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Research Article

Quality assessment of compost from Centralized windrow composter (CWC) and Source segregate automatic vessel composter (AVC) at Hyderabad city in India

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Abstract
Out of the millions of tons of Municipal Solid Waste (MSW) generated annually in India, only about 75-80% of the waste gets collected and out of this, only 22- 28% is processed and treated, and the remaining is deposited indiscriminately at dump yards. Hyderabad city generates around 5500MT of waste every day. And only 20% of the waste is used for composting using the windrow composting process. MSW composting is a rapidly growing method of solid waste management in Hyderabad and In-Vessel composting is the recent initiative by the Govt. of India to reduce the organic solid waste generated at the source. The present study was aimed to assess the degree of accumulation and contamination of the heavy metals in composts from Centralised Windrow Composter (CWC) and Source Segregated Accelerated Vessel Composter (AVC). Compost Samples from CWC and AVC were analysed for metals concentration using Energy Dispersive X-ray Fluorescence Spectrometers (ED-XRF). CWC samples were found with slightly high concentrations of heavy metals like Zinc (0.51 – 0.66%), Copper (0.36 – 0.45%), Nickel 0.03 – 0.05%), Iron (11.46 – 13.27%), and chromium (0.06 – 0.14%) compared to AVC. AVC samples contained high concentrations of Calcium (14.99 – 64.19%), Potassium (9.13 – 29.59%) and Phosphorous (1.55 – 3.43%) when compared to CWC. The current study does a comparative analysis on the process and nutrients available to assess the quality of the compost from both sources. Considering the above findings source segregated AVC seems to be a better composter than centralised CWC, as the concentrations of Ca, K, and P required by the plant were abundant in AVC. Also, considering the process aspect, there is always scope for cross contamination if the waste is separated after treatment which is the case in CWC.

Keywords: Compost, Municipal solid waste, Nutrients, Source segregation, Vessel compost

INTRODUCTION

India stands second to China in the world population, with a population of 1.37 billion, which is equivalent to 17.35% of today's world population. India's population density is 455 Km^2 and 34.5% of the population is in the urban area. Average growth rate stands at 1.15% annually (World Bank, 2019). Human habitations and their locations in the urban areas are seen increasingly generating economic activities and huge solid waste. Economic development and population growth can also be considered as factors for an increase in waste generation. This can be seen significantly in regions with high population and low- and middle-income countries.

Though we find waste generation rates to vary from nation to nation and within, there is a strong correlation with their per capita income (David, 2015). The economic growth of a country gives a positive correlation with the quality of waste generated when the population of an urbanised nation is also taken into consideration (Rana, 2015). MSW from developing countries indicates that 55-80% of waste from households and commercial or market area with varying quantities from the street, industries generate 10-30% of waste (Miezah, 2015).

About 2010 million tons (MT) of MSW was generated in the world during 2016 and by 2050 the numbers would increase and is expected to be around 3400 MT, this is a huge leap in production to the tune of 70% within a span of 30 years (Khandelwal, 2019).

India generates 1.5 Lakh tons of MSW per day, which amounts to 56 MT of waste production according to the Ministry of Environment and Forestry (MoEF) and it is further projected to increase to 125 MT by 2031. And according to Swachh Bharat Mission (SBW), roughly 98 percent of the waste generated is collected and 36 percent is treated, and another 33 percent is sent to landfills (Bandela, 2020). In the State of Telangana, it is estimated that about 8360 TPD is collected every day. Nearly 5747 TPD is treated, 869 TPD is going to sanitary landfill and remaining is disposed of in the open Landfill. The door-to-door collection in the State is about 95.9% (CPCB, 2019). The city of Hyderabad generates 5,500 tonnes of waste daily, 54 per cent of which is biodegradable. GHMC practices centralized as well as decentralized processing of waste. About 16 per cent of waste is sent to landfills (Bandela, 2020).

Food waste, Garden waste, Paper-cardboard and Wood constitutes more than 50% of the Waste composition which are biodegradable in nature. With the rise in income the biodegradable component declines, countries with the high-income, upper middle-income and lower middle-income have 28%, 54% and 59 % of the biodegradable fraction of MSW (Daniel Hoornweg, 2012).

The cost involved in managing urban waste is too high, which would shoot up the local administrative budget. In developing countries, often local administrative authorities have extremely limited resources and capacities for the management of waste. Due to the poor management of MSW, countries like India still struggles to implement a sustainable model. The current study seeks to assess the degree of accumulation and contamination of the heavy metals in compost from CWC to Source Segregated AVC.

