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Efficacy of Newly Developed Microbial Consortium for Composting of Rural and Urban Wastes

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A B S T R A C T

The newly developed cellulolytic microbial consortium was evaluated for its composting efficiency on rural and urban waste in open pit method. During composting highest temperature was recorded in second week in both the rural and urban waste compost pits. The temperature declined gradually thereafter in all the treatments upto 11th week and remained almost stable thereafter. The bacterial and fungal population in composting pits increased gradually and highest population was recorded in initial phase of composting *i.e.* between 60 to 90 days of composting in test consortium and commercial consortium treated pits, while in uninoculated control pits it took 90 to 120 days for reaching to its maximum. Thereafter a gradual decrease in bacterial and fungal population and increase in actinomycetes population was recorded. The population of actinomycetes was found at peak between 120 and 150 days of composting period. Test consortium reduced the composting period of rural waste by 22.68% while that of urban waste by 18.39% over uninoculated control. The treatment with test consortium on both wastes recorded numerically higher mineral content over commercial consortium and uninoculated control. Results indicated that the use of test consortium reduced the overall time required for composting besides producing the nutrient enriched compost product.

Introduction

Composting of organic wastes is a bio-oxidative process involving the mineralisation and partial humification of the organic matter, leading to a stabilised final product, free of phytotoxicity and pathogens and with certain humic properties (Zucconi and de Bertoldi, 1987). It serves as a mean of environmentally acceptable waste disposal on the one hand and produces organic fertilizers on the other. Composting is not only a waste treatment technique but also a recycling method as the end product can be used in agriculture as fertilizer. As a consequence of increasing fertilizer costs, fluctuating product prices and decreasing soil productivity, the farmers are shifting to the use of organic material as nutrient source. But the availability of organic matter is also factor to put organics in use. The utilization of biodegradable organic fraction of urban wastes, cattle waste and crop residues as a source of plant nutrient can solve the farmer’s problem.

The active component mediating the biodegradation and conversion processes during composting is the resident microbial community. Therefore, optimization of compost quality is directly linked to the composition and succession of microbial communities in the composting process (Taiwo and Oso, 2004). There is practically no substance existing in nature that is not used by one microorganism or another (Iranzo *et al.*, 2001). It is therefore necessary to identify the microorganisms present in the different processes, as several different species of microbes are usually involved. These microorganisms are also important to maintain nutrient flows from one system to another and to minimize ecological imbalance (Novinsak *et al.*, 2008).

The decomposition process is carried out by various microorganisms including bacteria, fungi and actinomycetes. Different communities of microorganisms predominate during the various composting phases. Initial decomposition is carried by mesophilic microorganisms, which rapidly biodegrade the soluble and easily degradable compounds. As temperature increases on oxidation of carbon compounds, thermophiles take over. Temperature in a compost pile typically follows a pattern of rapid increase to 49°C to 60°C within 24 to 72 hours of pile formation and is maintained for several weeks. This is the active phase of composting, in which easily degradable compounds and oxygen are consumed, pathogens viz., *Escherichia coli, Staphylococcus aureus, Bacillus subtilis, Clostridium botulinum* and weed seeds are killed, and phytotoxins are eliminated. As the active composting phase subsides, temperature gradually declines to around 38°C and mesophilic microorganisms once again take over the other types of microorganisms and the curing phase begins (Fourti *et al.*, 2008). Although, the microbial community naturally present in the wastes usually carries out the process satisfactorily, the inoculation of wastes with microorganisms that each of them produces one of the several polymer degrading extra-cellular enzymes at high level is a strategy that could potentially enhance the way the process takes place or the properties of the final product.

In the present study, microorganisms isolated from naturally decomposing wastes were evaluated in-vitro for cellulolytic activity. The consortium of efficient cellulolytic microorganisms was developed and experiment was conducted to see its efficacy on decomposition of organic wastes.

Materials and Methods

Initially cellulolytic microorganisms were isolated from naturally decomposing organic matter collected from different locations. These isolates were studied for cellulolytic activity and compatibility with each other. The highest cellulase producing microorganisms viz., bacterial isolate B-28 (*Bacillus* sp), fungal isolate F-13 (*Aspergillus terreus*) and actinomycetes isolate A-40 (*Streptomyces* sp.) were incorporated in the consortium. The developed consortium was tested with rural and urban waste for its decomposing ability. Six pits of 1mt X 1 mt with 1 mt depth were used for the non-replicated experiment. Three pits were used for composting of rural waste and remaining three for urban waste. Rural waste was collected from the nearby villages and urban waste from Rahuri town. The rural waste comprised of Farm waste, animal fodder waste, animal litter along with dung, while urban waste constituted of vegetable waste, roadside waste, kitchen waste, papers etc. Polythene bags, stones, glass etc. material were separated from the waste before pit filling. Remaining waste was filled in the respective pits.

