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Drum Composter - A New Technology for Management of Urban Solid Waste and Production of Quality Compost

H. C. Prakasha
Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS, GKVK, Bengaluru - 560 065
e-Mail : prakasha_hc@yahoo.co.in

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H. C. Prakasha : Conceptualization, design & development and manuscript finalization

Corresponding Author :
H. C. Prakasha

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Abstract

The urban solid waste contains about 52 per cent of biodegradable wet waste after segregation and it is very important in agriculture as it serve as an organic source, which improves the soil fertility and productivity. Drum composter is an innovative new technology for segregation and production of compost using organic waste. A project on recycling and utilization of urban solid waste in agriculture was initiated during 2012-13 at UAS, GKVK, Bengaluru under RKVY project to evaluate the efficiency of drum composter on compost preparation. The three treatments *viz.,* T_1 Windrow method T_2 Drum vermicomposter and T_3 Drum composter techniques were used to evaluate the quality of compost. The compost prepared from the Drum composters and Drum vermicomposting took 75 days for maturity compared to about 120 days by windrow method. The colour of the compost produced by drum composters were dark brown as compared to light brown colour in case of windrow method of composting. The moisture percentage ranges from 49.64 to 51.49 per cent with high values in windrow method (51.49 %). The chemical properties *viz.,* pH, EC and Organic carbon remained more or less almost same values in all the three methods. The drumvermi compost and drum compost recorded optimum values of N, P, K, Ca, Mg S and B and narrow C:N ratio compared to windrow method. The heavy metals *viz.,* Zn, Fe, Cu, Mn, Cd, Ni and Cr recorded higher concentrations in windrow method of composting as compared to the drum composts. The humic fractions like humic acid, fulvic acid and Humification index (HI) were also recorded higher values in drum composts as compared to the windrow method. The finger millet crop variety of ML-365 was grown as test crop with use of different composts during *kharif* 2013-14. The results indicated that the application of drum vermi compost and drum composts recorded higher grain and straw yield of finger millet ranges from 4827 to 4880 and 7231 to 7285 kg ha^{-1} compared to the windrow method of 4786 and 7183 kg ha^{-1}, respectively. The same trend of primary, secondary and micronutrients concentration were noticed in grain and straw of the finger millet crop.

Keywords : Drum composter, Vermi compost, Yield, Solid waste

Now a days, the population in the country increasing in cities, towns and producing enormous quantity of urban solid waste, which is causing environmental pollution. On an average, an individual produces about 250-400 g of wet waste in Indian cities and towns. Meena *et al.,* (2023) reported that India generates about 0.1kg, 0.3-0.4 and 0.5 kg per capita per day in small, medium and large cities and towns and with rising per capita income, it is estimated that the waste generation per capita will increase in comparison to other south-east Asian countries like Indonesia (0.7), Thailand (1.05), Singapore (3.763), etc (Jain, (2017). According to the CPCB (Central Pollution Control Board) report 2020-21, the overall quantity of solid waste generated stands at 160,038.9 tons per day (TPD) in the country. Out of which 152,749.5 TPD of waste is collected in an efficient manner. Out of the total collected waste, 79,956.3 TPD, constituting 50 per cent, undergoes some form of treatment, while 29,427.2

TPD, *i.e.,* 18.4 per cent, is directed to landfills and 50,655.4 TPD, representing 31.7 per cent of the total waste generated remains unaccounted. Municipal solid waste from Indian cities estimated to have 40 - 60 per cent organic matter, which could be recycled as compost (Manju Rawat *et.al.* 2013). As defined by Robinson (1986), solid waste refers to the byproducts of household or commercial activities that have lost their value to the original owner but may hold significance for others. Disposal of enormous quantity of waste in urban areas has become a herculean task. It is not only causing environmental hazards but also inflicting a huge loss of money from the government on routine cleaning of waste in the urban areas and transportation to dumping sites or land fills. The land filling needs larger area and also more number of dumping sites, which have become a cause of polluting the soil ecosystem, ground water as well as surface water contamination by leaching of nitrates, sulphates and other toxic elements and atmospheric air is adversely affected by emission of methane and other greenhouse gases. The crops grown in these dumping areas are loaded with heavy metals, which is affecting the human as well as animal health. In view of observations, decentralized disposal facilities would offer localized solutions for waste management, ensuring that waste is processed closer to its source.

