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# New concept in municipality solid waste management - a case study from Garulia and North Barrackpore municipalities, North 24 Parganas, West Bengal

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## ABSTRACT

*A study was conducted during 2010 – 2011 at Garulia municipality in coordination with North Barrackpore Municipality, West Bengal to evaluate a new biodegradation process called 'Novcom composting method' for management of municipality solid waste (MSW). Raw municipality solid waste and final compost samples collected on the 30th day of composting were analyzed for physicochemical properties, microbial status, stability and maturity/ phytotoxicity parameters. During the composting process high temperature generated (> 65°C) within compost heap for more than three consecutive days ensures the absence of any pathogenic microorganisms. As per the analysis report, final compost samples were stable ($CO_2$ evolution rate 2.15 mg$CO_2$ – C/g OM/day), mature and free from any phytotoxic effect (germination index varied within 0.76 – 0.94). Moderately high nutrient content (mean N, P and K status 1.38, 0.79 and 0.67 percent respectively) with moderately low C:N ratio (ranged from 13 : 1 to 16 : 1) and high microbial population in terms of total bacteria, fungi and actinomycetes (in the order of $10^{12}$ to $10^{16}$ c.f.u.) of the final compost sample conclusively proved that good quality compost can be generated from municipality solid waste using this composting method.*

**Key words:** Municipality solid waste, Novcom composting method, phytotoxicity, stability

Sustainable urban waste management has been a critical subject for mankind from the very inception of civilization. India generates about 50 million tons of municipal solid wastes (MSW) every year (CPCB, 2000) and is expected to increase significantly in near future (CPCB, 2004; Sharma and Shah, 2005). Majority (more than 90%) of these wastes are used for unscientific land filling or uncontrolled dumping on outskirts of towns and cities, which have serious environmental implications (Sharholy *et al.*, 2008; Narayana, 2009). Composting MSW is being considered as a low cost method of diverting organic waste materials into a product for agricultural use. However, in India, most of the MSW is dumped and only a fraction (less than 10%) is intermittently processed in mechanical compost plants (Shekdar, 1999). Improper choice of technology is one of the major hindrances towards efficient and effective MSW management in India (Das *et al.*, 2008).

## MATERIALS AND METHODS

The study was conducted in Garulia Municipality in municipality in coordination with North Barrackpore Municipality, North 24 Parganas, West Bengal (India) during the period of 2010 - 2011. The municipality solid waste used as raw material for composting was heterogeneous mixture of different waste materials *viz.* vegetable market waste, household refuse etc. Before using for composting only large size non biodegradable waste *viz.* plastic household refuse, rags, leather, rubber, tin cans, metal foils, stones, bricks, ceramics etc could be separate manually. Raw materials and final compost samples were drawn from 15 composting heaps and analyzed for different physicochemical properties, microbial status as well as stability, maturity and phytotoxicity parameters.

### Novcom® solution (MSW)

Novcom® solution (MSW) is a research product of Inhana Biosciences, (a R&D organization based in Kolkata, India). The solution contains biologically activated and potentized extract of *Bambusa bambos Druc*, *Sida cordifolia* L. and *Ocimum bascilicum*.

Physicochemical properties of compost *viz.* moisture content, pH, electrical conductivity, organic carbon, total ash content, total volatile solids as well as its tability were analyzed according to the procedure of Trautmann and Krasny (1997). Total N, P and K contents in compost were determined by acid digestion method (Jackson, 1973). Estimation of bacteria, fungi and actinomycetes were done using Thornton's media, Martin's media and Jensen's media respectively according to procedure outlined by Black (1965). Wheat (*Triticum aestivum*) as test seed was used for phytotoxicity bioassay test.

## RESULTS AND DISCUSSION

Physical changes were observed and temperature (measured at 1.5 ft depth from the outer surface of the composting heap) record of compost heap was maintained on regular basis, to assess the speed of biodegradation as well as for identification of the compost maturity stage.

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**Physical changes observed during biodegradation process**

The first change observed within 48 hours was the minimization of foul odour that is the inherent characteristic of raw MSW. The observation confirmed the initiation of an effective aerobic composting process within the heap, because once aerobic conditions are established, the bacteria will "eat" the odorous compounds (Cooperband, 2002). During this period the temperature of composting heap was also found to increase and recorded as approximately 65$^0$C. Also there were no flies around the heap, which are common at the MSW dump site and are the primary vectors for different types of diseases in humans.

