Utilisation of Municipal Waste Water in Aerobic Composting of Solid Organic Waste of Bhubaneswar City

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Abstract

Approximately 600 tons of solid organic wastes and a huge bulk of sewage water are generated in Bhubaneswar city, Orissa, India daily endangering the urban environment. Solid wastes in windrows with sewage water inoculum decomposed faster compared to cow dung slurry and plain water treated wastes. C:N and C:P ratios declined relatively faster in sewage water treated windrows than cow dung slurry and water treated windrows during the experimental period of 45 days. The results indicated that the Bhubaneswar Municipal sewage water would be successfully utilised in solid waste composting.

Keywords: municipal solid wastes (MSW), sewage water, aerobic composting, windrows. C:N ratio.

I. Introduction

Enormous increase in the quantum and diversity of waste materials generated in urban areas and their detrimental effects on the environment demand urgent need for adoption of feasible scientific methods for their disposal and utilisation (Williams, 1994). In recent years a number of techniques have been developed to help reduce the quantity of wastes, convert the wastes into organic manures and generate substantial decentralised energy (Chalapathi *et al.*, 2000). Among the most popular means for utilisation

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of organic wastes, aerobic composting has proved to be the most efficient and cost effective (Saha *et al.*, 2000, Hajra *et al.*, 2000). Aerobic composting is the biological decomposition process in which organic matter is decomposed to carbon dioxide and water while stabilised products principally humic substances are synthesised (Brunt *et al.*, 1985).

Literatures are available on survey and study of physico-chemical characteristics of municipal solid wastes and their qualitative improvement (Nanda *et al.*, 2000a; Nanda *et al.*, 2000b and Rao and Radhakrishna, 2001). Bhubaneswar, the capital city of Orissa State, has witnessed a rapid growth in the last decade and presently has a population of approximately 670,000. A huge quantity of solid organic wastes amounting to approximately 600 tons is produced daily which is disposed off in open dumps. Further, a huge volume of sewage water produced in the city is allowed to accumulate in small lakes which are connected to the rivers Daya and Kuakhai. No systematic study has been done on the municipal solid and liquid wastes of Bhubaneswar city and methods of its utilisation.

Hence the present study was conducted to assess the feasibility of utilising the municipal sewage water in the aerobic composting of solid organic wastes of Bhubaneswar city and its effect on percent N, P, K, C. C/N ratio and C/P ratio of the decomposing wastes.

II. Materials and Methods

Municipal solid waste was collected from local urban areas of Bhubaneswar. Sampling points were selected from all the 31 wards of the city. Sampling sites represented all types of localities, such as residential, commercial, slums and markets. The wastes were mixed thoroughly before collection from the sampling sites. Further, the waste samples collected from different wards were mixed thoroughly before the experiment. Percent C, P, N and K in the waste were measured as per Baruah and Barthakur (1997).

The sewage water sample was collected from the main city drain of Bhubaneswar Municipal Corporation which opens into the Vani Vihar Lake. Physical and chemical parameters such as temperature, pH, DO, BOD, COD, NO_3^-, $PO4^{-3}$, chloride, alkalinity, total hardness, turbidity, SO_4^{-2}, Na^+, K^+, TDS, TSS, TPS, TC, Fe and conductivity of the wastewater were measured following Standard Methods (APHA, 1985).

The aerobic composting of the MSW was done by windrow method (Brunt *et al.*, 1985). Three windrows of the size ($20 \times 3 \times 5$ ft) were constructed on a concrete floor. Each windrow contained 3 tons of wastes for experimental purpose. The windrow was designed as follows. There were three layers inside each windrow. In the first windrow the first layer contained 1 ton of garbage which was soaked with 80 litres of municipal sewage water. In the second layer 1 ton of garbage was soaked with 80 litres of municipal sewage water and it was spread above the 1st layer. The top or, third layer of 1 ton garbage was also soaked with 80 litres of sewage water and it was spread above the 2nd layer of garbage.