Drum composting is an alternative technology to land filling for solving theurban solid waste problems in urban, semi urban, towns and mulcipality areas. Using drum composting technology the compost production could be done at source of waste generation, which minimizes transportation cost and controls green house gases emissions and thus promoting a more sustainable and cost effective waste management system. Drum composting is the method of collection, segregation and decomposition of organic wastes into compost in the drums underaerobic process. Drum composting is a new technology of composting and is very simple, cheaper and a boon to unemployed youths, self-help groups for earning good incomeby production of compost and marketing by using the technology. In addition, drum composts is safely used in agriculture because, it yields good quality of compost and free from heavy metal contamination in the produce. Keeping these in view, a trial was conducted with an objective of preparation and assessing the quality of drum compost using urban solid waste and also study the drum composts on yield and quality of grain and straw of the crop as compared to windrow method of composting.

Material and Methods

The methods of compost preparation included were windrow method of composting, drum compost and drum vermi-compost. In windrow method, the urban solid waste was spread and piledin rows on theland surface and stored in a conical heap shape up to a height of 8 feet in order to facilitate easy movement of air. Turning of solid waste was given once in a month for better decomposition. With the progress in decomposition and repeated turning of solid waste, coarse organic material were degraded into brown and black powder (compost) in a time period of 120 days. The compost was also prepared by drums by using the urban organic waste in two types; 1 Drum vermicomposter 2. Drum composter methods. Drum composting is the method of collection, digestion, decomposition of wet organic materials produced from kitchen, market, school, colleges, offices, agriculture, and agro- based industrial wastes into compost in the drums by aerobic process, where the vents were made all around the drums for aeration. Care was taken to ensure the prevention of contamination of waste with other solid waste *viz.,* plastic, metals, chemicals, insecticides *etc.* to ensure quality of compost, only segregated organic wet and dry waste are used in the drums. A field trial was conducted to test the yield and quality of compost using finger millet as test crop and variety of ML-365 with three treatments and six replications and the statistical analysis was carried out byuse of RCBD design as outlined by Sundararaj, *et al.* (1972). Each treatment was imposed with 50 per cent Nitrogen, 100 per cent phosphorus and potassium through urea, single super phosphate and muriate of potash (100:50:50 NPK), respectively with compost @ 10 t ha^{-1} to the field and composts were applied through three sources *viz.,* Windrow, Drum vermi composter and Drum composter methods, respectively as per the treatment requirement and UASB package of practices at the time of transplanting. After imposing fertilizers and composts to the field, Ragi seedlings of 18 days old were transplanted with a spacing of 20 x 10 cm and another 50 per cent of nitrogen was applied at maximum tillering and panicle initiation stages. Harvesting of crop was taken during maturity stage at 135 days and recorded the weight of grain and straw according to treatments and replications after ideal drying. The grain and straw as well as soil samples were collected according to treatments and replications and kept for processing for chemical analysis in the laboratory.

Fabrication of Drum Composters and Drum Vemi Composters

The steps followed in fabrication of the drum composter is as follows- (Refer Fig. 1).