First pit from both the sets was inoculated with the test consortium, second with commercial consortium (MPKV's decomposing culture) @ 1 gm/kg of substrate. The third pit in both the sets served as uninoculated control. The pits were watered frequently so as to maintain 60-65% moisture level. Turnings were given at 15, 30, 60, 90 and 120th day of inoculation. Temperature in the core of pit was measured by hand thermometer weekly at fix time. For initial and final pH, samples were taken in 100 ml beaker and diluted 1:10 (1 part sample in 10 parts of distilled water) and placed on shaker for 1 hr. The samples were centrifuged at 4000 rpm for 30 min. and filtered through Whatman No.1 filter paper. pH of the suspension was measured potentiometrically using a combined glass electrode. Organic carbon content of substrates was determined by ignition method (Bremner, 1970). Total nitrogen content of the substrates was determined by modified Kjeldhals method (Piper, 1966). Total phosphorus content was estimated by following the procedure given by Jackson (1973). Total potassium content in an aliquot of tri acid mixture with suitable dilution was estimated using flame photometer (Jackson, 1973). Maturity of compost was recorded on the basis of pre-established maturity and stability parameters of compost (Ranalli *et al.,* 2001; Goyal *et al.,* 2005 and Raj and Antil, 2011).

Results and Discussion

Changes in temperature during composting

Changes in temperature at various stages of decomposition in different treatments are shown in table 1. The temperature in all the compost pits reached maximum (60.2 to 63.4ºC) within a week. In both rural and urban waste pits the highest temperature was recorded on inoculation with test consortium which denotes highest microbial activity, followed by MPKV consortium and uninoculated control. The temperature declined gradually thereafter in all the treatments upto 11th week and remained almost stable thereafter upto 20th week of composting.

Taiwo and Oso (2004) reported that in composting experiment a peak of about 70ºC was attained in the first week of composting. Goyal *et al.,* (2005), Gazi *et al.,* (2007) and Himanen and Hanninen (2011) recorded similar trend of initial increase in temperature and gradual decrease during later stages in composting experiment.

Microbial population during composting

The changes in microbial population were recorded periodically and are presented in table 2. Bacterial population in the compost pits treated with test consortium was maximum at 60 days of composting, while in commercial consortium treated pits and uninoculated control it took 90 days to reach at maximum. Thereafter the bacterial population gradually decreased in all the pits. The fungal population increased with time and reached maximum at 90 days of composting in both the consortium treated pits, while it took 120 days to reach maximum in the untreated pits. While the population of actinomycetes attained its highest in composting pits at 120 to 150 days of composting. Among the microorganisms, bacteria were active in the initial stages of composting, while with gradual decrease in temperature the fungi take over the process. Actinomycetes were active in the later stages of composting and were generally involved in the compost stability. Similar trends on microbial population during different stages of composting process have been reported by Hassen *et al.,* (2001), Haritha Devi *et al.,* (2009), Goyal *et al.,* (2005) and Gazi *et al.,* 2007.

Days required for compost maturity

In the present experiment, decomposition of rural waste treated with test consortium completed in least time i.e. 92 days, which reduced the composting time over control by 22.68% and over commercial consortium by 10.67%.

Table.1 Changes in temperature during composting of rural and urban waste

Sr. No.	Subst-rate	Consortia	Weekly Average temperature (°C)																			
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1	Rural waste	Test consortium	47.1	63.4	57.2	50.6	46.5	44.1	40.5	38.4	37.8	31.5	30.6	31.1	29.8	30.0	30.5	30.1	29.2	28.5	29.0	28.4
		Commercial Consortium	46.3	61.5	58.2	52.1	47.6	45.2	42.9	39.5	36.5	31.0	30.5	30.2	30.0	29.7	30.9	30.3	29.5	28.1	29.1	28.5
		Un-inoculated Control	42.9	60.2	59.5	53.0	48.2	45.6	42.1	39.0	36.8	31.2	30.7	31.2	30.1	29.8	29.9	30.4	29.6	28.4	29.2	28.4
2	Urban waste	Test consortium	49.0	62.5	58.7	51.6	42.5	40.8	40.2	39.1	36.6	30.8	31.4	29.7	30.4	29.2	30.0	29.8	29.5	28.4	29.2	28.3
		Commercial Consortium	47.8	61.4	58.9	52.4	42.6	41.2	41.0	39.4	36.5	30.9	30.7	30.1	30.4	29.4	30.2	29.7	29.4	28.2	29.3	28.5
		Un-inoculated Control	45.7	60.7	59.1	52.7	42.5	40.9	40.5	39.3	36.7	31.0	30.7	30.2	30.3	29.5	30.3	29.7	29.5	28.5	29.4	28.4

Initial C:N ratio: Rural waste- 59.43, urban waste- 36.67 Initial pH: Rural waste- 6.70, urban waste- 6.23