The second windrow ($20 \times 3 \times 5$ ft) contained 3 tons of garbage, which was soaked with 80 litres of cow dung slurry (2 litre water: 1kg cow dung) in subsequent layers. The third windrow ($20 \times 3 \times 5$ ft) of 3 ton garbage was treated as control which was treated with equal volume of plain water. The moisture level in the windrow was maintained at 50-60% and temperature of the windrow was maintained 44°C-50°C which is the optimal temperature for thermophilic bacteria, which accelerate the composting process. The turning of the organic waste materials was done at regular intervals for forced aeration, since oxygen is required for enhanced activity of the aerobic microbes. The windrows were covered with black polyethylene sheets to accelerate the thermophilic biodegradation. The percent of N, P, K of all the windrows were measured at an interval of 15 days for a period of 45 days. Fifty samples were taken for analysis in both control and experimental windrows. The experiment was conducted during the months of May and June of the year 2002.

III. Results and Discussion

The percent nitrogen, phosphorus, potassium and carbon of solid waste samples have been depicted in Table 1. Table 2 represents the physico-chemical characteristics of the municipal waste water. Figure 1 shows a gradual increase in percent-nitrogen from the day one to 45th day in all the windows. The rate of increase in percent nitrogen was the highest in sewage water treated windrow compared to cow dung treated and negligible increase in control. This corroborates the earlier observations by Horwath *et al.*, 1995 on grass straw decomposition that the percent nitrogen increased steadily from the first to 30th day in aerobic composting. The increase in percent nitrogen may indicate an accumulation of microbial by-products with decline in microbial carbon. The minimum percent of nitrogen was observed in the control.

The percent carbon of the windrows declined in all the windrows from the 1st to 45th day (Fig. 2). The highest decline was observed in the windrow treated with waste water in comparison to cow dung treated and control windrows. The decrease in percent carbon in the windrows might be due to utilisation of carbon by aerobic microbes and subsequent oxidation of carbon to carbon dioxide (CO_2). Similar findings have been reported by, Horwath *et al.*(1995) during aerobic decomposition of grass straw.

The C:N ratio declined from initial 24% to 23.98% in the control windrow in 45 days (Fig. 3). In the

Table 1. Changes in certain composting parameters during decomposition of solid organic wastes of Bhubaneswar city.

Days	N(%)	P(%)	K(%)	C(%)	C:N	C:P
			W_1			
0	0.5±0.3	0.1±0.01	0.4±0.01	12±3.1	24±4.61	120±8.45
15	0.53±0.01	0.2±0.01	0.51±0.11	11.90±2.1	22.45±3.91	59.5±3.36
30	0.56±0.02	0.28±0.03	0.58±0.01	11.65±2.4	20.80±4.12	41.60±2.99
45	0.6±0.02	0.3±0.01	0.9±0.02	11.35±2.7	18.91±3.13	37.8±2.35
			W_2			
0	0.5±0.02	0.1±0.01	0.4±0.01	12±2.1	24±4.51	120±8.4
15	0.52±0.01	0.15±0.01	0.5±0.011	11.97±2.2	23.01±3.5	79.8±3.5
30	0.54±0.02	0.2±0.01	0.51±0.01	11.96±2.2	22.14±4.2	59.8±2.99
45	0.55±0.02	0.28±0.02	0.7±0.021	11.94±2.4	21.70±3.9	42.64±2.34
			W_3			
0	0.5±0.01	0.1±0.01	0.4±0.02	12±2.4	24±4.21	120±8.34
15	0.51±0.02	0.11±0.01	0.4±0.02	12±2.41	23.98±3.9	109±7.89
30	0.51±0.03	0.11±0.01	0.41±0.01	12±2.4	23.98±4.1	109±7.89
45	0.51±0.01	0.11±0.01	0.41±0.01	11.99±2.7	23.98±3.8	109±7.89

W_1 = Windrow with sewage water treatment
W_2 = Windrow with cow dung slurry treatment
W_3 = Windrow with water treatment

windrow with cow dung slurry inoculation the C:N ratio declined from 24% to 21.7%. The highest rate of decline in the C:N ratio was observed in the windrow with municipal sewage water inoculation. The C:N ratio here declined from 24% to 18.91%. This indicates relatively faster decomposition process in the sewage water treated wastes in comparison to cow dung slurry treated and plain water treated wastes. This corroborates earlier reports on decomposition of organic wastes (Reinhart and Trainor, 1995; Horwath *et al.*, 1995).

