20th WEDC Conference Colombo, Sri Lanka, 1994

AFFORDABLE WATER SUPPLY AND SANITATION – Discussion paper

Composting of municipal solid waste

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THE CITY OF COLOMBO , which has a resident population of little over half a million, and a total area of 3731 hectares, is administered by a Municipal Council. The collection and disposal of solid waste generated within the City is a function of the Municipal Council, and is carried out by its six district offices.

The Colombo Municipal Council (CMC) collects around 500 metric tons of solid waste daily. The practice of disposal of this waste has, over the years, been dumping on open land, lowlying marshy areas within the city being used for this purpose. With the increase in the generation of garbage, and the diminishing supply of available land, the CMC was faced with the problem of finding new land for waste disposal. Sanitary landfilling, with compaction of the deposited waste , recovery of resources from the waste and composting of solid waste, thereby reducing the quantity of waste to be disposed of, and thus lengthening the lifespan of the existing landfills, was identified as one possible solution to this problem.

This study was undertaken to determine the feasibility of composting the solid waste collected by the CMC.

The study was made up of three parts: (i) a survey of the production of compost in Sri Lanka on commercial basis (ii) a literature survey on composting and (iii) a pilot study on the feasibility of composting the CMC solid waste. This paper looks at the findings of the first two parts of the study very briefly, and focuses on the findings of the third part, which is the pilot study.

Results of survey on commercial scale production of compost

Three organisations that produce compost on a commercial basis were identified in this survey . They were :(i) Hiat Aggro Ltd., which uses coir waste , leaves and poultry droppings to produce compost, most of which is exported, while any excess is sold locally. (ii) The department of agrarian services, where a cultivation officer uses garden waste and cowdung in pits to produce compost, which is marketed in 1 kg packets, and (iii) The Water Resources Board, where compost is produced from grass cuttings and cowdung, most of which is used in their own plant nursery, while any excess is sold in 2 kg packets at their sales outlet.

The literature survey findings

The literature survey revealed that there are several fundamental factors that govern the composting operation, such as carbon to nitrogen ratio, temperature, moisture content, shredding, aeration, etc. It was noted that it is desirable to have smaller particles in order to achieve a larger surface area for bacterial attack, better thermal insulation, moisture evaporation and water penetration, the ideal maximum particle size being 5 cm , that it is important to maintain the temperature within the pile around 60c for as long as possible, for the thermophilic micro-organisms to decompose the waste at a faster rate, and also for the destruction of pathogenic organisms and weed seeds, that aeration promotes decomposition, that the optimum range of carbon: nitrogen ratio is 25:1 to 35:1, and that the recommended moisture content is around 40-50%. (Gotaas, H.B. 1956, University of California, Technical Bulletin No. 9. 1953, Rabbani, K.R., Jindal, R. & Kubota, H. 1983, Golueke, G.C. 1973, Hang, R.T. 1980, and Obeng, L.A. & Wright, F.W. 1987)

The compost produced should be odourless, available as a dry powder and contain essential nutrients in required quantities, to be acceptable as a fertilizer. The range of values in which the different nutrients lie in most of the finished composts are recorded in Gotaas H.B 1956 as follows:

Organic Matter	20 - 50%
Carbon	8 - 50%
Nitrogen	0.4 - 3.5%
Phosphorous	0.3 - 3.5%
Potassium	0.5 - 1.8%
Ash	20 - 65%
Calcium	1.5 - 7%

The pilot study

Since composting is the result of the breaking down of organic matter by microorganisms, its effectiveness depends on : the size of particles, C/N ratio, moisture content, temperature and aeration.

In this research study, the size of particles was regulated by shredding and sieving; moisture content, carbon/nitrogen ratio and temperature were monitored; and aeration methods were studied. The non compostable particles were removed from the waste initially, by hand picking, and the remaining waste was chopped using a knife, and sieved through a 5 cm screen.

The waste was piled in windrows, formed to a base width of 120 cm, height of 90 cm, and length of 150 cm. The moisture content was controlled by wetting regularly and determining the moisture content by weighing samples approximately 1.5 kg, oven dried for 24 hours at 110 c. The C / N ratio in the waste was determined by a laboratory test, and its effect on the composting process was studied by varying the nitrogen content with the addition of urea. The temperature within the pile, which is an indication of the decomposition rate, was monitored daily, by measurements at three points at three depths in the pile. The effects of aeration was studied by comparing the decomposition pattern of waste, piled with and without aeration frames. All piles were turned regularly once in 4 to 6 days, in order to maintain aerobic conditions.

Observations

Pile no. 1: with an aeration frame.

The pile was wetted daily in the first two weeks, and the moisture content was above 50%, and wetting was stopped in the third week. The temperature rose to about 55 c during the first few days and then gradually dropped. It started to rise again in the third week. The pile was turned for aeration once a week. The C / N ratio was found to be 70:1.

