparison to trial 2, and this might be due to the addition of excess LS in trial 3 and 4. However, trial 2 was observed to follow proper degradation pattern in comparison to all other parameters. C/N ratio below 20 is indicative of proper compost, with a ratio of 15 or less being preferred (Van Heerden *et al.*, 2002). Fig. 3d shows the changes in C/N ratios during the composting period. In the present study, C/N ratio was reduced from 24, 22, 14 and18 to 16, 12, 19 and 14 in trial 1, 2, 3 and 4 respectively. However, combination of waste materials and addition of LS played a major role in proper degradation with regard to C/N ratio. Out of all the trials, trial 2 was observed with higher C/N ratio reduction, resulting in C/N 12 at the end of 20 days composting period. C/N ratio between 10 and 15 in the compost indicates a good degree of maturity (Singh *et al.*, 2009). The present study results were also observed with similar lower values of C/N ratio in trial 2 when compared to other three trials.

During the composting process, organic nitrogen is considered to increase due to net loss of dry matter as CO_2 evolution and water loss by evaporation with the heat generated during oxidation of organic matter (Kalamdhad *et al.*, 2009). In the present study, similar results were observed for organic nitrogen in the trial 1 and 2. However, in trial 3 and 4, gradual decrease in
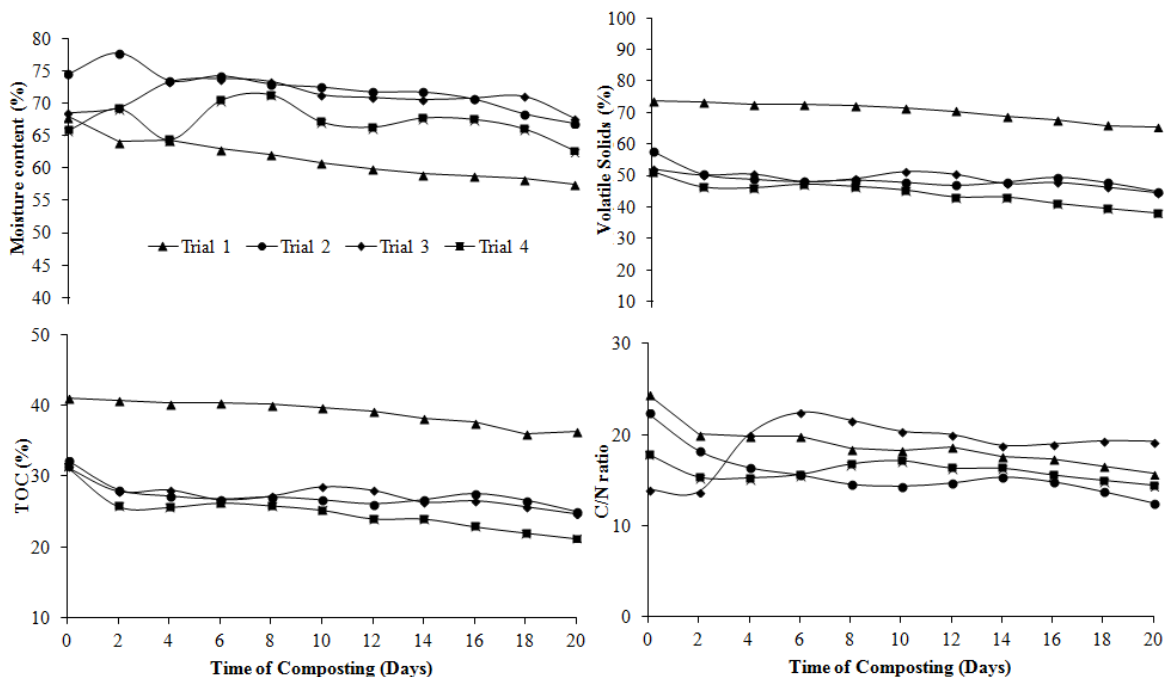

