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A Study on Quality of Windrow Compost Produced From Different Municipal Solid Wastes in India

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Abstract- **Indian Municipal solid waste (MSW) consists of 50-55 % of bio degradable organic matter. This typical composition suggests composting as a suitable option, if source segregation can be adopted. Composting of MSW is proved to be a sustainable option in many countries as the other methods of disposal pose challenges like demand for land, leachate pollution, gas production, low calorific value, heterogeneity of combustible materials, air pollution, etc. Composting organic material in MSW will result in compost, which can be used as soil conditioner in agriculture. With the cost of inorganic fertilizers on the rise in the recent decades, compost can be a good substitute for farmers. The present paper reports the results of a study wherein the quality of compost produced by adopting Windrow/aerobic Composting. As a part of above study Windrow/aerobic Composting samples are collected from different Municipal corporations which are using Windrow/aerobic Composting and the quality of compost is analyzed. Fertilizing Index and Clean Index are used for assessing the quality of the compost. The indices are categorized into marketable classes (A, B, C & D) or restricted use class (RU-1, RU-2 & RU-3) based on their fertilizing parameter and Heavy metal content.**

Key words: Municipal solid waste, composting, Fertilizing Index, Clean Index, Windrow/aerobic (WC) Composting

I. INTRODUCTION

In the recent years, several municipalities have started using composting as an option to dispose of segregated biodegradable portion. In this context, five locations namely, Indore (M.P), Bhopal (M.P), Mettupalayam(T.N), Himachal Pradesh, Udumalpet (T.N). A total of 5 grab windrow/aerobic compost samples of MSW composts were collected from different municipal corporations in India. The details are shown in Table 1.1

Grab sampling method is used for collection of the samples. The compost samples collected were specifically produced from Municipal solid waste. The municipal solid waste was either mixed waste, partially segregated or Source separated before composting. The information pertaining to type of raw material used and techniques or methods involved for composting, was collected from the Manufacturers of compost.

Table-1: Locations and Notations of Samples of MSW Composts Collected

S. No.	Code	Location	Relevant Practices
1	W1	Indore (M.P)	TN, Karnataka, TS, AP etc.,
2	W2	Bhopal (M.P)	
3	W3	Mettupalayam(T.N)	
4	W4	Himachal Pradesh	
5	W5	Udumalpet (T.N)	

The parameters of moisture content, volatile solids, pH, EC, Total organic carbon, plant nutrients such as N, P & K, C: N ratio, Carbon respiration and heavy metals were tested and are compared with compost guidelines given by FCO 1985. The heavy metals in the samples were also compared with MSW 2000 (handling) rule, Finland Compost standards, USA bio solids and EEC organic rule. The results are discussed here.

The physical and chemical parameters of all the large scale compost was tested in the laboratory. Parameters such as Moisture content, volatile solids, pH, EC, Total organic carbon, plant Nutrients such as N, P, K and C: N ratio, Carbon respiration and heavy metals. All the parameters

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Were compared with Compost guide lines given by FCO 1985. The heavy metals in the compost samples were also compared with MSW 2000 (handling) rule, USA bio solids and EEC organic rule.

II. ASSESSMENT OF COMPOST QUALITY:

The Main objective is to assess the compost quality. The standards prescribed for parameters such as Moisture content, pH, EC, Volatile solids, Total Organic carbon, Total Nitrogen, Total Phosphorus, Total Potassium and Carbon respiration are the same in every country having compost quality standards. But there are huge variations in the permissible limits of Heavy metals in Compost. Most European countries have their own set of standards regarding permissible heavy metal limits, while USA has an entirely different set of standards for permissible limits of heavy metals in compost. In India MSW handling rules (1999) prescribes a limit whereas The Fertilizer Control order 1985 (FCO) quality control prescribes a stricter set of limits set by MSW handling rules (2000). It can be observed in the table below that Finland has highest or strictest set of standards while there is a lot of lenience in USA bio solids standards with regard to Cu, Cr, Cd and Ni. Indian standards are neither in the both extremes.