Table.2 Population of microorganisms during composting of rural and urban waste

Sr. No.	Substrate	Test Consortium							MPKV Consortium							Uninoculated Control						
		Initial	30 days	60 days	90 days	120 days	150 days	180 days	Initial	30 days	60 days	90 days	120 days	150 days	180 days	Initial	30 days	60 days	90 days	120 days	150 days	180 days
A) Bacteria (x10^7 cfu/g of dry matter)																						
1	Rural waste	9.6	27.3	54.0	47.3	33.0	28.0	27.3	4.3	16.3	44.6	43.6	36.0	29.0	28.0	2.3	15.6	43.0	46.6	32.3	28.3	25.0
2	Urban waste	11.3	36.0	66.3	51.6	39.6	31.3	29.0	10.0	23.6	53.0	56.3	42.3	33.3	27.6	6.0	20.0	50.3	53.6	36.0	29.0	26.3
B) Fungi (x10^4 cfu/g of dry matter)																						
1	Rural waste	26.3	31.3	43.3	51.3	49.3	36.0	31.0	27.6	33.3	40.0	53.0	52.3	40.2	33.4	16.0	20.3	36.3	48.6	51.3	44.0	32.3
2	Urban waste	23.0	29.3	44.6	53.3	51.3	39.6	33.0	25.3	28.6	37.3	52.3	50.0	39.6	36.6	14.3	19.0	33.3	49.0	58.0	43.6	33.6
C) Actinomycetes (x10^5 cfu/g of dry matter)																						
1	Rural waste	17.6	21.3	24.0	36.3	53.3	50.6	46.0	4.3	8.6	16.6	24.3	41.0	48.3	43.3	3.6	14.3	20.6	39.6	49.0	43.3	40.0
2	Urban waste	15.3	20.0	24.3	36.0	64.6	56.3	49.0	3.6	6.0	13.3	26.6	47.0	33.3	46.3	3.3	11.0	23.3	41.6	54.6	50.3	44.3

(Initial population: 24 hrs. after inoculation)

Table.3 Average number of days required for compost maturity, its final C:N ratio, pH and mineral components

Substrate	Consortia	Days for maturity	C:N ratio	pH	Total nitrogen (%)	Total phosphorus (%)	Total potassium (%)
Rural waste	Test Consortium	92	14.47	7.07	0.59	0.46	1.09
	MPKV Consortium	103	15.53	7.11	0.57	0.42	1.07
	Uninoculated control	119	16.67	7.14	0.57	0.44	1.06
Urban waste	Test Consortium	71	13.69	6.94	1.26	0.97	0.67
	MPKV Consortium	79	14.01	6.90	1.13	0.89	0.64
	Uninoculated control	87	14.58	6.86	1.11	0.88	0.63

Same trend was recorded in the urban waste composting. The urban waste inoculated with test consortium decomposed in 71 days. The per cent decrease in time by test consortium treated urban waste over control (Commercial Consortium) was 18.39%, while over uninoculated control was 10.12%.

Thus, it is possible to increase the decomposition rate of organic matter, whatever the characteristics of the waste may be Gaur (1982) reported that due to inoculation of mesophilic fungi, the period of composting was reduced by one month.

Reduction in composting period due to inoculation of cellulolytic microorganisms has also been reported by Raut *et al.,* (2008), Iqbal *et al.,* (2010) and Sarkar *et al.,* (2011).

Changes in pH and C: N ratio

In the experiment, the pH of rural and urban waste shifted towards normal at maturity. Final pH of test consortium treated rural waste was 7.07 while that of urban waste was 6.94. The shift of pH towards normal is the indication of maturity of compost.

Decrease in C: N ratio in all the treatments over control was recorded. The per cent decrease in C: N ratio of rural waste over initial was 75.65, 73.86 and 71.95 per cent while of urban waste was 62.66, 61.79 and 60.24 per in treatments with test consortium, commercial consortium and uninoculated control, respectively.

The present results are in conformity with the results of research workers who revealed from their studies that the organic matter decomposes gradually with time, stabilizes with final pH of compost between 7 to 8 with reduction in C: N ratio (Ranalli *et al.,* 2001, Gade *et al.,* 2010; Raj and Antil, 2011; Himanen and Hanninen, 2011; Sarker *et al.,* 2013).

Mineral components of compost at maturity

In in-vivo composting experiment, minor differences in nutrient status was recorded at maturity within different treatments. In both rural and urban waste, the treatment with test consortium numerically recorded higher nutrient content at maturity over control (commercial consortium) and uninoculated control.

Several research workers estimated the nutrient value of compost prepared on inoculation with microbes over the uninoculated control. Patil (1994), Verma *et al.,* (1999) and Sarker *et al.,* (2013) revealed that the compost prepared on inoculation of microbes showed the better nutrient levels compared to uninoculated control. This is probably because of quick microbial activity leading to decrease in volume of the material. The present results are thus in conformity with the work done by earlier research workers.

Application of newly developed microbial consortium consisting of *Bacillus* sp. (B-28), *A. terreus* (F-13) and *Streptomyces* sp. (A-40) on wastes increased the microbial activity, maintain pH and reduced the period of composting and was superior over the commercial consortium and uninoculated control (Table 3). It is revealed from the results that incorporation of cellulolytic microorganisms enhance the rate of decomposition of organic matter, which will enable to convert the organic matter into valuable compost in short time.

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