Short communication

Microbial consortium for efficient composting of biosolid waste

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Abstract

Evaluation of formulated microbial consortium was carried out for validating the effectiveness of composting biosolid waste along with cow dung and uninoculated treatments. The newly developed microbial consortium was inoculated on biosolid waste in Thumburmuzhi composting units. Observations on volume reduction of biosolid waste and daily variation in temperature were recorded and microbial population in compost was assessed after maturation period. The maximum temperature during composting was recorded in inoculated treatment on the third day of composting and the temperature became stable after 13 days. The volume reduction of biosolid waste in Thumburmuzhi unit was recorded at different time intervals such as 15, 30, 45 and 80 days after inoculation. The results indicated that per cent volume reduction was non-significant among the treatments. However, numerically maximum per cent volume reduction was recorded in inoculated treatment over other treatments. After 80 days of composting, all the compost samples were assessed for microbial population. Significantly higher populations of bacteria and fungi were recorded in inoculated treatment. The results proved that composting of biosolid waste using microbial consortium is more efficient than cow dung and uninoculated method of composting. This investigation highlights the possibility of enhancing degradation of biosolid waste using microbial consortium in aerobic composting.

Key words: Aerobic composting, Biodegradation, Biosolid Waste, Microbial consortium.

Solid waste management mainly based on biological process like composting has gained importance since it involves resourceful and eco-friendly utilization of organic agro-industrial wastes. Composting of biosolid waste allows decomposition of waste materials into more compact form, which can be easily managed (Benson and Othman, 1993). Thumburmuzhi model aerobic composting unit is an eco-friendly technique for effective management of organic wastes. This technology is now being practiced for municipal solid waste recycling in large scale at different parts of Kerala (Girija et al., 2011).

Earlier reports indicated that microorganisms can hasten the process of composting. As microbes play a pivotal role in decomposition of cellulose, hemicelluloses and lignin, they can be manipulated for the effective management of biosolid wastes. Though bacteria, fungi and actinomycetes play unique and important roles during composting, mixed cultures of microbes enhance the rate of lignocellulose degradation due to their synergistic activity through utilization of intermediate degradation products (Kanotra and Mathur, 1994). Temperature and volume reduction are considered to be the important factors in composting process. High temperature builds up within the composting heap as a result of microbial activity in the waste, whereby heat is liberated through respiration of microorganisms (Finstein and Morris, 1975). Bacterial consortium brings down the time period of composting and reduces the foul smell during decomposition (Sarkar et al., 2011). Effect of microbial inoculum on volume reduction of vegetable waste was observed by Indumathi (2017).

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In the present study, a new microbial consortium was developed with potential microorganisms and its efficiency was evaluated on composting of biosolid waste.

Microorganisms were isolated from different compost samples and potential isolates were selected based on degradation efficiency and compatibility with each other. The consortium consisted of *Bacillus subtilis* BaBc-1, *Trichoderma asperellum* (KAU isolate) and *Bacillus* sp. BaOu-1 which are good cellulose degraders. In order to evaluate the degrading ability of the consortial formulation under *in vivo* condition, large scale replicated trial of Thumburmuzhi composting units were used.

The three treatments in the experiment were :T_1: Consortium I (*B. subtilis* BaBc-1 + *T. asperellum*+ *Bacillus* sp. BaOu-1), T_2: Cow dung, and T_3: Uninoculated. Completely randomized design was adopted, with five replications. Thumburmuzhi composting unit is an aerobic composting unit of dimensions 4 ft x 4 ft x 4 ft. Microbial cultures were mass produced in broth cultures (nutrient broth and potato dextrose broth) in two litre conical flasks and incubated at ambient temperature (26±2^0 C). After incubation period the mass produced cultures were mixed to produce the inoculum. The microbial count of the individual components in the inoculum were maintained as 1 x 10^8cfu/ml. Six inch layers each of dry leaves and biosolid waste (vegetable and fruit waste) was layered and 250 ml inoculum (50 ml inoculum diluted in 200 ml of water) was sprayed over the layer of dry leaves in the treatment unit. Totally 15 Thumburmuzhi composting units were used, five each for inoculated, cow dung added and uninoculated treatments. A total of 700 kg of biosolid waste was added in each unit, and in cow dung added treatment, 100 kg of cow dung was applied instead of the microbial consortium. Observations were recorded at regular intervals on temperature and volume reduction (daily up to 30 days and then once every week). The temperature was recorded daily using digital thermometer and the maximum temperature in each treatment was noted. The change in volume from initial volume was calculated as volume reduction. The final volume reduction was determined in per cent with respect to the initial volume. After 80 days of inoculation, compost maturity was determined based on temperature, colour, foul odour and C:N ratio (recommended limit of FCO standard <20:1). Microbial population of compost was analyzed after the maturation of compost.

