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Original Article

Effect of forced aeration on lab scale composting of fruits and vegetable waste

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Abstract

In developing countries solid waste management is one of the biggest environmental challenges. The situation is worst in Pakistan, as the public concern and Governmental efforts are far beyond declaring the urban environment hygienic. Tons of solid waste comprising mainly of kitchen and restaurant left over are produced daily in the city Lahore. Their utility in raising fruitful composting will lessen the solid waste disposal problem. In the present study peels of apple (A), banana (B), oranges (C) and potatoes (D) were composted in glass jars under aerobic condition. Filtered aeration was provided with the help of electric air pumps. Four jars including one control (containing autoclaved substrate) for each of substrate were kept at room temperature for 21 days. Samples were taken at zero and every seventh day for analysis of pH, EC, ash, moisture and seed germination. pH and ash content of all the four compost samples increased while an increase in EC of the samples B and D and decrease in samples A and C were observed. A significant increase in seed germination indices for the samples B and D was observed. The aeration and incubation temperature appear promising in terms of enhancing seed germination index and reducing the wastes into a value added phytotoxin free compost, fertilizer. Such efforts are likely to yield useful organic fertilizers while solving the urban solid waste problems.

Key words: Aerated composting; Organic fertilizers; Food wastes.

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INTRODUCTION

Continuous accumulation of solid wastes, a consequent of increasing population and urbanization, has become a potential source of land, water and air pollution. In developing countries thousands of tons of wastes are disposed in low-lying areas, on outs skirts of towns, cities and along the rivers' banks without any treatment. Sharma *et al.* (2011) have described that unscientific disposal of wastes leads to many problems like global warming, scarcity of land, contamination of environment and also provide breeding places for disease vectors. In short organic wastes are one of the greatest causes of environmental pollution and require adequate management to avoid their negative impacts on environment and human health (Lima *et al.,* 2004; Garcia *et al.,* 2005; Hamoda, 2006; Perez, 2006; Vargas-Garcia *et al.,* 2006). At present, most of biodegradable municipal solid waste (BMSW) is disposed of in landfills. Solid wastes of food and yard, agricultural and paper origin are also clogging landfills (Briski *et al.,* 2003). To cope with the situation treatment methods of composting, anaerobic digestion, incineration, thermolysis and gasification have been developed (Park and Shin, 2001).

During the composting ecological portion of MSW is biologically converted through the activity of diverse microorganisms into a valuable product that can be utilized as soil conditioner (Obeng and wright, 1990; Jeong and Kim, 2000; Boulter *et al.,* 2002; Abu Qadis and Hamoda, 2004; Mirdamadian *et al.,* 2011).Organic rich solid wastes could be used as fertilizers, but their direct incorporation without prior treatment may cause several ailments in plants; therefore it is more fruitful to convert them into compost because most pathogens are inactivated during the heating phase of composting (Bollen *et al.,* 1980; Ylimaki *et al.,* 1983; Hoitink and Fahy, 1986).

In addition to pathogens depressing/ killing consequences of composting, enhanced soil fertility potential of a composted material is major incentive. Being rich source of nutrients

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with high organic matter content incorporation of compost may tone physical and chemical properties of soil including moisture retention, which result into higher crop yields (McCohnell *et al.,* 1993; Wong *et al.,* 1996; Hussain *et al.,* 2001). Pascal *et al.* (2000) have described that composted material enhances soil fertility by increasing enzymatic activity of soil and regulating biological agents. In short, use of composted material benefits both biological and physical mechanisms of the soil and a wide variety of plants cultivated in compost incorporated soils exhibit superior gain. Sanchez-Monedero (2004) has reported that land application of biosolids causes an increase of both size and activity of soil microbial biomass. This in turn stabilizes organic wastes and renders more efficient carbon mineralization.

Huge amounts of domestic and restaurant kitchen solid wastes generated in Lahore remain piled up within the city for a few days to weeks in different locations. This study identifies different phases of controlled forced aeration for composting of apple, banana, oranges and potatoes peels. A compost product prepared in the light of these information is likely to find demanding utilizations as soil conditioner/fertilizer with concomitant solution of urban solid wastes.