MATERIALS AND METHODS

A comprehensive study was conducted to assess the quality of the compost, particular with reference to CWC and AVC. The study mainly focused on the composition of nutrients availability, heavy metals of the Source Segregated AVC. In AVC, the main raw material/ biodegradable waste was food waste. AVC is an intuitive technology working on a similar principle to that of Bioreactor where optimal conditions are maintained with several integrally related components (Kumar A., 2015).

Composting reactor

As claimed by the manufacturer, the AVC processes the food waste in 24 hours. The Unit consists of a decomposition tank to hold the food waste, Rotatory Blades to mix the waste homogeneously. Other parts include air inlet to control the aeration in the unit, Insulator and heater to maintain the required temperature for the micro-organism. There is an exhaust system for moisture to evaporate through the outlet, Deodorise chamber and a fully Automated control system with temperature and moisture monitoring.

Composting materials

Food waste was segregated and shredded if required into small size based on the Machine type (some composters had blades to break down the food material into smaller pieces). Based on the capacity of the decomposition tank waste was fed into the machine. Sawdust was added to maintain the C: N ratio and proprietary bio inoculum which is a mixture of microorganism cultures that accelerates the aerobic composting was added. The machine was run automatically for a period of 24 hours where Blades within the tank stir the contents several times an hour; temperature was automatically maintained by the system. No leachate was produced, and moisture evaporated through the venting system. For volume reduction to take place and compost to come out, the system was shut down for 24 hours to allow the contents to fully process. The material thus removed was placed for curing for 15-20 days before applying to the plants.

Sample

Site visit were made to various Mechanical Biological Treatment Plants (MBTP), which operated AVC in and around Hyderabad. As part of the New Solid Waste Management Rules 2016, Bulk Generators having 100 kg and above of waste generation per day shall process and dispose of waste through composting or biomethanation at the source. The aerobic MBTP's located at Commercial Establishment and Residential Areas were selected as sample locations. AVC Samples (SS01, SS02, SS03, and SS04) from a different make of AVC's were collected at MBTP after the curing phase was completed. Curing time for each MBTP differs as per their machine manufactures technology. Moisture, pH and temperature were measured at the sample site. In addition to these plants, a Compost sample (MSW01, MSW02) from Hyderabad's Integrated Municipal Solid Waste Plant was collected which operates on the Centralised Windrow composting (CWC) method for a comparative study. Below table 1 depicts the details of each MBTP; Location, Sample type, raw material used, Composting time, Amendments, Curing time, operation type.

Analytical methods

The samples were analysed using Energy Dispersive X-ray Fluorescence Spectrometers (ED-XRF), a non-destructive method of analysis. XRF for Environmental samples has the advantage of being rapid and cost-effective. Instead of using the acid digestion method for elemental analysis through this method, Quantitative and qualitative analyses are performed in a very short span (Ene and Georgescu, 2010). The Samples were first sun-dried, followed by drying in a Hot air oven at 110°C. Pulverized homogeneously and then sieved using 0.2 mm mesh. A pre-cut polypropylene film was used to hold the finely powdered compost samples in the sample cup. An instrument of make Shimadzu EDX -8000 was used for sample analysis.

Physico-chemical analysis

Loss of self-heating and general appearance like dark colour, uniformity with the earthy smell is reliable Physical signs of Stability when compared to other parameters. When the temperature of the compost is equal to that of the ambient temperature at this stage, it is believed to be stable. (Chukwujindu, 2006) Sensory evaluation (Smell, Sight and Touch) was done for a few Physical parameters; there is no universally accepted measure for Odour quantification. Its general thumb rules that are reasonable, mature compost have an earthy smell. Mature compost would be dark brown, non-sticky and crumbly to touch. Initially, temperature, pH and Moisture of the samples were also taken at the MBTP site. For pH analysis sample was mixed with distilled water at the ratio of 1: 5 and stirred for 5 minutes, allowed to settle for 10 mins before the pH of the samples was measured with pH meter. An infrared thermometer was used to measure the temperature of the samples. Moisture measuring Pin Meter was used to test the moisture of the compost onsite (Table 2).

