RESEARCH ARTICLE OPEN ACCESS

Compost Quality Assessment Of Greater Hyderabad Municipal Corporation (GHMC), India

B. Vinod*, A. Ravindernath**
*(Department of Environmental Science, Osmania University, Hyderabad-07)
** (University College of Technology, Osmania University, India)

ABSTRACT
India produces about 3000 million tons of MSW annually out of which 40 –50 % are compostable. Compost Quality plays a very important role in making MSW compost a marketable product as they are tested for fertilizing parameters, heavy metal parameters and harmful pathogens. In the present study, an attempt has been made to understand the quality of compost so formed by the windrow composting process from the MSW obtained from Jawahar Nagar, and the vegetable waste from the commercial area Hyderabad by it analysis (Laboratory as well as statistical) and the quality of composts was found out using Quality control Indices such as Fertilizing Index and Clean Index.Parameters like Moisture content, pH, EC, TOC, Total Nitrogen, Total Phosphorous, Total Potassium, C/N ratio, and heavy metals like Zinc, Copper, Cadmium, Nickel, Lead, and chromium were analyzed and it was found that all the parameters are within the permissible limits prescribed by FCO. Further Fertility Index and Clean Index were determined for both the samples and it was found that both the samples had a fertility index value of 4.2 and clean index value of 4.2 for sample I and 3.6 for Sample II was determined. These Indices values are used to find out the class to which the compost belongs to; and hence it was found out that sample I belonged to Class A category whereas Sample II belonged to Class C category. Hence it can be recommended that proper segregation of the solid waste is important from composting point of view because mixed waste affects the quality of compost.
Keywords - C/N ratio, Clean Index, Compost, Heavy metals, MSW.

I. Introduction

India is the world's second highest populated country after China with the population of 1.21 billion containing 17.5% of the world's population, with the growth rate of 3.35% (2011 census). It is interesting to note that currently 1 out of 3 persons is living in urban areas and it is projected that as much as 50% of India's population will live in cities in next 10 years [1]. In spite of heavy expenditure by civic bodies, Management of municipal Solid waste (MSW) continues to remain one of the most neglected areas of urban development in India.

The MSW amount is expected to increase significantly in the future as the country strives to attain an industrialized nation status by the year 2020[2]–[5]. Poor collection and transportation are responsible for the accumulation of MSW at every nook and corner. The management of MSW is going through a critical phase, due to unavailability of suitable facilities to treat and dispose the larger amount of MSW generated daily in Metropolitan cities. Unscientific disposal causes an adverse impact on all components of environment and human health [6]–[13]. The difficulties in providing the desired level of public service in Urban centres are often attributed to the poor financial status of the managing municipal corporations [14]-[18]. For most of the urban local bodies in India solid waste is a major concern that has reached alarming proportions requiring management initiatives on a war-footing and the present scenario provides a clumsy picture in terms of service delivery as evidenced by absence of adequate overall waste management mechanism [19].

Municipal Solid Waste Management (MSWM) is one of the major environmental problems of Indian megacities. It involves activities associated with the generation, storage, collection, transfer and transport, processing and disposal of solid waste. The management of MSW requires proper infrastructure, maintenance and upgrade for all activities. Municipal Solid Waste (Management & Handling) Rules, 2000 (MSW Rules) are applicable to every municipal authority responsible for collection, segregation, storage, transportation, processing and disposal of municipal solids.

India produces about 3000 million tons of MSW annually out of which 40 –50 % are compostable [20]. The composition of Municipal solid waste on an average in Indian cities is (% by weight)) Paper – 5.7, Textile – 3.5, Leather – 0.8, Plastic – 3.9, Metals – 1.9, Glass – 2.1, others (Inerts) – 40.3, Compostable matter – 41.80 [21]. It can be noted that most of the MSW is Inerts (30-40%) and Compostable matter

(40-50%). It was also found that the relative percentage of compostable matter increases with decreasing order of socio-economic status. Some of the common methods to treat and dispose MSW in India are Windrow Composting, Vermicomposting, Incineration, Refuse Derived Fuel (RDF) Plants, and Biomethanation.