On the 20$^{th}$ day i.e. during second turning, the colour of the composting material turned darkish brown and an earthy smell was also noted. On the 30$^{th}$ day i.e. after completion of the composting process, the compost samples were visually interpreted as dark brown with earthy smell deemed necessary for mature compost, as also suggested by Epstein (1997). Prolific earth-warm activity was also observed within the composting heap, which confirmed compost maturity and absence of any toxic environment. The presence of macro fauna in the compost heap during final stage of composting, particularly earthworms and grubs, served as an indication of the stage of compost maturity because time is required for these invertebrates to re-colonize the substrate after it cools down (Ndung'u, 2004). The presence of earthworms in compost is once again evidence of good microbial activity as well as absence of any toxic environment.

**Variation in temperature during biodegradation process**

The temperature variation curve (Fig. 1) showed that there was steady rise of temperature within composting heap from day 2, which reached the peak (72.0$^0$ C) on 5$^{th}$ day. The steep rise of temperature indicated initiation of microbial activity (Bertoldi *et al.*, 1983), which might be under the influence of energized Novcom solution. After restructuring of heap on 10$^{th}$ day, again the temperature rose steadily to approximately 60.4$^0$ C but the average temperature rise between 1$^{st}$ turning (10$^{th}$ day) and 2$^{nd}$ turning (20$^{th}$ day) was lower than the initially recorded data. After 2$^{nd}$ turning i.e. on 20$^{th}$ day, steady rise of temperature (approximately 72.0$^0$) was again noted but once again the average temperature variation during this quarter (21$^{st}$ day to 30$^{th}$ day) was lower than the previously recorded (after 1$^{st}$ turning) data.

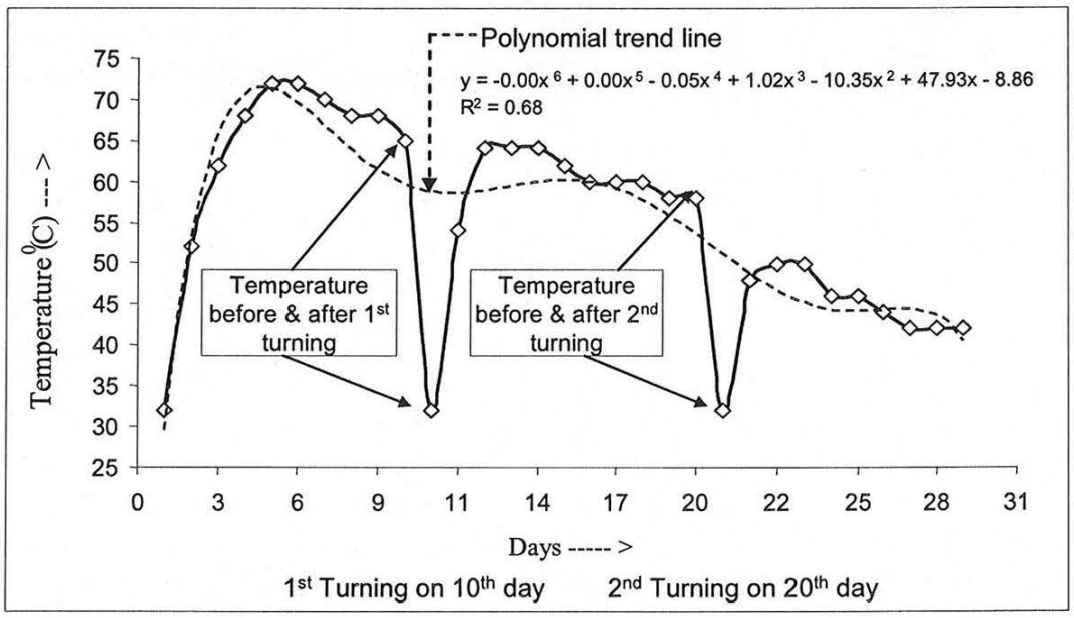


**Fig 1: Temperature variation within MSW Novcom composting heap during the biodegradation process**

After 27$^{th}$ day the temperature within the composting heap was below 45$^0$C and the temperature curve was almost parallel to X axis, which confirmed the completion of composting process or simultaneously compost maturity (Tchobanglous, 1977). Maintenance of a stable temperature of more than 145$^0$F (> 62.8 $^0$C) within the compost heap, for more than three consecutive days has been found to be effective for destruction of most of the human pathogens, insect larvae and weed seeds within the compost heap (Rynk *et al.*, 1992). Hence generation of a temperature of >145 $^0$F (> 62.8 $^0$C) within composting heap for consecutive 3 days even after 1$^{st}$

turning undoubtedly confirmed that all the decomposing waste got sanitized.