RESULTS AND DISCUSSION

Macro nutrients

The key to sustainable agriculture is soil organic matter management by using composted organic waste. (Mohammad , 2004). High yielding crops require sufficient nutrients like Potassium, Phosphorus and trace elements like copper and Zinc which are essential for plant growth. When compared to the CWC, the decentralised AVC's seems to be having a good percent of macronutrients. This is evident from the reading below. Since for AVC, the raw material was source segregated food waste, and for CWC raw material was a mixed waste. The availability of Potassium (K) was observed to be at a range of 6.89 to 8.56% for CWC and 9.13 to 29.59% for AVC. Phosphorous (P) content was lower at 0.01 to 0.08% for CWC and 1.55 to 3.43% for AVC. Sulphur (S) contents were recorded at 3.38 to 3.72% for CWC and 2.50 to 5.68% for AVC. Calcium values were exceedingly high in both CWC and AVC, and they were recorded between 30.46 to 36.84% and 14.99 to 64.19%, respectively (Figure 01).

Micro nutrients

Micronutrients (Trace elements) are essential for plant, animals, and Microorganisms in fewer concentrations, but when applied in excessive, they might dampen the growth reducing the quality of food material by the plant (Rajaie, 2016). The values for Iron (Fe) were in the range of 11.46 to 13.27% for CWC and 2.25 to 22.36 for AVC. Zine (Zn) availability for the CWC sample was between 0.51 to 0.66 % and 0.14 to 0.34 % for

Table 1. Details of MBTP's used for sampling.

DETAILS	MSW01	SS01	SS02	SS03	SS04
Location	HiMSW*	Star Hotel	Commercial Trade Centre	Food Court	Rythu Bazar
Sample Type	MSW	Source Segregated	Source Segregated	Source Segregated	Source Segregated
Raw material	Mixed Waste	Food Waste	Food Waste	Food Waste	Vegetable Waste
Initial Composting Time	33-36 days	24 Hours	24 Hours	24 Hours	12 Hours
Compost Removal	Periodically	10-15 days	24 Hrs	24 Hrs	24 Hrs
Curing Time	10-15 days	10-15 days	7 -10 days	21 Days	14 days
Operation Type	Manual	Automatic	Automatic	Automatic	Automatic
End to End Processing Time	43-52 Days	15 Days	10 Days	21 Days	14 days

*HiMWS – Hyderabad Integrated Municipal Solid Waste Site

Table 2. Physical parameters of the samples collected from MBPT's.

Parameters	MSW01	SS01	SS02	SS03	SS04
Temperature	37	34	36	41	33
pH	7	8	7	7	8
Colour	Dark Brown	Light Brown	Dark Brown	Dark Brown	Dark Brown
Odour	Earthy	Earthy	Earthy	Smokey	Earthy
Moisture	Normal	Normal	Medium	Max	Less

AVC. Though the availability of Copper (Cu), Manganese (Mn) in CWC were found to be 0.36 to 0.45% and 0.19 to 0.22%, for AVC the values were very negligible. Nickel (Ni) was only available in the CWC sample. Chromium was present in CWC samples at 0.06% to 0.14 % and present in the SS03 sample of AVC. (Figure 2).

Advantages of AVC over CWC

We can broadly classify the MBT system as two simple concepts; either treat the waste and then separate or segregate the waste and then treat (DEFRA, 2013). Our samples MSW01 & MSW02 were collected from MBTP operated at a centralised place where waste from different sources was collected and processed without segregation. There might be loss of nutrients through leachate; Leachate is a liquid by-product of compost that contains N, P, K, and other trace elements. The concentrations of Marco Nutrients of CWC were less when compared to that of AVC. This was due to concentration loss in leachate. The maximum concentration of P and K were found to be 0.08% and 8.56% respectively in CWC, whereas in AVC the maximum concentration was 2.67% and 29.59%. This is because in AVC there was no production of liquid leachate as the composting was done in a controlled manner. Coming to trace elements, the essentiality and toxicity of trace elements by plants and animals vary depending on their species. Therefore, to protect soil fertility and food safety, the most sensitive plant and animal tolerance are to be considered (Epstein, E., 1992). Trace elements like Zn, Cu, Ni concentrations are more in CWC compost which was at 0.66%, 0.45% and 0.03%. These concentrations in AVC are less when compared to CWC. This increase of concentration in CWC can be attributed to cross-contamination of the compost as the waste was separated after treating since mixed waste contains batteries, paint, oil, plastic, and glass, which act as a source for the MSW stream. The concentration of Cr was found only in CWC samples at an average of 0.10%. Concentrations of heavy metals and metalloids in the samples are dependent on their presence in the input raw material (Mladenov, 2018). CWC compost raw material was mixed waste gathered as part of the MSW management plan and composted in an open space using Windrow method. In AVC the raw material was Food waste; the organic fraction of waste was segregated and collected at the source by the user. Amendments like Sawdust are used to maintain C: N ratio, which was essential for metabolic activity. C: N utilised by living organism is around 25:1 to 23:1 (Pathak, 2011), which is most desirable for rapid and efficient composting during the aerobic process.