MATERIALS AND METHODS

Peels of apples, banana, potatoes and oranges were collected from different fruit shops of student's hostels of the University of the Punjab Lahore. These wastes were then separately chopped in a chopping machine to obtain pieces of 2-3 mm to give better exposure for microbial treatments. Small sized sterile screwed capped glass containers measuring 12 and 06 cm in length and diameter, respectively, were employed for the controlled composting of 120 grams of each substrate in separate jars. The containers were closed with lids fitted with inlet and outlet plastic pipes for aeration and incubated at 37°C for three weeks, with a constant flow of filtered sterilized air. Turning was done on alternate days to maintain porosity of the substrate for effective aeration. Compost was sampled every seventh day and processed for the determination of various physiochemical and biological parameters. Moisture content were measured following by oven drying at 105°C for an over night period (Mohee et al., 2002).The dried samples were ignited at 550°C for 5-6 hrs for measuring ash content (Gupta, 2000) To measure pH & EC, 1 gram of a sample was mixed in 10 ml of distilled water, shaken at 150 rpm for one hr and then centrifuged (10,000 rpm) for 10 minutes and filtered. The parameters were recorded by using calibrated pH and electrical conductivity meters. For seed germination test, one gram of a sample was mixed in ten ml of distilled water and shaken for one hr at 200 rpm. Then 5 ml of each extract was pippeted into sterilized pertiplates lined with Whattman filter paper No.1. Ten gram seeds were evenly distributed on filter paper and incubated at 20-25°C for 48 hrs (Wong *et al.,* 2001). Observations recorded were then used for calculating the germination index (GI) according to the following formula

$$GI = \frac{\text{Seed Germination \% x Root length of treatment \%}}{\text{Seed Germination \% x Root Length of control \%}} \times 100$$

Statistical analysis

The data were analyzed statistically for comparisons between means of different parameters employing SPSS 12 programme for ANOVA

RESULTS AND DISCUSSION

Moisture contents of all the four substrates decreased as the experiment progressed while their pH increased with the progression of composting from day zero through the last observational point. pH of the substrates A (Apple peels) and C (orange peels) were in acidic range (3.3-3.4) where as those of the substrates B (Banana peels) and D (potato peels) were in basic range i.e. 6.5-9.8 (Table I and II). This increase in pH has been considered indicative of active composting (Strom, 1985). Increase in pH is not only a function of microbial activities which in turn is consequence of microbial diversity, but nature of the waste being worked upon by the microbe greatly influence the pH of compost (Baca *et al.,* 1992; Ovisago *et al.,* 2010; Haydar and Masood, 2011). The EC of the substrates B and D increased as the process progressed, while decline in the parameter was noticed for the substrates A and C (Table I).

Electrical Conductivity indicates the level of dissolved salts within a medium. Elevations in EC values have been reported by other authors (Inbar *et al.,* 1993; Kirchman and

Widen, 1994; Wang *et al.,* 2004). According to Neves et al. (2009) high EC value will stress the plants and cause productivity losses by limiting plant growth and seed germination. However, increased EC values of compost may be diluted when applied in soil (Rajbanshi and Inubushi, 1998). Ash contents decreased for substrate A while for the substrates B, C and D the parameter increased (Table II). Increase in percent ash contents in composting is a well known phenomenon (Wang *et al.,* 2001; Chang *et al.,* 2006) and is reflective of mineralization trend of organic matter (Wang *et al.,* 2001).

Table I: pH of the compost samples of different stages.

Substrate	Compost stage (week)			
	0	1	2	3
A	3.36 ± 0.009	3.46 ± 0.04	3.42 ± 0.05	3.43 ±0.1
AC*	3.53 ± 0.03	3.42 ± 0.01	3.34 ± .006	3.530 ± 0.032
B	6.54 ± 0.03	8.84± 0.32	9.21 ± 0.27	9.87 ± 0.182
BC*	5.64 ± 0.07	8.1 ± 0.02	8.85 ± 0.02	9.73 ± 0.06
C	3.24± 0.02	3.49 ± 0.23	3.68 ± 0.14	3.82 ± 0.23
CC*	4.19 ± 0.006	3.78 ± 0.02	3.38 ± 0.11	3.81 ± 0.02
D	6.26 ± 0.08	8.20 ± 0.12	8.53 ± 0.08	9.74 ± 0.39
DC*	7.8 ± 0.006	5.19 ± 0.02	8.48 ± 0.04	8.73 ± 0.05

*Respective autoclaved (Control) substrates, Values represent means of three replicates ± S.E.M.

Table II: Electrical conductivity (ms) of the compost samples of different stages.

Substrate	Compost stage (week)			
	0	1	2	3
A	210.67 ± 0.33	204.00± 2.31	205.33 ± 2.67	205.67 ± 5.79
AC*	188.33 ± 4.49	205.33 ± 2.34	207.00 ± 2.52	195.0 ± 1.53
B	27.00± 1.16	118.33 ± 14.33	131.33 ± 15.7	168.33 ± 10.28
BC*	61.67 ± 4.49	68.67 ± 2.030	105.33 ± 1.77	163.00 ± 4.59
C	216.00 ± 1.00	201.33 ± 13.13	189.67 ± 7.89	183.00± 13.54
CC*	66.67 ± 3.18	177.33 ± 3.48	212.00 ± 3.47	179.00 ± 1.73
D	43.67 ± 3.53	48.40± 20.86	94.67 ± 5.90	178.67 ± 4.34
DC*	56.33 ± 3.18	97.33 ± 4.64	91.33 ± 2.40	119.00 ± 5.14

*Respective autoclaved (Control) substrates Values represent means of three replicates ± S.E.M.