Fig. 3. Changes in (a) Moisture, (b) volatile solids, (c) total organic carbon and (d) C/N ratio during composting

organic nitrogen was observed. The reason in reduction of organic nitrogen might be due to the excess amount of LS addition that has increased the pH to alkaline conditions and favored the escape of ammonia gas. The decrease in organic nitrogen of trial 3 and 4 were in accordance with the increased amount of ammoniacal nitrogen during the composting period. Initially, organic nitrogen was observed to be in the range of 1.68, 1.44, 2.24 and 1.75% and finally was in the range of 2.31, 2.01, 1.28 and 1.47% in trial 1, 2, 3 and 4, respectively (Fig. 4a). Except in trial 1 and 2, the other two trials were observed to lose organic nitrogen at the end of composting period which might be due to alkaline conditions by the excess amount of LS addition. However, 39.5% increase of organic nitrogen was observed in trial 2, whereas in trial 3 and 4 reduction of 42.8 and 16% was observed. Correspondingly there was a gradual decrease of NH_4-N in trial 2 and increase in trial 3 and 4 was observed. During the initial stage of composting NH_4-N was in the range of 0.13, 0.26, 0.24 and 0.16% and finally was observed in the range of 0.09, 0.21, 0.33 and 0.25% in trial 1, 2, 3 and 4 respectively at the end of 20 days (Fig. 4b). The concentration of total nitrogen usually increases during composting when organic matter loss is greater and the present study results were in agreement with the data of Inbar *et al.* (1993) for trial 1 and 2. However in trial 3 and 4, there was a higher release of NH_4-N with gradual decrease in organic nitrogen. A maximum of 18% reduction of NH_4-N was observed in trial 2. However, in trial 3 and 4, 40 and 60% increase of NH_4-N was

observed at the end of 20 days of composting period.

Addition of LS had no effect on the available and total phosphorous (AP and TP) as the composting progressed. The release of phosphorous during composting process was considered due to the mineralization of organic matter (Kalamdhad *et al.*, 2009). Higher amount of phosphorous was observed in the initial days of composting which might be due to higher amount of vegetable waste and cow dung. Hence, AP was observed in the range of 1.41, 1.49, 1.71 and 1.54%; and TP in the range of 1.49, 2.96, 2.75 and 3.06% in trial 1, 2, 3 and 4 respectively (Fig. 4c and 4d). As the composting proceeded there was a gradual increase of both of AP and TP in all the four trials and was observed in the range of 1.49, 2.11, 2.34 and 2.16% in AP; and 4.3, 3.57, 2.94 and 3.78% in TP of trial 1, 2, 3 and 4, respectively at the end of 20 days. Overall there were 5.9, 41, 37 and 40% increase in AP and 26, 20, 7 and 23% increase of TP in trial 1, 2, 3 and 4, respectively at the end of 20 days. Table. 2. Illustrates the total concentration of micro nutrients (Na. K, Ca, Mg) and heavy metals (Cr, Cd, Ni, Pb, Fe, Mn, Zn and Cu) in trial 1, 2, 3 and 4 respectively. These nutrients and heavy metals are observed to increase during the composting with loss of organic matter (Fang and Wong, 1999).