Conclusion

The present study concluded that compost played a vital role in replenishing nutrients to the depleting soil quality by recycling organic fraction back into the soil. This is an affordable, sustainable, and waste to wealth option in Solid waste management practice. If a proper management system is developed to better utilise the waste, wealth can be automatically created out of it. A centralised system like windrow composting would require huge men and material to manage the composting process, starting from the collection, transportation, waste processing and disposal. This system may invite public dissent due to odour, noise, dust, and land acquisitions to set up such centralised management facilities. Though the study on composting found no adverse effect on a nearby population's health, there is always a concern that open composting would have negative effects on the health of those living in proximity. A decentralised System like source segregated AVC has considerable advantages over the Centralised system to make use of the compost as plant nutrient. It eliminates the multiple steps in the process like collection,

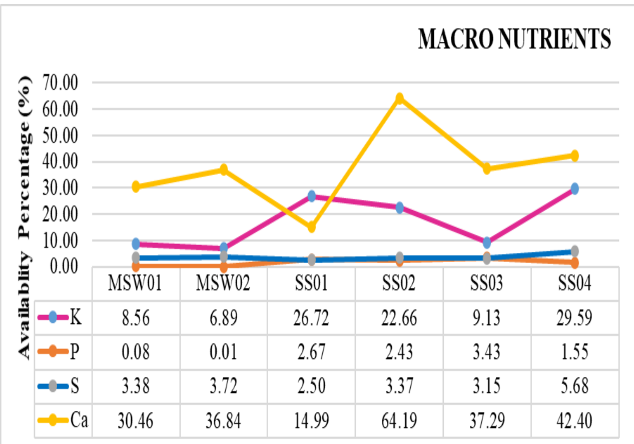

Fig. 1. *Macro nutrients availability percent in compost samples.*

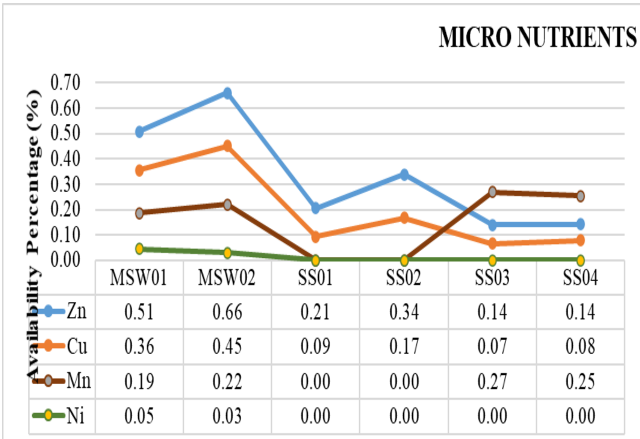

Fig. 2. *Micro nutrients availability percent in compost samples.*

transportation, and open disposal and reduces the processing time by 50%. This process outputof the precess has better quality than that of the decentralised system, which manifests from the above observations. Hence, it is imperative to go for such technologies as there is a demand for Quality Compost in India. Best practices require better policies, so based on the analysis and observations made during the study, the following recommendations are made.

- To scale up the production capacity and consumption of AVC, Production Quality protocols needs to be defined for its usage.
- Provide subsidies on the cost of AVC for better reach to the common public.
- Provide incentives/tax rebates for using AVC, which would reduce the financial burden on Govt. infrastructure for collection and transportation of waste.
- Encourage budding entrepreneur to design and develop cost-effective smaller AVC for individual household use, this would encourage composting at the source.

As part of CSR activity, Private institutions can install and maintain such compost plants near parks and commercial establishments where residents can drop wet waste at these centres for further processing.

Conflict of interest

The authors declare that they have no conflict of interest.

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