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ASSESSMENT OF MUNICIPAL SOLID WASTE COMPOST CHARACTERIZATION AND COMPLIANCE

P. B. VYAS

Sigma Institute of Engineering Bakrol, Vadodara, India

Key words : Municipal Solid Wastes (Management and Handling) Rules, 2000, Municipal Solid Waste (MSW), Municipal Solid Waste Compost (MSW Compost), Physico-chemical characteristics, Heavy Metals.

ABSTRACT

The Central Pollution Control Board (CPCB) undertook a comprehensive study on assessment of quality of Municipal Solid Waste (MSW) Compost of a few compost plants located at Bangalore, Malad, Delhi, Bhopal, Nashik, Ahemdabad and Gwalior in India. The Municipal Solid Waste (MSW) that was fed to the MSW Compost plant and the MSW Compost produced in the plants were collected, processed and analyzed for various physico-chemical characteristics and heavy metals. The average values of physico-chemical parameters determined were compared with the standards, specified for different parameters specified in the Municipal Solid Wastes (Management & Handling) Rules, 2000 (MSW Rules). It was observed that the heavy metals in MSW Compost samples from cities like Ahemdabad and Nashik were within limits for all the heavy metals except for Pb, while in other cities like Bangalore, Malad, Delhi and Gwalior, the concentration of heavy metals in MSW Compost exceeded the limits.

INTRODUCTION

Municipal Solid Waste (MSW) contains a large organic fraction ranging from 30 to 50% of the total waste generated. This organic content tends to decompose leading to odour problem. Ensuring a safe disposal of the MSW and to reduce the required capacity of the disposal site/landfill site, it is necessary that waste is processed. Several processing options are available for this purpose and these could be attempted as per their applicability. Amongst the common and familiar known processing technologies is, "Composting", which could be adopted to achieve the said objectives. Composting is defined as an aerobic biological decomposition process in which some of the organic material is decomposed te carbon dioxide and water, with stabilized products, principally synthesis of humic substances, (Golueke, 1977; Kawata *et al.* 1977). Composting can be carried out in two ways, aerobically and anaerobically. During aerobic composting, aerobic microorganisms oxidize organic compounds to CO_2, $NO_2$and NO_3 and carbon from organic compounds is used as a source of energy while nitrogen is recycled. Due to exothermic nature of the reaction, temperature of the mass rises. During anaerobic process, the anaerobic microorganisms, while metabolizing the nutrients, break down the organic, compounds through a process of reduction.

***Address for correspondence - Email** : vyas paulomi68@gmail.com

A very small amount of energy is released during the process and the temperature of composting does not raise much and the gases evolved are mainly CH_4 and CO_2. An anaerobic process is a reduction process and the final product is subjected to some minor oxidation when applied to land. Composting is mainly applied for treating about 20 % of the total amount of MSW being disposed (Yuan-Song Wei *et al.* 2000). MSW compost is the product yielding greatest enhancement of soil enzymatic activity or balanced enhancement of soil biological activity after the application of organic residues (Albiach, 2000). After the waste is composted, only the non-decomposable fraction remains to be disposed off on land. Thus, the land requirement, which is a critical component and is in short supply in urban centers, is substantially reduced leading to overall economy. In recent past, large numbers of municipalities have either installed compost plants for utilizing MSW or have taken initiatives to set up such facilities. However, compost so produced should meet the specified standards as per Municipal Solid Wastes (Management & Handling) Rules, 2000 (MSW Rules). Presently, there is no information available on quality of compost produced by the existing operated compost plant. With an objective to ascertain quality of compost produced and its compliance with the standards prescribed under MSW Rules, CPCB instituted a study for this purpose.

MATERIALS AND METHODS

To assess the quality of compost produced at a few plants, Central Pollution Control Board(CPCB), India undertook the present comprehensive study. The study was aimed to assess the composition of compost particularly with reference to the standards specified in the Municipal Solid Wastes (Management and Handling) Rules, 2000.