There was negligible increase in the percent phosphorus (Fig. 4) and potassium (Fig. 5) in the control windrow in 45 days and in the cow dung treated windrow the percent phosphorus increased from 0.1 to 0.28 and percent potassium increased from 0.4 to 0.7. Similarly in the wastewater treated windrow the percent phosphorus increased 0.1 to 0.3 and percent potassium increased from 0.4 to 0.9.

The highest percent phosphorus was recorded in the waste water treated windrow on the 45th day (Fig. 4). Brown *et al.* (1998) have reported during composting of MSW that biological activity of microbes is dependent on availability of phosphorus. An increase in the biological activity has been reported with higher percentage of available phosphorus. The C:P ratio in all the windrows declined during 45 days of composting (Fig. 6). The maximum decline was observed in wastewater treated

Table 2. Certain physico-chemical parameters of the sewage water.

Paramp, °C	35.4±3.1
pH	7.41±2.1
DO, mg/l	4.43±1.1
BOD, mg/l	26.6±2.1
COD, mg/l	76±4.1
NO_3^-, mg/l	0.595±0.02
PO_4^{-3}, mg/l	1.83±0.2
Cl^-, mg/l	74.74±4.1
Alkalinity, mg/l	76±4.1
Total Hardness, mg/l	40±3.2
Ca Hardness, mg/l	32±2.2
Mg Hardness, mg/l	8±0.4
Turbidity, NTU	12.6±1.2
SO_4^{-2}, mg/l	12.85±1.1
Na^+, mg/l	21±3.1
K^+, mg/l	5.33±0.2
TDS, mg/l	266.3±15.9
TSS, mg/l	53.66±3.1
TS, mg/l	317.33±19.4
Coliforms, MPn/100 ml	1,60,000±500
Fecal Coliforms, MPn/100 ml	70,000±200
Conductivity, μmho/cm	507±50.8
Ammonia-Nitrogen, mg/l	17.33±02.2
Fe, mg/l	0.508±0.01

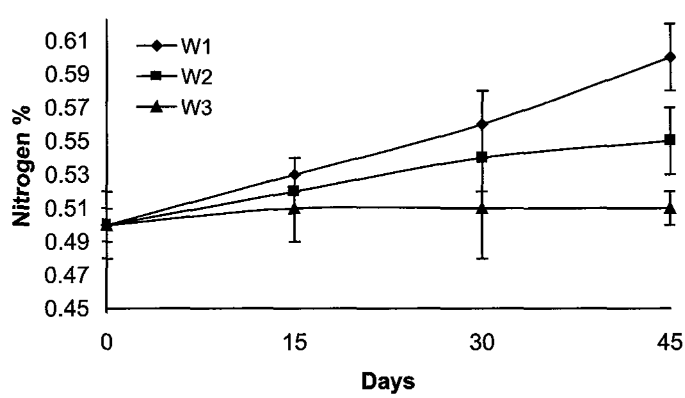

Fig. 1. Increase in percent nitrogen during 45 days of composting.

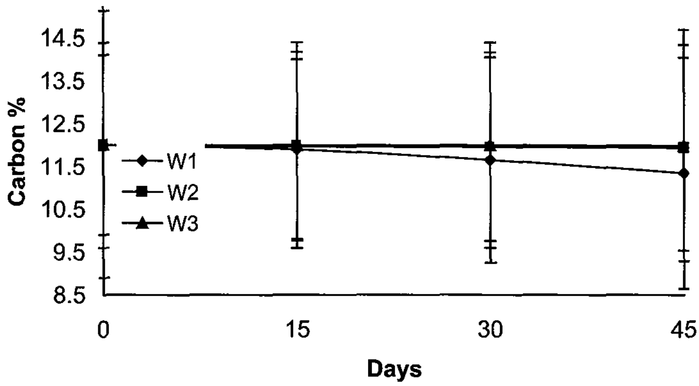

Fig. 2. Decrease in percent carbon during 45 days of composting.