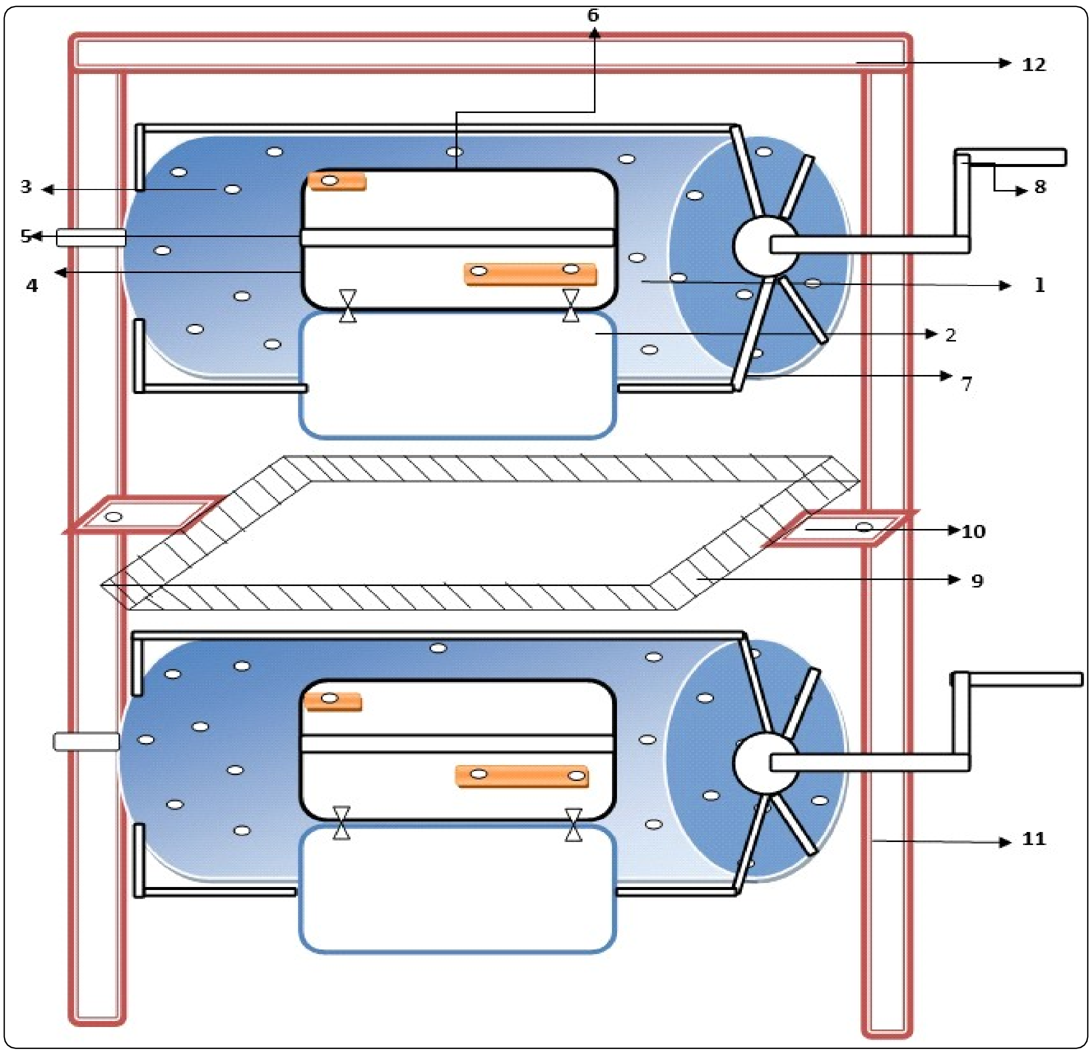

Fig. 1 : Schematic diagram of Drum Composter

1. Plastic drums [2 numbers] (200 lit.cap.); 2. Door shutter (2w x1.5 b ft); 3. Vents (8 mm size.); 4. Wooden edges [1 ft l x2 inches w (3 edges/drum)]; 5. G.I rod (5 x1.25 inches); 6. Door opening (2w x1.5 b ft); 7. Steel drum holders [2ft l x 1.5 inches w (4 numbers/ drum) 4 ft x1.5 inches (4 numbers/ drum (4 ft l x 1.5 ft w)]; 8. Drum rotator; 9. Steel tray (2 numbers/drum 4 ft w x 2ft w); 10. Wooden tray holder; 11.Wooden poles [8ft H x 1 ft w (2 numbers)]; 12. Horizontal wooden poles fixer [4 ft l x 0.75ft w (2 numbers)]

Two plastic drums of 200 litres capacity with height of 4 ft and width of 2ft were selected and doors (2 feet width x 1.5 feet length) was made horizontally in the middle of the drum and Vents (8 mm diameter) were provided at half feet interval all-round the drums.

G.I pipe of 5 feet length and 1.25 inches diameter was introduced horizontally through centre of the drum so as to extend beyond either side of the drum. In addition, the drums were secured using metal steel plates attached to G.I pipe at both end of drum and in turn are attached to the steel bearing box for rotation purpose as shown in the Fig. 1.

Two wooden poles (eight feet height) were placed in pits of 1.5 feet depth dug in the ground and firmly secured using cement mortar at a distance of 4.5 feet interval.

The drums (with door and vents) were fixed horizontally between the erected poles and a handle was provided at one end of a G.I pipe of the drum to facilitate turning.