The studies mainly focused on the assessment of concentration of heavy metals, particularly to ascertain their presence in the raw waste that is fed to the compost plant and that of the concentration of heavy metals in the final product. To take into consideration of the variation in the raw waste characteristics, food habits, climatic conditions etc., field visits were made to various mechanical composting plants set up at different geographical locations. Visit to these plants were made at different times of the year for ensuring that the results obtained could help in drawing proper conclusions.

The compost plants, which are based on aerobic windrowing method located at Delhi, Bhopal, Gwalior, Malad (Mumbai) and two plants at Bangalore were selected for the study. In addition to these plants, one of the plants located at Ahemdabad and one at Nashik, were also visited and the samples were collected.

At every plant site, samples were collected from the raw MSW input as well as from the Final MSW Compost. The samples were collected, analyzed for physico-chemical characteristics at the plant site and also a detailed chemical analysis was done in the laboratory.

Physico-Chemical Analyses : Physico-chemical parameters such as pH, Moisture, Organic matter, Carbon, Nitrogen, Phosphorus as P_2O_5, Potassium as K_2O, Pesticides, Toxicity Characteristic Leaching Procedure (TCLP) and heavy metals (Katia *et al.* 2006) were analyzed comparing the standards as shown in Table 1 and according to standard procedures (Bidlingmaier, 1978).

Standard procedures were followed for determining N (Kjeldhal's method), Potassium (Flame photometer), Pesticides (Gas Liquid Chromatography/ High Performance Liqud Chromatography (GLC/ HPLC) and heavy metals (Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) present in MSW Compost (Dubendorf, 1978 and Suess 1976) and the appropriate bacteriological test methods are applied to MSW and its Compost (Suess, 1982).

Table 1. Standards for MSW compost

S.No.	Parameters	Concentration not to exceed
1.	Arsenic	10.00
2.	Cadmium	5.00
3.	Chromium	50.00
4.	Copper	300.00
5.	Lead	100.00
6.	Mercury	0.15
7.	Nickel	50.00
8.	Zinc	1000.00
9.	C/N ratio	20-40
10.	pH	5.5-8.5

Note : Values in mg/100g except C/N ratio & pH.

RESULTS AND DISCUSSION

Physico-Chemical Analyses: The standard methods/ protocols for the physico-chemical Analysis of Solid Wastes were followed to estimate the physico-chemical parameters of MSW and its Compost.

The average values of various parameters of MSW that was fed to the mechanical composting plants in various cities was observed and the average paper content was 3.2% and ranged from 0.53% to 6.13%. Paper is amenable to composting. However, the inks used contain heavy metals and this may add to the heavy metal content to the compost. The rubber, leather and plastics recorded values were comparable to that of paper and ranging from 0.38 to 5.47% and 2.24 to 6.8% respectively. These materials are not amenable to composting and have been removed and disposed off as rejects. The average metal content of the waste was only 0.22% and was ranging from 0.03% to 0.75% which denotes that the metals have been extensively recovered and recycled. The stones, crockery, earthen wares constitute nearly 10% of the input waste and have been separated and disposed off as they are non-degradable and their presence in the composting process may affect the quality of the final product. The fines represent an average of 8.77% and ranged from 2 to 30.79%. These mostly contain ash, earth and fine organics. The heavy metal content of the fines add to the heavy metal content of the compost. The visits to these compost plants were followed with sample collection and the percentage of total compostable matter present in various cities was found to be in the range from 44% to 82%, which on decomposition yields the final product as humus. Based on the analysis of raw MSW input and the finished MSW Compost sample, further characterization has been made and the findings are as under;

pH : The average pH value of the raw MSW input was 7.11 and the values ranged from 6.57 to 7.64. The neutral pH indicates that the Municipal Solid Waste received at the plants was afresh. The pH of the MSW Compost samples was found to be on alkaline side with the average value of 7.24 and the values were ranging from 6.89 to 7.79.