The microbial activity in the compost can be directly measured in terms of CO_2 evolution rate and the OUR. OUR and CO_2 evolution rate can be measured for stability of compost as unstable compost has high demand of oxygen and with high evolution of CO_2,
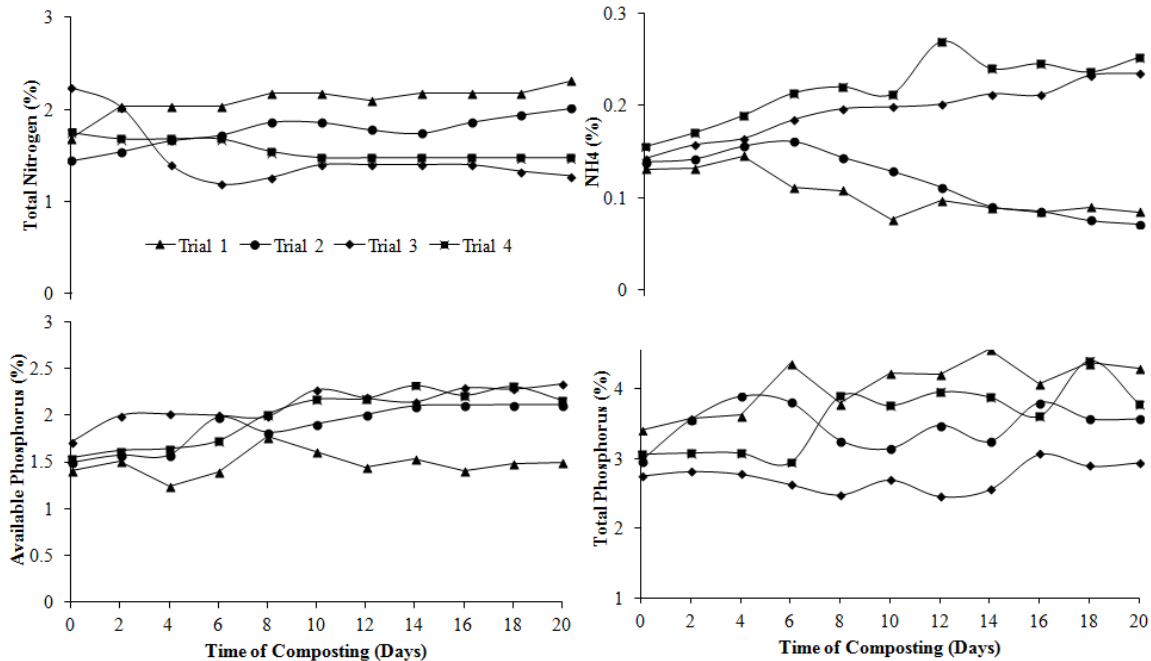

Fig. 4. Changes in (a) Nitrogen and (b) phosphorous dynamics during composting

thereby representing the instability of the compost (Bernal *et al.*, 1997; Varma and Kalamdhad, 2014a). Compost stability is an important aspect of compost quality as it determines the compost nuisance potential, nitrogen immobilization and phytotoxicity (Lasaridi and Stentiford, 1998). Hence with different combinations of waste material and LS addition different degradation pattern was observed. The CO_2 evolution rates decreased from 14.97, 6.94, 5.64 and 7.24 mg/g VS/d to 2.28, 0.89, 2.30 and 3.11 mg/g VS/d in trial 1, 2, 3 and 4, respectively, at the end of 20 days (Fig. 5a). Irrespective of the trials, the degradation pattern progressed in different pattern which was clearly observed from the evolution rates. With higher biodegradable matter in vegetable waste and propagation of microorganisms, OUR will be observed high during the composting process (Iannotti *et al.*, 1993). The rates of oxygen demand will be reduced with lower food available to the microorganisms as the compost proceeds. Similar findings were observed in the present study with initial values ranging in the order of 21.26, 10.05, 12.04 and 11.24 mg/g VS/d denoted higher microbial activity and finally reduced to 4.49, 3.21, 3.98 and 4.21 mg/g VS/d in trial 1, 2, 3 and 4 respectively (Fig. 5b). The lower values of OUR at the end of 20 days clearly states that the vegetable waste has been degraded by the microorganisms and converted to a stabilized compost (Varma and Kalamdhad, 2014a).

The organic fractions in the compost mix can be directly measured as soluble BOD and COD. The percentage of the readily bio available organics has been considered important for the compost quality (Bernal *et al.*, 1997). The organic fraction degradation can be measured by the decrease in soluble BOD and COD. The degradation of the organic fractions is majorly played by microorganisms during the composting process (Kalamdhad *et al.*, 2008). The composting process is considered to proceed till the amount of these biodegradable organic matter is stabilized (Wang *et al.*, 2004). Soluble BOD values decreased from 17.3, 12.6, 13.6 and 13.3 g/kg of wet waste to 4.9, 6.6, 7.5 and 6.4 g/kg in trial 1, 2, 3 and 4 respectively, at the end of 20 days of composting period (Fig. 5c). Correspondingly, soluble COD values decreased from 44.4, 47.4, 47.4 and 45.6 g/kg of wet waste to 23.2, 16.5, 16.6 and 14.4 g/kg of wet waste in trial 1, 2, 3 and 4 respectively (Fig. 5d). Therefore, with proper mixing and agitation higher degradation was carried out during the process by which the soluble BOD and COD were decreased drastically, resulting in decreased emission of carbon dioxide, ultimately indicating the stabilization of compost.