Saha et. Al. (2009) developed indices such as fertilizing index and clean index to grade the compost and then determine its quality. It helps to standardize the quality of compost. And it also can be used to find the method used to get the best quality of compost from Municipal solid waste.

2.1.1 Fertilizing Index:

Each analytical data affecting the fertilizing value (responsible for improving soil productivity) of compost, like total C, N, P and K contents as well as C:N ratio and respiration activity, are assigned to a 'score' value as per the category given in Table 2 While assigning score values, analytical values of these fertilizing parameters obtained for source separated biogenic waste composts are considered. The minimum values of above fertilizing parameter obtained for such composts were placed under score value '3'. Higher value of any fertilizing parameters were assigned higher score value. On the basis of scientific knowledge on their role in improving soil productivity, each of these fertility parameters was assigned a 'weighing factor'.

The 'Fertilizing index' of the MSW composts is computed using the formula

$$\text{Fertilizing index} = \sum W_i S_i / \sum W_i \quad \text{---(1)}$$

Where 'Si' is score value of analytical data and 'Wi' is weighing factor. The values of Si and WI for fertilizing index are given in table 2.

2.1.2 'Clean index'

Value was calculated by the following formula. Higher score is ascribed for less heavy metal content and thus, composts with less heavy metal contents attain higher value of 'Clean index'.

$$\text{Clean index} = \sum W_j S_j / \sum W_j \quad \text{---(2)}$$

Where 'Sj' is score value of analytical data and 'WI' is weighing factor of the 'j'th heavy metal. (Saha et al 2009)

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Fig1: Municipal Solid Waste shredder, compost piles.

III. RESULTS AND DISCUSSION

The physical and chemical parameters of all the large scale compost was tested in the laboratory and presented table 2. Parameters such as Moisture content, volatile solids, pH, EC, Total organic carbon, plant Nutrients such as N, P&K, C: N ratio, Carbon respiration and heavy metals. All the parameters were compared with Compost guide lines given by FCO 1985. The heavy metals in the compost samples were also compared with MSW 2000 (handling) rule, USA bio solids and EEC organic rule.

Results of Windrow/aerobic Composts are shown in Table 1.2

It is important for the survival of microorganism which decomposes the organic matter; the optimum value of moisture content in a compost sample must be 20 – 30% (FCO 1985). The compost should not be too dry or too clumpy. The WC samples had moisture content ranging from 5.10 – 40.7 %..The samples had volatile solids ranging from 31.90 – 87.50 % dm..The EC value ranged from 2.65 – 7.18 dS/M.. The pH of the samples showed very less variation and all the samples had pH within the optimum range i.e. 6.5 to 8.5.

In large scale Windrow/aerobic composts, the amount of total organic carbon (TOC), ranged from 17.7 – 48.6 % dm. Windrow/aerobic(WC) composts had Total N, P, K contents ranging from 0.50 – 1.81 % dm, from 0.01 to 0.10 % dm, from 0.13 – 0.34 % dm respectively. Samples of C:N ratio ranged from 14.8 – 97.20 as the table 1.2 which is higher than the permissible limit. The compost respiration for Windrow/aerobic composts ranged from 0.6 – 1.5 CO2 – C/g VS d.

WC had heavy metals ranging between 81.80 – 658 mg/Kg for Zn, between 21.50 – 367 mg/kg for Cu, between 1.10 – 3.20 mg/kg for Cd, between 5.70 – 1000 mg/kg for Pb, between 5.70 – 51.20 mg/kg for Ni, between 7.70 – 67.90 mg/kg for Cr. The WC samples W1 & W2 had lead (Pb) limits higher than the permitted limit.