Table III: Percent ash contents of the compost samples of different stages.

Substrate	Compost stage (week)			
	0	1	2	3
A	10.26 ± 2.02	7.37 ±2.83	15.6± 5.538	4.88 ±1.09
AC*	1.9 ±0.07	3.72±0.14	6.94 ± 2.05	4.9 ±0.3
B	12.74± 1.02	12.16 ± 3.58	10.77 ± 2.19	28.3 ±1.1
BC*	5.82 ±0.54	11.73 ± 0.41	16.04 ± 1.38	15.93 ±0.41
C	6.96 ±2.6	5.55 ±1.81	8.56 ± 0.69	8.75 ±0.07
CC*	5.27 ±0.05	4.90±0.72	2.10 ± 0.17	8.46 ±0.12
D	4.95 ±0.86	34.64 ± 2.39	26.01± 4.29	41.52 ±2.1
DC*	4.84±0.38	20.98 ± 0.39	23.81± 1.12	27.73 ±1.51

*Respective autoclaved (Control) substrates Values represent means of three replicates ± S.E.M.

Table IV: Percent ash and moisture contents of the compost samples of different stages.

Substrate	Compost stage (week)			
	0	1	2	3
A	79.0 ±0.58	77.7 ± 1.2	75.3 ± 1.8	43.0 ± 0.6
AC*	79.0± 0.58	76.7 ± 0.7	67.67 ± 0.89	41.3 ± 0.9
B	91.3 ±0.3	85.3 ± 1.9	65.0 ± 1.2	44.3 ± 1.2
BC*	87.0 ±0.6	82.0 ± 1.5	83.7 ± 1.2	43.7 ± 0.9
C	76.3 ±0.7	52.3 ± 2.3	45.7 ± 1.2	37.3 ± 2.9
CC*	80.0 ±0.6	75.3 ± 1.2	47.7 ± 1.8	31.3 ± 1.4
D	80.7 ±0.3	86.7 ± 0.3	82.3 ± 2.3	37.3 ± 3.9
DC*	78.0 ±0.6	85.7±0.9	70.3 ± 1.8	50.7 ± 0.9

*Respective autoclaved (Control) substrates Values represent means of three replicates ± S.E.M.

Table V: Percent germination index of the compost samples of different stages.

Substrate	Composting stages (week)			
	0	1	2	3
A	20.51 ± 2.32	20.18 ± 2.56	6.38 ± 1.94	19.44 ± 4.63
AC*	16.06 ± 1.85	16.06 ± 1.85	18.54 ± 1.29	23.96 ± 3.18
B	30.2 ± 2.15	67.29 ± 5.11	45.2 ± 5.05	56.35 ± 6.46
BC*	30.2 ± 1.04	42.23 ± 2.30	24.45 ± 2.28	30.43± 3.12
C	24.0 ± 2.91	22.33 ± 5.23	9.76 ± 2.95	16.86 ± 1.3
CC*	25.25 ± 2.32	12.45 ± 1.54	11.93 ± 1.2	12.81 ± 1.36
D	28.02 ± 3.4	37.60± 14.29	31.49 ± 6.5	53.43 ± 1.86
DC*	24.55 ± 2.64	16.66 ± 1.45	9.32± 2.50	11.88 ± 1.14

*Respective autoclaved (Control) substrates Values represent means of three replicates ± S.E.M.

Seed germination assay exhibited that of all the substrates, substrate D (potato peels) had highest seed germination GI i.e. 90.68%.Second to the rank was Substrate B having germination index of 86.58%. Low increase in % germination index was observed for A, AC, BC and CC substrates (Table III). Seed germination assay is the most sensitive parameter for determining the compost maturity. According to Zucconi *et al.* (1981) a GI value of greater than 50% indicates a phytotoxin-free compost. Tiquia *et al.* (1996) have reported that GI value greater than 80-85% is indicative of disappearance of phytotoxicity. Conclusively, composting of the waste, fruits and vegetables at 37°C with forced aeration can be accomplished within three weeks. Expense of aeration can be compensated for obtaining composts with higher GI indices than the threshold value defining phytotoxicity. Results obtained from above discussed composting experiment pave for attempting the composting of potato and banana peels with bulking agent like wheat straw at bin level as well to study the monocultured composting employing appropriate bacterial inoculants.

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