Higher temperature and addition of LS during composting had major effect on the survival of indicator organisms (Wong and Selvam, 2009). The average number of total coliform (TC) was initially observed in the range of 0.93×10^{11}, 0.53×10^{12}, 0.14×10^{11} and 0.12×10^{11} MPN/g of wet weight in trial 1, 2, 3 and 4 and finally reduced to 0.21×10^3, 0.15×10^2, 0.092×10^2 and 0.11×10^2 MPN/g at the end of 20 days. However, faecal coliform (FC) was in the order of 0.14×10^7, 2.4×10^6, 0.75×10^6 and 1.2×10^5 MPN/g in trial 1, 2, 3 and 4 and
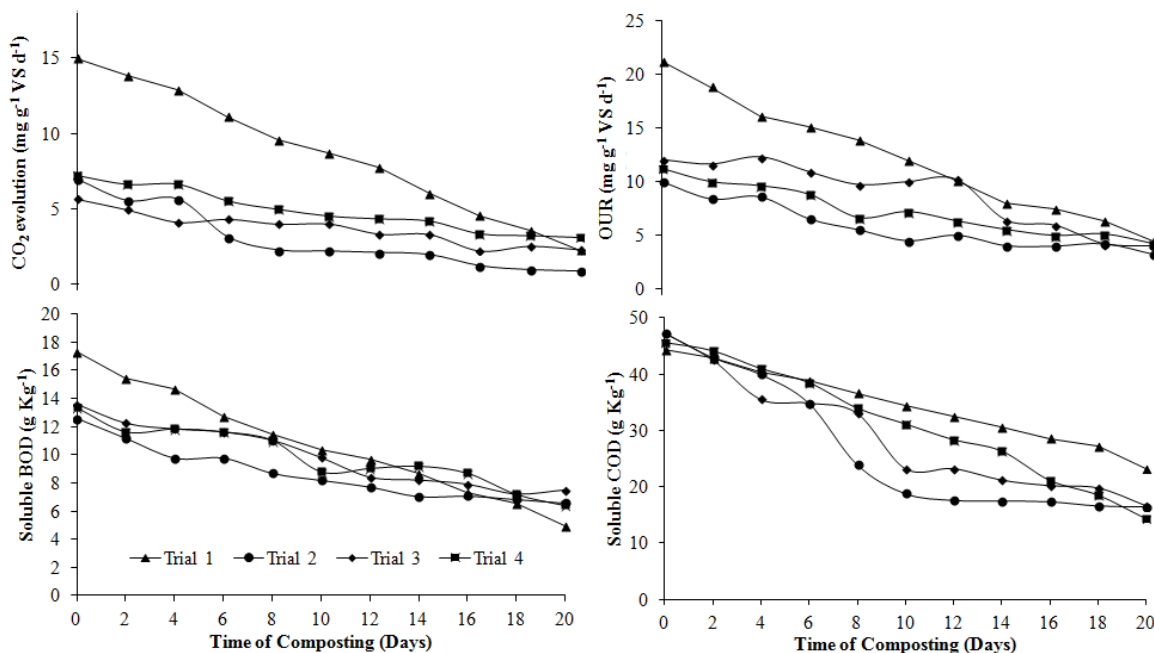

Fig. 5. Changes in (a) CO_2 evolution, (b) OUR, (c) soluble BOD and (d) COD variation during composting

Table 3. Concentration of micronutrients and heavy metals (dry weight) during composting