The second drum was fixed horizontally above the first drum at 3 feet apart between the poles.

A G.I tray was placed below the drums to collect leachate produced during decomposition of urban waste.

The materials required for fabrication of drum composter is given in the Table 1

Working of Drum Composter

Segregated urban organic wet waste 1 part and 3 parts of organic dry waste (125-150 kg) was filled into 200 lit. Capacity plastic drums.

Microbial consortia of about 50 g and cow dung slurry (1kg cow dung: 2 lit water) was added and allowed for decomposition in a closed drum container.

Initially (1-14 days) leachate (brown liquid) is produced from the decomposing urban waste and the leachate was collected in the G.I tray. The leachate can be used as foliar nutrient spray on dilution at 1 leachate : 10 water.

The drums were turned 15-20 times in the morning and evening daily to facilitate aeration and ideal

TABLE 1

Material required for fabrication of drum composters

Materials	No.
Two plastic drums - 200 litres capacity	2 No.
Wooden / Steel poles (Height 8 feet, diameter 1 feet	2 No
Wooden / Steel plate (Height 4 feet, width 0 .75 feet	2 No
G.I pipes(5 feet length x 1.25 inches diameter)	2 No
L angle MS plates measuring 1.5 feet length X 1.5 inches width	2 No
MS plates measuring 4 feet length X 1.5 inches width	4 No
MS plates measuring 2 feet length X 1.5 inches width	4 No
Steel bearings measuring 33 mm diameter	4 No
G.I/ plastic tray 4 feet width X 2 feet length	2 No
Sieve 4mm mesh	1 No
Bioculture-*Trichoderma viridae, Trichoderma harzianum, Pseudomonas fluorescence, Phanerochaet chrysosporium, Bacillus subtiles, Bacillus megaterium, Azatobactor chrococcum*	1-2kg/drum (biocomposter)
Cow dung	2-3kg
Earth worms-*Eudrilius euginae, Perionyx excavates and Aesenia fateda*	1kg/drum (vermicomposter)

Note : Drum size and material required depends on the quantity of solid waste generated at the source moisture (60%) was maintained during composting to ensure microbial degradation of the urban waste.

With progress in decomposition, the volume organic waste was reduced and colour of the urban waste changed to brown and dark brown colour. Within sixty days, the composting of organic urban waste reached advanced stage by formation of brown to black powder.

Within 75 days the compost was ready with black colour and powder was odourless indicating maturity of the compost. The powder was sieved through 4 mm sieves and was analysed for various physico-chemical properties to assess maturity of the compost.

Working of Drum Vermi composter

Segregated urban wet waste 1 part and 3 parts of organic dry waste (125-150 kg) was filled in measuring 200 litre capacity plastic drums and allowed to decompose with rotation of drums for 21 days only.

The process of decomposition of waste was confirmed by measuring the temperatureof decomposing waste, which stabilizes at 25-35^{0}C. Ideal moisture (60%) was maintained during composting to ensure microbial degradation of the urban waste.

After stabilization of temperature of the organic waste, One kilogram of earthworm consortia was spread over on the pre-decomposed urban waste and a wet jute bag was placed over the waste. After the earth worms are introduced, the rotation of drum was stopped to facilitate earth worms remains active and undisturbed until final collection of vemicasts and this facilitates the earth worm to feed on the pre decomposed urban waste.

After 10-15 days of introducing the earth worms, the vermicast was gently harvested using the hand at an interval 10-15 days and harvesting process was continueduntil all the waste is converted into vermicast.

Always the ideal moisture was maintained and wet jute bags are placed over the urban waste after each interval of collecting the vemicast.

The process continued until ninety five percent of urban waste is converted to vermicast known as vemicompost.

Finally the earth worms remained at the bottom of the drum were collected and transferred to another pre decomposed urban waste which is prepared in the second drum.