**Physicochemical parameters of compost**

Average moisture content varied from 45.26 to 56.42 percent, which was conducive for microbial proliferation (Rahman, 1993). pH value of the compost samples (Table 1) ranged between 7.41 to 8.16 with mean 7.71, which was well within the stipulated range for good quality and mature compost (Jime`nez and Garcia, 1989). Electrical conductivity value of the compost samples ranged between 1.61–2.44 with mean 1.91, indicating its high nutrient status at the same time being safely below (< 4.0) the stipulated range for saline toxicity (Evanylo, 2006) with few exceptions.

The organic matter content of compost is useful in estimating its stability and physical characteristics (Benito *et. al.*, 2003). The decrease in carbon content of wastes during composting indicates higher mineralization of organic matter (Bishop & Godfrey, 1983). Organic carbon content in the final compost samples ranged between 17.84 to 22.04 percent with mean value of 19.62 which was well within the standard reference range (16 to 38 percent) as suggested by Evanylo, (2006).

**Table 1: Analysis of raw materials and Novcom treated municipality solid waste compost samples**

| Parameters | Novcom treated municipality solid waste | | | | | |
|---|---|---|---|---|---|---|
| | Raw Material | | | Final Sample | | |
| | Range value | Mean | Std. Er. (±) | Range value | Mean | Std. Er. (±) |
| **Physico-chemical properties and nutrient status** | | | | | | |
| Moisture (%) | 21.42 – 39.64 | 27.05 | 2.09 | 45.26 – 56.42 | 50.50 | 1.07 |
| pH ($H_2O$) | 6.42 – 6.87 | 6.67 | 0.24 | 7.41 – 8.16 | 7.71 | 0.20 |
| EC ($dSm^{-1}$) | 1.41 – 3.48 | 3.11 | 0.43 | 1.61 – 2.44 | 1.91 | 0.21 |
| Ash Content (%) | 38.37 – 56.84 | 49.38 | 3.14 | 60.33 – 67.89 | 64.68 | 2.04 |
| Volatile Solids (%) | 43.16 – 61.63 | 50.62 | 3.08 | 32.11 – 39.67 | 35.32 | 2.12 |
| Organic carbon (%) | 23.98 – 34.24 | 28.12 | 3.11 | 17.84 – 22.04 | 19.62 | 2.17 |
| Total N (%) | 0.67 – 1.13 | 0.94 | 0.11 | 1.16 – 1.54 | 1.38 | 0.06 |
| Total $P_2O_5$ (%) | 0.10 – 0.47 | 0.31 | 0.06 | 0.48 – 1.06 | 0.79 | 0.03 |
| Total $K_2O$ (%) | 0.37 – 0.52 | 0.41 | 0.05 | 0.63 – 0.76 | 0.67 | 0.04 |
| C:N | 28 : 1 – 36 : 1 | 30 : 1 | 0.57 | 13 : 1 – 16 : 1 | 14 : 1 | 0.53 |
| CMI | 1.12 – 2.37 | 1.76 | 0.13 | 3.08 – 3.38 | 3.30 | 0.12 |
| **Microbial parameters (c.f.u. per gm moist compost)** | | | | | | |
| Total bacterial count | $(29–73) \times 10^5$ | $56 \times 10^6$ | $\pm 7.4 \times 10^6$ | $(19–63) \times 10^{16}$ | $40 \times 10^{16}$ | $\pm 5.1 \times 10^{16}$ |
| Total fungal count | $(14 – 51) \times 10^4$ | $29 \times 10^4$ | $\pm 3.1 \times 10^4$ | $(12 – 37) \times 10^{14}$ | $23 \times 10^{14}$ | $\pm 2.6 \times 10^{14}$ |
| Total actinomycetes count | $(6 – 21) \times 10^3$ | $14 \times 10^3$ | $\pm 1.6 \times 10^3$ | $(11 – 21) \times 10^{12}$ | $5 \times 10^{12}$ | $\pm 1.3 \times 10^{12}$ |
| **Stability parameters** | | | | | | |
| $CO_2$ evolution rate ($mgCO_2$ – C/g OM/day) | 5.84 – 10.62 | 6.44 | ±0.19 | 1.24 – 2.95 | 2.15 | ±0.13 |
| **Phytotoxicity bioassay (*Triticum aestivum* as test seed)** | | | | | | |
| Seedling emergence ( %) | 44.12 – 67.34 | 52.14 | ±4.13 | 84.42 – 94.78 | 91.76 | ±3.20 |
| Root elongation ( %) | 70.14 – 89.54 | 84.12 | ±3.02 | 90.26 – 99.44 | 98.68 | ±2.32 |
| Germination index ( %) | 0.31 – 0.60 | 0.44 | ±0.16 | 0.76 – 0.94 | 0.91 | ±0.08 |