The low highest temperature reached during the decomposition, and the decrease in temperature after the 4th day could be due to:

- high C / N ratio due to the presence of large quantity of leaves in the waste used
- high moisture content due to the daily wetting of the pile and exposure to the rain, and / or
- insufficient aeration due to low frequency in turning of the pile, resulting in possible anaerobic conditions.

Due to the unsatisfactory composting of this pile, which was found to be not a good representative sample of CMC waste, study of pile no.1 was abandoned at the end of the third week.

Pile no. 2: with an aeration frame,

This pile was also abandoned after a few days, as it was found that the waste composed largely of fish market waste, which is not truly representative of the CMC solid waste .

Pile nos. 3, 4 and 5: These were made with waste carefully selected to represent CMC solid waste. The three piles were formed at the same time, and subjected to three different environmental conditions.

Pile no. 3: without an aeration frame.

Pile no. 4: with an aeration frame, and

Pile no. 5: with aeration frame and 2 kg of urea per cubic meter of waste added to the pile.

The moisture content was maintained between 40 and 50% in all three piles, and they were protected from the sun and rain by drawing a plastic cloth above them. The piles were turned once in 4 to 6 days.

It was observed that the degradation process was best in the Pile no. 4, and that the addition of urea to Pile no. 5, did not appear to improve the process. It was also noted that the C / N ratio of the raw waste from both piles 4 and 5 were 88 :1, according to test results.

Pile no. 3, which was formed without an aeration frame, had an irregular temperature pattern, with the temperature rising and dropping intermittently. It had a long duration of low temperature after the initial rise, suggesting setting up of partial anaerobic condition. It took one week longer for stabilisation and was very

much infested with worms.

Pile nos. 6 and 7: Both piles were formed using waste from the same collection, and with aeration frames, and 6 kg of urea added to Pile No. 6. The moisture content was maintained between 40 and 50%, and both piles were turned at the same interval, once in about 4 days. The C / N ratio of the waste in Pile no.6 was 10:1, while that in Pile no. 7 was 23:1. Ammonia gas was observed to be emanating from Pile no.6 during the turning operations. It was also observed that Pile no. 6 was less infested with worms than Pile no. 7. Both piles seemed to be behaving similarly as far as temperature rise and fall, and the total time for stabilisation were concerned. Thus no significant advantage could be observed by the addition of urea to the waste.

Conclusions

The following conclusions were drawn from the study.

1. The CMC solid waste, collected from residential areas in the city, is suitable for composting, after sorting, shredding, and screening.
2. The C : N ratio of the CMC waste is in the range of 25:1 to 90:1, and the study showed that the waste stabilized equally well, within this range. Thus it could be concluded that C / N ratio need not be adjusted by any additives, if it is within this range.
3. The temperature and moisture content should be monitored, and controlled. The temperature within the pile should be maintained close to 60 c as long as possible, during the period of active stabilization . This may be achieved by reducing the pile dimensions if the temperature is too high, and by increasing the dimensions to a manageable size (up to about 1.5 m height) and improving the aeration if the temperature is too low. The optimum moisture content is 40-50% and this should be protected from sun and rain
4. Stacking waste over an aeration frame is a low cost method of maintaining aerobic conditions within the waste pile.
5. Municipal waste material of particle size less than 5 cm, develops temperatures above 60 c continuously for periods of over 7 days, and reaches maturity in 35 to 40 days, when stacked over an aeration frame, and the moisture content is maintained at 40-50%.
6. Only about 50% of the original volume of solid waste collected would be acceptable for composting after sorting, shredding and screening. A volume reduction of about 60% is achieved during the composting

process. Thus, the net reduction in volume achieved would be about 80% of the original volume . However, if the compost produced is marketable, or is useable in some way, then this would reduce the volume of waste to be disposed of in the landfill by 50% .

7. The study showed that the compost produced with municipal waste is deficient in nutrients, particularly phosphorus. Thus, if the compost is to be used as an organic fertilizer, it should be supplemented with the deficient nutrients.

8. Worms and larvae in the waste piles can be reduced to a large extent by suitably locating the composting yard, and by maintaining a high temperature (about 60 c) within the pile, and frequent turning.

References

1. Golueke, G.C. (1973), "Composting: A study of the process and its principles." Rodale Press, Inc.

2. Gotaas, H.B. (1956)." Composting: Sanitary Disposal and Reclamation of Organic Wastes." WHO Monograph Series No. 31.

3. Haug, R.T. (1980). "Compost Engineering : Principles and Practice", Ann Arbar Science Publishers, Inc., U.S.A.

4. Obeng, L.A. & Wright, F.W. (1987). "Co-composting of Domestic Solid and Human Wastes". W.B Tech. paper 57.

5. Rabbani, K.R., Jindal, R. & Kubota, H. (October 1983). "Composting of domestic refuse". Environmental Sanitation Reviews, No. 10/11. Ensic Bangkok. Thailand.