Soil Analysis

The soil pH was determined in 1:2.5 soils: water suspension using digital pH meter with glass electrode (Jackson, 1973). The electrical conductivity of soil was determined in clear filtrate of 1:2.5 soils: water suspension using conductivity bridge (Jackson, 1973). The organic carbon was determined by following the Walkley and Black (1934) wet-oxidation method. The available nitrogen was determined by following alkaline permanganate method as out lined by Subbiah and Asija (1956). The available phosphorus was estimated by using Bray-1 reagent. The extracted P was estimated by ascorbic acid method using spectrophotometer (Bray and Kurtz, 1945). Available potassium was determined flame photometrically after extracting the soilwith neutral normal ammonium acetate as described by Page *et al.* (1982). Available sulphur was extracted using 0.15 per cent calcium chloride solution and estimated using a suitable aliquot of the above extract by Barium chloride turbidometric method (Black, 1965). Hot water soluble Boron in the soil samples were determined by Azomethine-H method (Dhyan Singh *et al.,* 2007). DTPA extractable micronutrients and heavy metals were analyzed usingthe method developed by Lindsay and Norwell (1978) using DTPA (Diethylenetriaminepenta acetic acid) was followed for the estimation of micronutrient (Zn, Cu, Mn and Fe) and heavy metals (Cd, Ni and Cr).

Plant and Compost Analysis

pH was determined in 1:10 organic material water suspension by using a glass calomel electrode method (Jackson, 1973). Electrical conductivity (EC) was determined from the filtrate of 1:10 organic material water suspension using conductivity bridge (Jackson, 1973). Organic carbon (OC) content by Walkely and Black's wet oxidation method (Jackson, 1973). The Nitrogen by microkjeldal method, Phosphorus by Vanadomolybdic yellow colour method, Potassium by Flame photometry, Calcium and Magnesium by Compelxiometry, Sulphur by Turbidometry method as outlined by piper (1966), Boron by Curcumin method (Jaiswal 2003), Heavy metals by Atomic absorption Spectrophotometry (Lindsey and Norwell 1976).

Results and Discussion

The Physico-Chemical Properties of Urban Solid Waste Compost

The physico-chemical properties of compost are shown in the Table 2. The compost prepared from using urban solid wet waste in drum vermi composter and drum composters were taken 75 days to maturity of compostand 120 days in case of windrow method of composting. The compost prepared by using drum vermiculture and in the drums composter were faster compared to windrow method which might be attributed of better control of oxygen and temperature in the closed containers generated by mesophilic and thermophilic bacteria and conservation of optimum moisture which enhanced multiplication of microorganisms and might have helped for faster digestion of waste into the compost. Mukeshkumar Awasthi *et al.* (2018) also reported that in-vessel composting can accelerate the composting processand reduce the composting time (Antizar-Ladislao *et al.,* 2005, Sangamithirai *et al.,* 2015 and Walker *et al.,* 2009).

The colour of the compost prepared from drumcomposters and drum vermi-composters was dark brown in colour, which might be due to complete decomposition and maturity of the compost as compared to light brown in windrow method (Table 2). All the compost samples appeared dark brown in colour with an earthy smell, deemed necessary for mature compost (Epstein, 1997). The moisture content is a significant parameter for the growth of microbes as well as in the physio-chemical properties of the compost. Application of cow dung is a good source of microbes which increases the activity and the degradation rate of organic matter (Dayananda sharma and kunwar 2018). The table shows the optimum moisture content of 51.49,49.64 and 50.15 per cent in windrow method, drum vermicomposter and drum composter, respectively indicating better microbial activities which enhance maturity of the composts (Table 2).

Table 2

Physico-chemical properties of Urban Solid waste Composts prepared by different methods

Parameters	Windrow method	Drum vermicompost	Drum compost
Moisture (%)	51.49	49.64	50.15
Days for maturity	120 days	75 days	75 days
Colour	Brown	Dark brown	Dark brown
Bulk Density (gcc^{-1})	0.75	0.52	0.50
pH	7.13	7.24	7.45
EC(dsm^{-1})	1.30	1.32	1.72
Organic carbon (%)	25.20	23.8	24.0
C:N ratio	21.35	18.88	18.75
Humic Acid (%)	9.53	10.30	12.10
Fulvic Acid (%)	6.60	5.90	6.50
HA/FA	1.44	1.74	1.86

Dayananda Sharma and kunwar (2018) also reported that the average bulk density of compost varies but generally falls between 0.40 to 0.70 g cc^{-1} for optimal aeration, though it can range from lower (very porous) to higher (very wet/compacted) values, with screened compost at 50 per cent moisture often around 0 58g cc^{-1}. Lower density indicates better aeration, while higher density suggests that excess moisture or mixed with soil might be lead to compact nature of compost, which hinders microbial activity. The BD of the compost prepared by windrow method compost recorded 0.75 g cc^{-1} indicating higher values due to contamination of soil particles as the method of composting was carried on the soil surface, whereas, compost prepared from drums composters with no contamination of soil recorded the lower values of 0.52 g cc^{-1} and 0.50 g cc^{-1} indicating better aeration with good microbial activities (Table. 2).