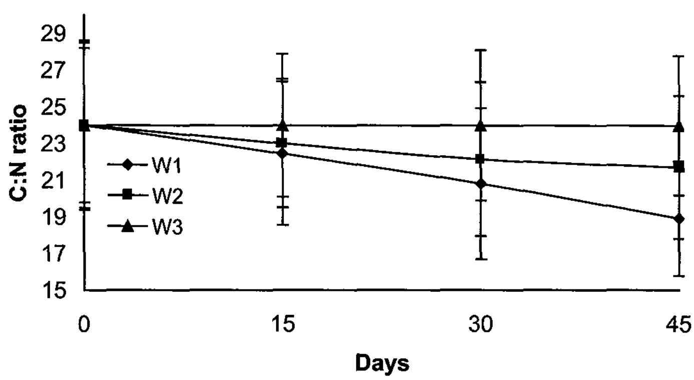

Fig. 3. Decrease in C:N ratio during 45 days of composting.

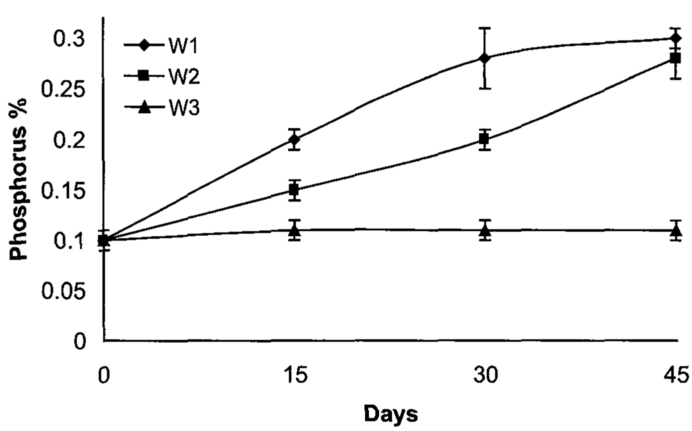

Fig. 4. Increase in percent phosphorus during 45 days of composting.

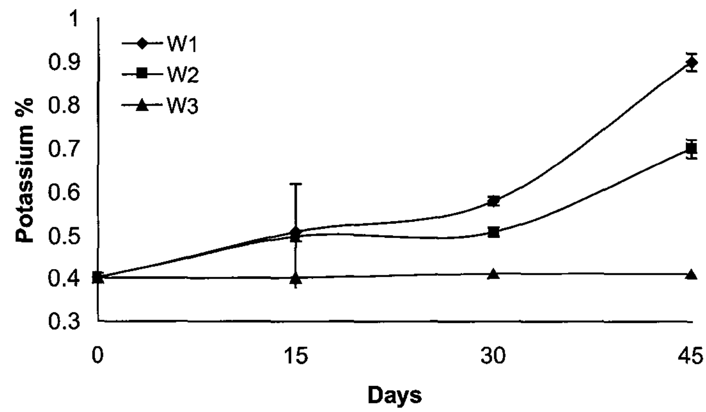

Fig. 5. Increase in percent potassium during 45 days of composting.

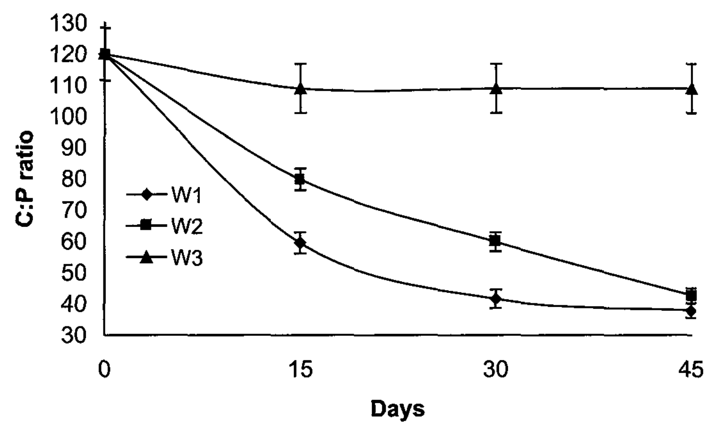

Fig. 6. Decrease in C:P ratio during 45 days of composting.

windrow and minimum in the control. A relatively low C:P ratio has been reported to be congenial for faster decomposition due to enhanced activity of decomposing microbes (Brown *et al.*, 1998). The present finding supports the above observation.

The above findings clearly indicate that Municipality waste water inoculum accelerates the rate of decomposition processes in municipality solid wastes in comparison to cow dung and water. Hence the municipal waste water from Bhubaneswar City can be utilized for large scale composting. This obviously will minimise water pollution problems and help in urban solid waste management.

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