Effect of microbial consortia on physical parameters of composting

Composting temperature

The temperature during composting was recorded daily for 30 days and then once in a week. The data on daily variation in composting temperature in different treatments for 30 days are presented in Fig. 1. Irrespective of the treatments, temperature gradually increased to a maximum and later declined to a stable range. Initial temperature was maximum in T_1 (45.98^{0}C). The highest maximum temperature (64^{0}C) was recorded in T_1, on third day after inoculation and the temperature was stabllized after 13 days. The highest final temperature was recorded in uninoculated control and lowest final temperature was in T_1 (*B. Subtilis* BaBc-1+ *T. asperellum*+ *Bacillus* sp. BaOu-1).

During composting of biosolid waste, maximum temperature was observed in T_1 (64^{0}C) on 3rd day. This might be due to the increased microbial activity during composting. After 14 days, temperature in all the treatments declined gradually. According to Taiwo and Oso (2004), highest temperature during first week of composting was 70^{0}C. Similar trend was also reported by Goyal et al. (2005), Gazi et al. (2007) and Himanen and Hanninen (2011). Game et al. (2017) reported that maximum temperature (60.2 to 63.4^{0}C) was attained in the compost pits within seven days and thereafter it decreased gradually.

Volume reduction of biosolid waste

Volume reduction of biosolid waste during composting was recorded at different time intervals viz., 15, 30, 45 and 80 days after inoculation. Data on per cent volume reduction during different time intervals are presented in Table 1. The results indicated that per cent volume reduction was non-significant among treatments. However, the inoculated treatment T_1 recorded numerically higher per cent volume reduction at 15, 30, 45 and 80 days after inoculation (48.19, 56.90, 64.63 and 73.02 per cent, respectively). The cow dung added treatment showed lowest volume reduction at 30, 45 and 80 days after inoculation.

Volume reduction of biosolid waste recorded at different time intervals (15, 30, 45 and 80 days), was found to be 63 to 76 per cent (80 days after inoculation). Earlier researchers have opined that self-heating activity during aerobic bio-degradation could reduce the volume of waste by 40 to 50 per cent of the actual volume, which resulted in good quality compost (Finstein and Morris, 1975; Pare et al., 1999).

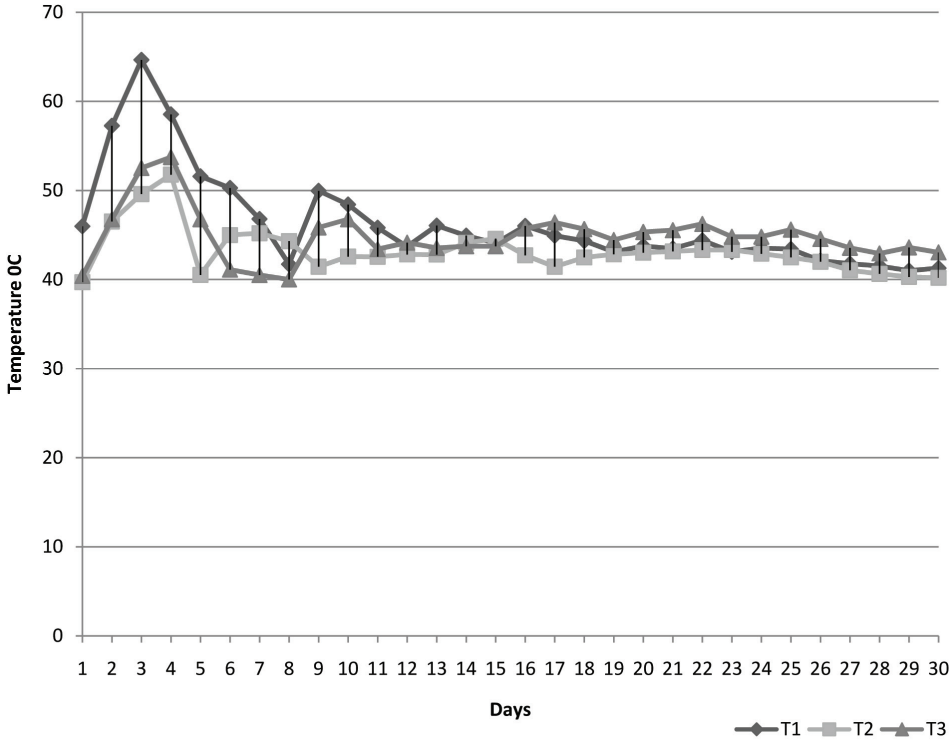
Table 1. Effect of microbial consortia on volume reduction of biosolid waste