The pH was recorded neutral values (7.13, 7.24 and 7.45 in drum vermi composter and drum composter and windrow method of composting, respectively) in all the three methods of composting might be attributed to better decomposition accelerated by microbial activities (Table 2). Mukeshkumar Awasthi *et al.* (2018) indicated in the report that for optimal composting, a neutral pH is very crucial for the decomposition of organic acids and proteinaceous substrate combined with production of gaseous ammonia. Awasthi *et al.* (2015) reported that under aerobic conditions, organic N is transformed into NH_3 or NH_4 during ammonification which was responsible for increasing the pH of the compost. The stable pH value during co-composting is due to the buffering capacity of humus, which was synthesized during the maturation phase of composting. The range of pH for the matured compost was between 6 and 8 (Wong *et al.,* 2001).

The Table 2 indicated that EC values of 1.30.1.32 and 1.72 dsm^{-1} were recorded in windrow method of composting, drum vermi composter and drum composter, respectively showing the values are within the permissible limit of 4.0 dsm^{-1} as referred by FCO 1985. The degradation of organic matter in thermophilic phase releases mineral salts such as ammonium, phosphate and thus increases the electrical conductivity. Similar values of electrical conductivity in water hyacinth and municipal waste composting were also reported by Kalamdhad and Kazmi (2008) and Awasthi *et al.* (2015).

The Organic carbon content in all the three compost samples ranged between 23.8 and 25.20 per cent isqualifying criteria for field application (16 to 38 percent) as per the range suggested by FCO (1985).

The C:N ratio is a very important criterion for evaluating the rate of maturity, the load of microbial growth, the quality of compost and nutrients status in the final compost. The microorganisms present in the compost utilize the carbon as a source of energy and the nitrogen for building cell structures. The compost maturity was linearly dependent on primarily C:N ratio. Table 2 showed that the C:N ratio at maturity indicated 21.35 in windrow method of composting, 18.88 in drum vermicomposting and 18.75 in drum composter technology indicates the maturity of composts. Similar values of C:N ratio was observed during the composting of organic waste by several researchers (Guo *et al.,* 2012 and Zhang & Sun, 2014).

Humic substances are bio stimulants that enhance nutrition efficiency, abiotic stress tolerance and crop quality. Organic waste rich in polyphenols, amino acids, and reducing sugars can promote overall Humic substances production (Marge Lanno *et al.* 2022). The Table 2 indicates that Humic acid recorded higher values of 9.53, 10.30 and 12.10 as compared to lower values of fulvic acid consisting of 6.60, 5.90 and 6.50 per cent, respectively in windrow method, drum vermi composter and drum composters indicating maturity of composts. Marge Lanno *et al.* (2022) also shown that during composting, the concentration of Fulvic Acid (FA) decreased, whereas the concentration of Humic acid (HA) increases. Humic acid are generated in the last stage of composting; thus, an increased concentration of HA indicates a higher maturity of the compost and it is considered mature if the HA/FA ratio is higher than 1. The present data also shows that HA/FA ratio of 1.44, 1.74 and 1.86 recorded in windrow method, drum vermi composter and drum composter, respectively which further confirm the better maturity of composts.

Primary, Secondary Nutrients and Heavy Metals Contents in Urban Solid Waste Composts

Table 3 indicates the presence of final concentration of nutrients in different type of the composts. The nutrients like N, P, K, Ca, Mg, S and B were recorded higher values in drum vermi-compost and drum compost and lowest value in windrow method. This is attributed to better decomposition and mineralization processes might have contributed in release of more nutrients into available form compared to windrow method of composting. Municipal solid wastes has been reported to be effectively supply N, P and K with increasing application rates (Iglesias jimaenz *et al.* 1994). Iyengar and Bhave (2006) used an in-vessel composting system for converting household wastes into humus for improving the soil nutrients. Zhenhu Hu *et al.* (2009) also reported that the final cured compost consist of major nutrients (carbon, nitrogen, calcium, magnesium, phosphorus, potassium, sulfur and sodium), the compost also contained trace amounts of zinc, manganese, copper and boron, indicating that the material can be used as a good resource for plant nutrients.