**Nutrient content and microbial status**

Total nitrogen content in the compost samples ranged between 1.54 to 1.16 percent, which was well above the Indian standard (FAI, 2007) of 0.5 percent as well as and average value obtained for MSW (Average 0.63 percent) compost produced in different cities of India (Saha *et al*, 2010). Mean value of total phosphate (0.79 percent) were also higher than the minimum suggested standard of 0.22 percent (FAI, 2007) where as mean potash percent (0.67 percent) is slightly lower than FAI standard ( 0.83 percent) which might be due to low potash content (mean 0.41 percent) in the raw materials. However, the value was once again well above the

average status as recorded in general for MSW compost (Average 0.46 percent) produced in different cities in India (Saha *et al*, 2010).

The microbial population, their biomass and activity, are key parameters that can also be used to elucidate the composting process (Tiquia *et al.* 2002a). In open-air composting processes, colonization of mirobes in compost material occurs naturally during heap construction as well as turning of heap (Wallace *et al.*, 2004). Total count of bacteria, fungi and actinomycetes in per gram moist compost sample increased from $56 \times 10^5$, $19 \times 10^4$ and $14 \times 10^3$ c.f.u. respectively in raw materials to $40 \times 10^{16}$, $23 \times 10^{14}$ and $5 \times 10^{12}$ c.f.u. respectively in final compost. Such high generation of microbial population might have been possible due to the generation of an ideal micro atmosphere within composting heap as influenced by the application of Novcom solution.

**Stability, maturity and phytotoxicity parameters of compost**

Stability, maturity and phytotoxicity rating of compostare the most important criteria for qualifying for filed application / landfill as immature compost may contain high level of free ammonia, organic acids or other water soluble compounds, which can limit seed germination and root development (Thompson *et al*, 2002). Maturity is assessed by measuring various parameters *viz.* seedling emergence, root elongation and phytotoxicity bioassay index (Mathur *et al.*, 1993; Briton, 2000).

In order to evaluate compost stability, respirometric techniques based on $CO_2$ production are more widely accepted (Francou *et al.*, 2005). Mean respiration rate ($CO_2$ evolution) in final Novcom compost sample was 2.15, being well within the stipulated range for stable compost (2 -5) as proposed by Trautmann & Krasny (1997). The value obtained was also in close conformity to the respirometry stability class rating for compost maturity/ stability (Thompson *et al.*, 2002).

The change in C/N ratio of the composting material has also been considered in terms of stability. This is because as the readily available C in the organic matter is oxidized and released as carbon dioxide, there is a general reduction in carbon content over time (Bishop and Godfrey, 1983). Novcom MSW compost also qualified the additional criteria for compost stability i.e. C/N ratio of < 20 (FAI, 2007) and $C:N_{final}$/ $C:N_{initial}$ ratio < 0.75 (Jimenez and Garcia, 1989), confirming that it attained maturity within the period of 30 days.

A direct assessment of phytotoxicity can be made by growing plants in compost media and calculating seed germination and root elongation percent over control (Brinton, 2000). Test results of compost samples revealed that percent seed germination and root elongation over control ranged from 84.42 to 94.78 and 90.26 to 99.44 respectively, being well above (in most cases) the standard value (> 90), which indicated 'very mature compost with no phytotoxic effect' (USCC, 2002).

The phytotoxicity bioassay test, as represented by the germination index provided a means of measuring the combined toxicity of whatever contaminants may be present (Zucconi *et al.,* 1981). The mean germination index value (0.91) of Novcom MSW compost was well within the highest order of rating (0.8 to 1.0), which indicated the absence of phytotoxicity within the compost (Tiquia *et al.*, 1996).

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