The Fertilizing Index and Clean Index were calculated using equations 1 and 2. The score values are given in Tables 1.3&1.4 and Graph1.2

Samples W1& W2 were classified as Ru-3 as it had FI above 3.0 but at least one heavy metal (Pb) as the table 2.1 was above the permitted limit. The samples W3 and W4 were classified as Class D as they had FI between 3.1- 3.5 and CI between 3.1 and 4.0. W5 was classified as Class C as it had a FI above 3.5 and CI between 3.1 and 4.0.As shown table 1.5the compost use in different areas is mentioned in ***Table 1.5.***

Sl. No.	Parameters	UOM	W1	W2	W3	W4	W5	FCO/ MSW 2000	Finland Class		USA	EEC Organic Rule	EU Range
									A	B			
1	Moisture content	%	13.7	13.4	6.8	40.7	5.1	20-30	NA	NA	NA	NA	NA
2	Volatile solids	%	72.8	76.9	87.5	31.9	82.2		NA	NA	NA	NA	NA
3	pH		7.7	7.5	8.9	7.3	9.0	6.5-7.5	NA	NA	NA	NA	NA
4	EC	dS/m	3,71	3.44	2.65	3.60	7.19	3.14	NA	NA	NA	NA	NA
5	Total Organic C	%dm	40.4	42.7	48.6	17.7	45.7	>16	NA	NA	NA	NA	NA
6	Total N	%dm	0.8	0.9	0.5	1.2	1.8	>0.5	NA	NA	NA	NA	NA
7	Total P	%dm	0.014	0.013	0.037	0.097	0.061	>0.22	NA	NA	NA	NA	NA
8	Total K	%dm	0.31	0.34	0.14	0.13	0.2	>0.83	NA	NA	NA	NA	NA
9	C:N Ratio		50.6	47.5	97.2	14.8	25.4	20.01	NA	NA	NA	NA	NA
10	Carbon Respiration	mg(CO_2-C/g Vs d)	0.8	0.9	0.6	0.8	1.5	2-8	NA	NA	NA	NA	NA
Heavy Metals													
11	Zinc as Zn2+	mg/kg	658	560	81.8	100	92.1	92.1	<1000	75	2800	200	210-4000
12	Copper as Cu2+	mg/kg	367	285	91	21.5	61.4	61.4	<300	25	1500	70	70-600
13	Cadmium as Cd2+	mg/kg	3.2	2.2	1.6	1.3	1.1	1.1	<5	0.7	39	0.7	0.7-10
14	Lead as Pb2+	mg/kg	1000	872	46.7	5.7	20.3	20.5	<100	65	300	45	70-1000
15	Nickel as Ni+	mg/kg	51.2	46.8	23.5	5.7	20.5	20.5	<50	10	420	25	20-200
16	Chromium as Cr3+	mg/kg	67.9	47.6	47	7.7	24.2	<50	50	50	1200	70	70-200

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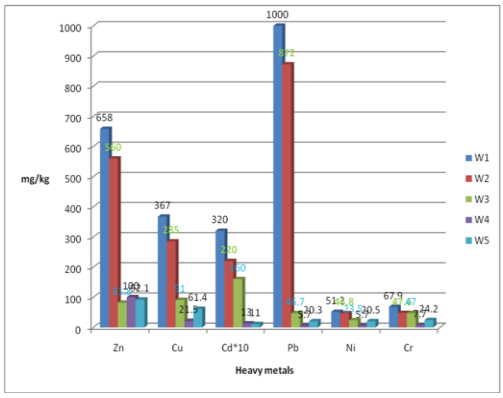

Fig2: Percentage of heavy metals present in each large scale WC sample

Table 3: Fertilizing Index of Large scale WC sample

Fertilizing Parameters	W1 (Si)	W2 (Si)	W3 (Si)	W4 (Si)	W5 (Si)	Wi
Total Organic carbon	5	5	5	4	5	5
Total N	3	3	2	4	5	3
Total P	1	1	1	1	1	3
Total K	2	2	1	1	2	1
C:N Ratio	1	1	1	4	2	3
Carbon Respiration	5	5	5	5	5	4
Fertilizing Index = ∑Wi Si/ ∑ Wi	3.2	3.2	3	3.5	3.6	