The heavy metals concentration like Fe, Mn, Cu, Zn, Cd, Cr,Pb and Ni were found higher values in windrow method as compared to drum vermi compost and drum compost methods. In windrow method of composting Cd noticed 2.47, Cr of 210.50, Pb recorded traces and Ni recorded 272.30 mg kg^{-1} indicating Cr and Ni were higher than the critical limits. In case of drum vermi-compost and drum composts methods, the values were found tracer values except Cr recorded 16.10 and 16.50 mg kg^{-1}, respectively which is lies below the critical limits as referred by FCO. 1985. Zhelijazov and Warman, (2004 b) opined that total and exchangeable soil Mn, Cu, Zn concentration tended to increase with addition of urban solid waste compost, which might be due to addition of unsegregated urban solid waste compost. Therefore, the mature compost from segregated MSW in the drum compost donot pose heavy metal toxicity and safely used in Agriculture.

TABLE 3

Composition of Primary, secondary nutrients and heavy metals in Urban Solid waste Composts

Parameters	Windrow-method	Drum vermin-compost	Drum compost
N (%)	1.18	1.26	1.28
P (%)	0.45	0.52	0.55
k(%)	0.22	0.58	0.48
Ca (%)	0.85	1.35	1.30
Mg (%)	0.42	0.90	0.85
S (%)	0.72	0.75	0.78
Na (%)	2.60	2.71	2.80
Fe (mg kg^{-1})	3915.50	510.70	578.00
Mn (mg kg^{-1})	378.3	160.00	170.00
B (mg kg^{-1})	0.65	0.71	0.70
Cd (mg kg^{-1})	2.47	traces	traces
Cr (mg kg^{-1})	210.5	16.10	16.5
Pb (mg kg^{-1})	traces	traces	traces
Ni (mg kg^{-1})	272.3	traces	traces

Effect of Urban Solid Waste Compost on Yield of Finger Millet

The finger millet crop grown in different types of compost are shown in the Table 4. The data indicated that the application of three types of compost recorded the grain and straw yields, where, grain yield ranges from 4827 and 4880.00 Kg ha^{-1} and the straw ranges from 7231 and 7285 Kg ha^{-1}. The highest value of 4880.00 Kg ha^{-1} grain and 7285 Kg ha^{-1} straw were recorded in the treatment received drum compost followed by drum vermi-compost recorded 4827 and 7231 Kg ha^{-1} of grain and straw, respectively. The lowest value was recorded in compost prepared from windrow method recorded 4786 and 7183 Kg ha^{-1} of grain and straw, respectively. This might be due to the fact that compost prepared from drum

TABLE 4

Effect of different types of composts on crop yield of finger millet *Eleusine cocacana (L) Gaertn*

Treatment No.	Treatment Details	Grain yield (Kg ha^{-1})	Straw yield (Kg ha^{-1})
T_1	Drum vermi-compost	4827.00	7231.00
T_2	Drum compost	4880.00	7285.00
T_3	Windrow method	4786.00	7183.00
	F-Test	2.62	2.91
	Sem	29.13	29.89
	CD at 5% level	76.32	86.98

composter and drum vermi-composter contains more nutrient status due to efficient mineralosation as noticed in the Table 2 & 3 and which might have contributed for more nutrients absorption by plants and contributed higher yield as compared to windrow method. Farrell and Jones, 2009 also reported that municipal solid waste composts consists of rich source of plant nutrients, which significantly enhanced the plant growth.