Moisture Content: The percentage of moisture content of Municipal Solid Waste was found to be 50.71% and ranged between 44.53 to 56.11%. The average moisture content of the MSW compost was 25.01% and was ranging from 18 to 32%.

Organic Matter: The organic matter of the MSW on an average was-52.37 % and was ranging from 30.65 to 73.74 %. The organic content in MSW at Malad, Bangalore, Nashik and Gwalior plants was more than 50 % while that of Bhopal and Ahemdabad was slightly more than 40%, but for Delhi it was as low as 30 %. The organic matter in Delhi, Bhopal and Gwalior MSW compost samples were found to be much lesser though in all the cases it was more than 25%. The average value of organic matter of MSW Compost was 27.92% and ranges were between 17.21 to 40.5 %.

C/N Ratio: The average nitrogen content of the MSW was 0.85 % and the MSW at Malad, Bangalore, Bhopal and Nashik recorded values higher than this

Table 2. Average Values of Chemical Analysis of MSW and MSW Compost.

			Parameters							
Sr. No.	Component	Name of the City	pH	O.M.%	C%	N%	C/N	K20%	P_20_5%	Moisture
1.	MSW	Bangalore	7.07	59.35	32.97	0.91	37.04	0.64	0.81	44.53
2.		Malad	6.57	65.69	36.93	1.06	35.47	0.67	0.88	53.63
3.		Delhi	7.27	30.65	17.02	0.50	36.03	0.64	0.93	51.74
4		Bhopal	7.64	41.07	22.81	0.89	26.04	0.42	0.61	56.11
5.		Nashik	7.20	73.74	40.97	0.91	45.07	0.70	0.82	48.00
6.		Ahmedabad	6.94	43.70	24.28	0.81	30.33	0.76	0.78	50.75
7.		Gwalior	7.11	52.39	28.69	0.84	33.89	0.68	0.89	50.24
8.		Average	7.12	52.37	29.16	0.85	35.00	0.64	0.81	50.79
9.	MSW Compost	Bangalore	7.09	27.79	15.39	1.02	15.19	0.65	0.89	25.24
10.		Malad	6.89	35.60	19.91	1.26	17.93	1.03	0.66	24.50
11.		Delhi	7.27	22.10	12.28	0.64	19.38	0.70	0.35	23.29
12.		Bhopal	7.79	18.01	10.00	0.56	19.26	0.79	0.42	28.22
13.		Nashik	7.20	40.50	22.49	1.19	18.53	1.00	1.00	31.67
14.		Ahmedabad	7.28	34.20	19.00	1.10	17.38	0.86	1.00	31.67
15.		Gwalior	7.18	17.21	9.56	0.40	24.14	0.78	0.15	18.68
16.		Average	7.24	27.92	15.52	0.88	18.83	0.83	0.64	25.01

Table 3. Average values of heavy metals of MSW and MSW compost.

			Parameters								
Sr. No.	Component	Name of the City	Pb	Ni	Cd	Cr	Cu	Zn	Mn	Fe	Hg
1.	MSW	Bangalore	184.54	62.59	5.58	113.52	345.37	626.34	34.86	18778.21	0.01
2.		Malad	100.38	36.58	2.63	37.06	219.04	341.80	101.78	13912.65	0.23
3.		Delhi	56.09	57.41	3.34	110.94	176.61	479.88	539.11	23909.11	0.05
4.		Bhopal	79.55	35.83	6.49	30.71	288.49	547.10	493.11	27602.89	0.07
5.		Nashik	46.81	30.98	1.50	7.50	173.29	334.5	222.20	10669.00	0.02
6.		Ahmedabad	47.05	38.47	3.98	48.41	288.29	361.00	263.50	19396.00	0.03
7.		Gwalior	91.68	58.86	3.12	101.11	294.42	489.31	462.13	15219.30	0.08
8.		Average	86.58	45.82	3.81	64.18	213.15	454.27	302.38	14941	0.07
9.	MSW Compost	Bangalore	247.92	76.70	11.11	176.47	1655.38	1771.26	157.47	19142.05	0.03
10.		Malad	108.92	39.72	8.63	44.64	566.12	237.96	18.75	12631.46	0.31
11.		Delhi	201.75	78.31	7.14	351.84	518.96	858.05	530.47	21456.11	0.06
12.		Bhopal	187.73	37.87	12.14	75.68	131.82	996.52	594.78	31917.22	0.08
13.		Nashik	102.95	8.30	6.30	25.20	130.99	232.22	478.70	27054.00	0.01
14.		Ahmedabad	125.95	24.42	3.80	37.07	210.33	298.67	233.70	13004.00	0.02
15.		Gwalior	303.13	55.65	10.84	81.39	373.22	976.67	573.86	15917.47	0.05
16.		Average	182.62	48.85	8.58	113.18	512.4	767.33	369.68	20160.33	0.08