Table 4: Clean Index of Large scale WC samples

Heavy Metals	W1 (Sj)	W2 (Sj)	W3 (Sj)	W4 (Sj)	W5 (Sj)	Wj
Zinc as Zn2+	2	2	5	5	5	1
Copper as Cu2+	2	2	4	5	4	2
Cadmium as Cd2+	1	1	2	2	2	5
Lead as Pb2+	0	0	5	5	5	3
Nickel as Ni+	3	3	4	5	5	1
Chromium as Cr3+	4	5	5	5	5	3
Clean Index = ∑Wj Sj / ∑ Wj	1.7	1.9	3.8	4	3.8	

All the WCs had a FI of 3.3 and CI of W1 & W2 was below 2, W3 and W5 were 3.8 while only W4 was 4.

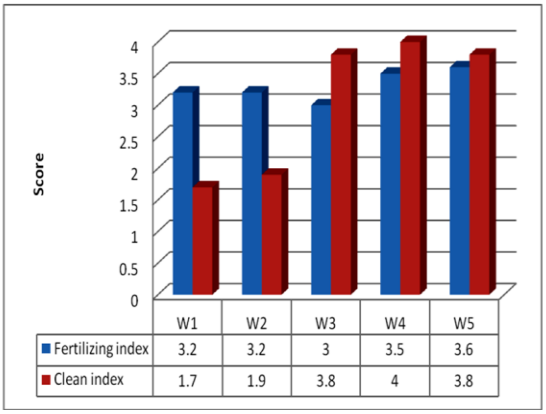

Fig3: Windrow compost large scale Sample Vs. Score Value of Indices

Table 5: Classification of WC sample based on score value

S.No	Sample	FI	CI	Class	Quality	Remarks
1	W1	3.2	1.7	Ru-3	Restricted use	Restricted use. Should not be allowed to market. Can be used only for developing lawns/gardens (with single application),rehabilitation of degraded land
2	W2	3.2	1.9	Ru-3	Restricted use	Restricted use. Should not be allowed to market. Can be used only for developing lawns/gardens (with single application),rehabilitation of degraded land
3	W3	3	3.8	D	Medium Quality	Medium Fertilizing Potential complying for all heavy metal parameters
4	W4	3.5	4	D	Medium Quality	Medium Fertilizing Potential complying for all heavy metal parameters
5	W5	3.6	3.8	C	Good Quality	High fertilizing potential and medium heavy metal content

IV. CONCLUSIONS

The compost produced by adopting windrow/aerobic composting is assed and reported in this work. This will gives the suitability application of municipal waste produced compost. The important physical and chemical characteristics of the compost produced indicates good quality of compost especially in terms of MC, TC, N, P, K and C: N. The results suggest windrow/aerobic can be suitable option as it reduces burden on landfills and is much cheaper option than incineration. Also it is suitable, clean option when compared with incineration. In terms of CI &FI also the windrow/aerobic from WI&W2 is restricted use; it can be used only for developing lawns

/gardens, means low fertilizing Potential but it should not be allowed to market due to low fertilizing potential. However, these can be used as soil conditioner. W3&W4 Medium Quality Medium fertilizing potential and low heavy metal content and w5 is good quality means high fertilizing potential and medium heavy metal content.

Efforts can be made to find the cause for poor quality of composts. This finding the CI &FI will gives the suitability application of produced compost where we supposed use to minimize the land pollution consumable pollution. Considering the existing conditions is still a challenge in adopting composting in addition to marketing the compost. A revenue model needs to be evolved to makes this a suitable practice which loading the large quantities of MSW

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