Day	Sodium (g/kg)				Potassium (g/kg)			
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3	Trial 4
0	1.25 ± 0.14	0.834 ± 0.014	0.772 ± 0.061	0.807 ± 0.038	14.08 ± 0.40	5.527 ± 0.045	5.055 ± 0.049	4.922 ± 0.053
20	1.36 ± 0.04	1.447 ± 0.031	1.455 ± 0.056	1.297 ± 0.088	25.67 ± 0.67	5.210 ± 0.028	8.227 ± 0.314	7.681 ± 0.141
Day	Calcium (g/kg)				Magnesium (g/kg)			
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3	Trial 4
0	8.27 ± 0.80	7.912 ± 0.053	13.910 ± 0.268	24.945 ± 0.219	5.40 ± 0.33	5.10 ± 0.21	6.42 ± 0.25	6.66 ± 0.33
20	10.36 ± 0.94	8.671 ± 0.134	15.482 ± 0.579	32.245 ± 0.572	7.41 ± 0.32	6.99 ± 0.33	7.85 ± 0.11	8.12 ± 0.45
Day	Chromium (g/kg)				Copper (g/kg)			
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3	Trial 4
0	0.054 ± 0.004	0.062± 0.001	0.074 ± 0.002	0.084 ± 0.002	71.00 ± 0.71	0.077 ± 0.002	0.085 ± 0.001	0.142 ± 0.004
20	0.039 ± 0.003	0.071± 0.002	0.096 ± 0.003	0.091 ± 0.001	68.50 ± 0.71	0.089 ± 0.002	0.095 ± 0.001	0.328 ± 0.010
Day	Nickel (g/kg)				Lead (g/kg)			
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3	Trial 4
0	0.184 ± 0.010	0.265 ± 0.005	0.310 ± 0.004	0.298 ± 0.004	0.99 ± 0.06	0.839 ± 0.002	0.917 ± 0.004	0.871 ± 0.004
20	0.191 ± 0.002	0.303 ± 0.003	0.277 ± 0.003	0.306 ± 0.002	0.96 ± 0.05	0.902 ± 0.003	0.844 ± 0.003	0.886 ± 0.010
Day	Iron (g/kg)				Manganese (g/kg)			
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3	Trial 4
0	11.80 ± 0.62	5.511 ± 0.101	5.617 ± 0.031	5.671 ± 0.637	0.562 ± 0.005	0.443 ± 0.003	0.424 ± 0.004	0.404 ± 0.001
20	12.40 ± 0.05	5.682 ± 0.095	7.096 ± 0.033	5.642 ± 0.282	0.588 ± 0.004	0.419 ± 0.001	0.419 ± 0.001	0.493 ± 0.003
Day	Zinc (g/kg)				Cadmium (g/kg)			
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3	Trial 4
0	0.235 ± 0.001	0.248 ± 0.010	0.193 ± 0.003	0.212 ± 0.005	0.15 ± 0.03	0.052 ± 0.001	0.058 ± 0.001	0.052 ± 0.001
20	0.295 ± 0.001	0.279 ± 0.002	0.168 ± 0.007	0.210 ± 0.014	0.05 ± 0.00	0.059 ± 0.001	0.047 ± 0.001	0.053 ± 0.002

reduced to 0.15×10^2, 0.93×10^1, 0.43×10^1 and 0.06×10^2 MPN/g at the end of 20 days. Therefore it can be concluded that higher temperature in trial 1 and addition of LS in trial 2, 3 and 4 had major effect on the reduction of the pathogens.

CONCLUSIONS

With different proportions of waste lime sludge addition, trial 2 was observed with higher degradation in volatile solids and high nutrient value at the end of composting period. Longer thermophilic phase was observed in trial 2 due to increased metabolic activity of microbes by appropriate addition of LS. However, higher addition of LS to compost materials led to volatilization of organic nitrogen as ammonia and raising the pH towards alkaline condition, thereby deteriorating the quality of final compost. However, phosphorous was not affected by the addition of LS, as it had adverse effects on nitrogen and degradation pattern. Therefore, it can be concluded that addition of 1% LS for composting of vegetable waste mixture can be suggested for higher organic matter reduction within shorter time period using rotary drum composter.

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