Treatments	Volume reduction (%)			
	15 DAI	30 DAI	45 DAI	80 DAI
T1	48.19	56.90	64.63	73.02
T2	44.9	54.60	59.86	66.11
T3	44.9	56.08	62.50	69.07
CD (0.05)	NS	NS	NS	NS

Effect of microbial consortia on biological parameters of composting

Microbial population in compost

The total population of bacteria, fungi and



T_1: *B. subtilis* BaBc-1 + *T. asperellum* + *Bacillus* sp. BaOu-1 T_2: Cow dung T_3: Uninoculated control

Figure 1. Effect of microbial consortia on composting temperature

Table 2. Effect of microbial consortium on microbial population in compost

Treatments	*Population (cfu/g)	
	Bacteria(x 10^6)	Fungi(x 10^4)
T^1	45.67(1.66)[a]	29(1.47)[a]
T^2	26.00(1.41)[b]	1(0.20)[c]
T^3	7.33(0.85)[c]	11.33(1.05)[b]
CD (0.05)	0.213	0.479

*Mean of three replications
In each column values followed by same letter do not differ significantly according to DMRT
Log transformed values given in parentheses

actinomycetes in compost samples were recorded. Data on microbial population of compost 80 days after inoculation are presented in Table 2. The bacterial count ranged from 7.33 x 10^6 to 45 x 10^6 cfu/g with significantly highest population recorded in T_1 and lowest population was recorded in uninoculated control. The population of fungi was significantly higher in T_1 with a population of 29 x 10^4 cfu/g followed by uninoculated control (11.33 x 10^4 cfu/g) and the lowest fungal population was observed in cow dung added treatment (1 x 10^4 cfu/g). However actinomycetes were absent in all the treatments. This might be due to the dominance of bacteria and fungi, which could have adversely affected the growth of actinomycetes.

Higher microbial population in inoculated treatment is an indicative of the survival and proliferation of microbes in the consortial formulation. The ambient temperature in the inoculated treatment during final stage of composting might have also contributed to the population of mesophilic microorganisms. These findings are in agreement with Game et al. (2017), who observed highest microbial population in the test consortium inoculated treatment during composting of urban waste. The population of bacteria was found to be higher compared to the population of fungi and actinomycetes. Ryckeboer et al. (2003) suggested that generally, bacterial population are higher than fungal population due the difference in growth rate of bacteria and fungi. Dominance of bacteria might be due to their smaller size and more surface area, which allowed quick absorption of soluble substrates.

In the present study, inoculation of microbial consortium on biosolid waste significantly influenced the efficiency of decomposition process by increasing the temperature of composting and rapid reduction of substrate volume. The maximum microbial population of final compost was also highest in the inoculated treatment, which indicated the biological quality of final compost. Thus the above results revealed that the formulated consortium could be used for efficient composting of biosolid waste. As the composting process involved a thermophilic phase with the highest temperature peak reaching 64^0C, the isolates might also possess thermal tolerance that could efficiently be used for imparting abiotic stress tolerance. The degradation capacities, found to be high in these isolates, also indicated that these were only a part of the wide spectrum of activities they could perform.

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