Effect of Urban Solid Waste Compost on Nutrient Composition of Grain and Straw in Finger Millet

The data showing in the Table 5, indicated the concentration of nutrients *viz.,* N, P, K, Ca, Mg, S and B in both grain and straw of finger millet crop due to application of compost by drum vermin-composter and drum composter and windrow composting methods. The concentration of N, P, K, S and B in grain and straw were found significantly superior values by application of compost prepared by drum composter and drum vermicomposting as compared to windrow method of composting and Ca and Mg were found no significant values in grain and significant values in straw of finger millet. The significant values of mineral nutrition in the crop by application of composts prepared by drum composter and drum vermi composting might be due to better nutrient availability by efficient mineralization process in the drum composters. Roohi *et al.* (2018) also reported that segregated urban solid waste compost increases nutrient uptake due to complimentary effect of organics upon mineralization increased major and secondary nutrients availability in the soil results in uptake of nutrients. Protima, *et al.* (2023) also noticed same trend of nutrient concentration by application of urban solid compost in rice crop.

TABLE 5

The nutrients concentration in grain and straw, respectively in finger millet as influenced by different composts

Treatments	N (%)		P (%)		K (%)		Ca (%)		Mg (%)		S (%)		B (mg kg^{-1})	
Drum vermi-compost	1.20	0.80	0.07	0.19	0.44	2.00	0.72	1.41	0.52	Mg	0.14	0.43	0.33	0.09
Drum compost	1.21	0.80	0.09	0.22	0.42	2.10	0.72	1.44	0.52	0.62	0.12	0.45	0.41	0.12
Windrow method	1.15	0.52	0.06	0.18	0.41	1.95	0.71	1.33	0.51	0.64	0.12	0.42	0.31	0.08
F-Test	**	**	**	**	**	**	ns	**	ns	0.61	ns	**	**	**
Sem	0.01	0.01	0.01	0.03	0.01	0.04	0.01	0.01	0.01	ns	0.01	0.01	0.01	0.01
CD at 5% level	0.03	0.03	0.003	0.02	0.03	0.18	-	0.03	-	0.01	-	0.03	0.05	0.02

TABLE 6

Concentration of heavy metals in grain and straw of finger millet (mg kg^{-1}) as influenced by different composts

Treatments	Zn		Fe		Mn		Cu		Ni		Cr	
Drum vermi-compost	36.00	50.00	388.0	591.50	158.33	165.00	14.57	7.67	161.00	44.00	71.67	43.00
Drum compost	35.50	42.00	360.67	471.17	170.67	184.17	14.17	6.33	167.17	43.00	81.17	43.33
Windrow method	38.17	60.17	557.33	609.00	210.67	270.00	15.63	8.10	175.33	47.50	106.5	45.00
F-Test	**	**	ns	**	**	**	ns	**	ns	ns	**	Ns
Sem	0.87	0.74	20.13	19.40	5.70	4.99	0.40	0.35	4.67	1.61	1.02	1.04
CD at 5% level	2.67	3.21	86.97	83.80	24.61	21.55	-	1.09	-	-	4.42	-

The results obtained in the Table 6, indicated that concentration of Zn, Fe and Mn, were recorded found superior values in both grain and straw of finger millet crop which received composts from drum composters. The concentration of Cu was found non-significant in grain and significant values in the straw. The values of Ni were found non-significant in both grain and straw, whereas, Cr concentration was found significant in grain and non-significant in the straw.

However, the concentration of Zn, Fe, Mn, Cu, Ni and Cr were recorded higher values in windrow method of composting as compared to drum composters technologies, which might due to contamination of wet waste with solid materials *viz.,* plastics, papers, metals, chemicals, cosmetics; insecticides etc. and non-segregation of waste might have contributed higher concentration of heavy metal concentration in windrow method of composting as compared to drum composters. The increase concentration of micronutrient was probably due to chelation of heavy metals with organic ligands and further mineralization process might have enhanced availability of micronutrient and better absorption of nutrients by the plants. The results of the study are also in accordance with findings of Katyal and Sharma (1991).

Urban solid waste compost prepared from drum composters noticed early maturity of compost by 75 days with dark brown in colour,.optimum bulk density, narrow C:N ratio and higher humic acid than fulvic acid with HA/FA ratio recorded more than one indicating the maturity of composts. The major, secondary and micronutrients were found optimum values and heavy metals like Cd, Cr, Pb and Ni were found within the critical limits (FCO 1985) in drum composters method indicating good quality compost as compared to windrow method. Use of drum compost also recorded higher yield with better quality and optimum nutrient contents in finger millet crop in contrast to windrow compost. Therefore, composts prepared from segregated urban solid waste in drum composters are saferto use in agriculture.

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