percentage while that at Delhi it was only 0.5 %. The MSW in Bhopal was having low C/N ratio of 26.04 while the C/N ratio in all other plants was more than 30. The average nitrogen content of the MSW Compost was 0.88 % and the nitrogen content of MSW Compost in Delhi, Bhopal and Gwalior samples was also low while in all the other cities it was exceeding I %. Whereas the C/N ratio of Bangalore was less compared to all other cities with an average value of 18.83%.

Potash and Phosphorus : The average values of potash and phosphorus of MSW were 0.64 and 0.81 % and were ranging from 0.42 to 0.76 % and 0.61 to 0.93 % respectively. The average values of phosphorus and potassium of MSW compost were 0.64 and 0.83 % and were in the range of 0.15 to 1 % and 0.65 to 1.03% respectively.

The recorded values of the parameters like pH, Organic Matter (O.M), C/N ratio, Potassium and Phosphorus for MSW and MSW Compost samples were shown in Table 2.

Heavy Metals : The average values of heavy metal in the MSW fed to the various mechanical composting plants are: The Pb contents ranged from 47.05 to 184.54 mg/kg, while the Ni content ranged from 30.98 to 62.59 mg/kg, Cd content ranged from 1.5 to 6.49 mg/kg and the Cr content ranged from 7.5 to 113.52 mg/kg. The Cu, Zn and Mn recorded comparatively high values and the respective ranges were 173.29 to 345.37, 334.5 to 626.34 and 34.86 to 539.11. The Fe content was very high and ranged from 10669 to 27602.89 mg/kg. The Hg content was very low and ranged from 0.01 to 0.23 mg/kg.

The heavy metals contained in MSW compost samples collected from the various plants are: The Pb content was observed to range from 102.95 to 303.13 mg/kg, while Ni content ranged between 8.3 to 78.31 mg/kg. Cd was comparatively on the lower side and ranged from 3.8 to 12.14 mg/kg and the Cr content ranged from 25.2 to 351.84 mg/kg. The Cu recorded comparatively higher values and the values were from 131.82 to 1655.38 mg/kg. The Zn was also found to range from 232.22 to 1771.26 mg/kg while Mn contents were comparatively lower with values ranging between 18.75 to 594.78 mg/kg. The Fe values were again very high and ranged between 12631.46 to 31917.22 mg/kg. The Hg was comparatively negligible and the values recorded were in the range of 0.0 1 to 0.31 mg/kg. Leeper (1978) reported that toxicity of some heavy metals at concentration as low as a few PPM have been documented. The values of heavy metal concentration of MSW and MSW Compost were shown in Table 3.

Toxicity Characteristic Leaching Procedure (TCLP) : The TCLP values were obtained using distilled water and the values were ranging from 0.88 mg/kg to 32.63 mg/kg for Cd, Cr, Cu, Zn, Mn, Ni, Hg and Fe metals. The TCLP values for the MSW Compost samples were comparatively on the lower side and the average values of Mn, Zn, Cr. Cd and Ni were less than 10 mg/kg while those of Pb, Cu and Fe were above 10 mg/kg.

Pesticide : The pesticide content of the input waste was observed to be aldrine; Benzene Hexa Chloride (BHC) and Dichloro-Diphenyl-Trichloro ethane (DOT) present in very small concentration, which were always less than 0.53 mg/kg. As the pesticide content in the waste fed to the plant was low, very low values were again recorded in the MSW compost samples.

Bacteriological Test : The final product gives a negative bacteriological value in all the samples at Nashik. However in all other plants, a few samples were always answering positive for bacteriological test.

CONCLUSION

Currently there is a widespread interest on the part of local Governments in incorporating Municipal Solid Waste (MSW) composting into their integrated solid waste management systems. A total of seven compost plants, located all over the country represented all the variations in the factors affecting the physico-chemical characteristics were studied. The pH of the MSW Compost samples was found to be on alkaline side with the average value of 7.24 and the values were ranging from 6.89 to 7.79. Heavy metal are generally insoluble at the initial ash alkaline pH and so leach over the long-term.

The average values of heavy metals in the MSW that was fed to various composting plants indicated that the Pb ranged from 47.05 to 184.54 mg/kg, Ni between 30.98 and 62.59 mg/kg and Cd between 1.5 to 6 49 mg/kg. The Cr was observed to range between 7.5 to 113.52 mg/kg. The Cu, Zn, Fe & Mn recorded comparatively higher values, which ranged between 173.29 to 345.37, 334.5 to 626.34, 10669 to 27602.89 and 34.86 to 539.11 respectively. The Hg content was very low and ranged from 0.01 to 0.23 mg/kg. The heavy metal content in the MSW Compost samples collected from various plants indicated Pb values between 102.95 to 303.13 mg/kg while Ni & Cd ranged between 8.3 to 78.31 mg/kg and 3.8 to 12.14 mg/kg respectively. The Cu recorded comparatively higher values and ranged between 131.82 to 1655.38 mg/kg. The Zn & Mn values ranged between 232.22 to 1771.26 and 18.75 to 594.78 mg/kg respectively. The Fe content was again very high and ranged between 12631.46 to 31917.22 mg/kg. The Hg content was very low and ranged between 0.01 to 0.31 mg/kg. When these values are compared with the permissible values of different heavy metals specified in the MSW Rules (2000) it was observed that the heavy metais in MSW Compost samples from cities like Ahmedabad and Nashik were within limits for all the heavy metals except for Pb as per the standards while other cities like Bangalore, Malad, Delhi and Gwalior exceeded the limits.

It was felt that the heavy metal content in the compost could be kept within limits when only organic waste material of plant origin is fed to the composting plant. And the impact of heavy metals on landfill site was found to be less when MSW was pretreated under aerobic composting.

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REFERENCES

Albiach, R. Canet, R. Pomares, F. and Ingelmo, F. 2000, Microbial biomass content and enzymatic activities after the application of organic amendments to a horticultural soil. *Bioresource Technology*. 75 (1) : 43-48.

Katia Lasaridi, Loanna Protopapa, Maria Kotsols, George Pillidis, Thakis Manios and Adamantini Kyriacou, 2005. Quality assessment of composts in the Green Market The need for standards and quality assurance. *Journal of Environmental Management*. 80 (1) : 58-65.

Suess, M.J. 1976. *Standard Methods for the Examination of Water and Wastewater*, 14th ed. New York American Public Health Association, American Water Works Association & Water Pollution Control Federation.

WRC, Water Resource Centre, 1985. The Agricultural value of sewage sludge -A farmer's guide. WRC.

Yuan-Song Wei,Yao-Bo Fan, Min-Jian Wang and Ju-Si Wang, 2000. Composting and compost application in China. *Resource Conservation and Recycling*. 30 (4) : 277-300.