The bacterial conversion of the organics present in MSW in the presence of air under hot and moist conditions is called composting, and final product obtained after bacterial activity is called compost (Humus), which has very high agricultural value. It is used as fertilizer, and it is non-odorous and free of pathogens [18], [22]. As a result of the composting process, the waste volume can be reduced to 50-85%.

The first large-scale anaerobic composting plant in the country was set up in Mumbai in 1992 to handle 500 t/day capacity while the other plant with 150 t/day capacity has been operated in the city of Vijaywada, and over the principle cities of the country such as Delhi, Bangalore, Ahemedabad, Hyderabad, Bhopal, Luknow, Gwalior, etc. Now, about 9% of MSW is treated by Composting [10], [11], [13], [20], [23]-[29].

The emergence of compost quality had come in to focus mainly in Europe and USA where biodegradable waste was converted to compost and used widely as fertilizers. But many farmers began to notice plastics & Glass pieces mixed with the compost due to improper segregation and shredding. Many surveys during 1990 's indicated the presence of heavy metal in Municipal solid waste coming from domestic households and the presence of toxic pesticides and fertilizers was also detected [30]. This led to the urgent need of formulating a standard for compost and eventually Quality of compost came into the picture. Depending on the quality its appropriate use was considered.

Compost Quality plays a very important role in making MSW compost a marketable product. The Quality of the compost plays a vital role in the effectiveness of the compost for its use in agriculture. Quality of the compost varies depending on the method and the source of raw materials used for composting. The physical and chemical parameters of compost also determine the quality of compost. The presence of heavy metals in compost can decrease the fertilizing potential and instead become a pollutant by itself. One of the major causes for poor marketing is inferior quality of compost produced from MSW [31]. Mostly the composts are tested for Fertilizing parameters, Heavy metal parameters and Harmful Pathogens. The quality is determined based on how these parameters adhere to the respective countries compost standards.

The quality control guidelines for compost till present time are not adequate to indicate overall compost Quality. Hence, Quality control indices such as Fertility index and clean index are used to indicate the overall quality of compost. It also helps to grade the compost and specifies were the compost can be used according to its Grade based on the Fertility Index and clean index. The fertility index was calculated from the values of total organic Carbon, Nitrogen, Phosphorus, Potassium, Carbon – Nitrogen ratio and Stability parameters. The Clean Index was calculated from the contents of heavy metals, taking the relative importance of each of the parameters into consideration. The quality of MSW compost depends on Waste composition. In most cases the MSW is manually segregated for Bio degradable organic wastes such as Green vegetables, Shrubs, Food waste and Paper. It also can help in reviving the poor financial status of municipal corporations. The quantity of the MSW has increased tremendously with the increasing population because of improved life-style and social status of the populations in the urban centres.

In the present study, an attempt has been made to understand the quality of compost so formed by the windrow composting process from the MSW obtained from Jawahar Nagar, and the vegetable waste from the commercial area Hyderabad by it analysis (Laboratory as well as statistical) and the quality of composts was found out using Quality control Indices such as Fertilizing Index and Clean Index.

II. Study Area

Hyderabad city is located at l7° 20' North Latitude and 78° 03' East Longitude, in the west central part of Andhra Pradesh with an altitude of 536 m above mean sea level. The population of Greater Hyderabad Municipal Corporation as per 2011 census is about 90.55 Lakhs and spread over an area of 638 km^2.

Table 1: Salient features of Hyderabad City

Area (2008)	638 sq. km (included added area in 2007)
Population (2011)	90.55 lakhs (including population from added area)
Geographical Features	Altitude - 536 meter above mean sea level Latitude- $17^0$20' North Longitude – 78.03' East
Climatic features	Winter Temperature: Min 12^oC, Max 22^oC

	Summer Temperature: Min 22°C,Max 40°C Rainfall: (June to September): 89 cm Best season: June to February
Regional significance	Hyderabad is one of the India's largest metropolises and also the Capital of the state of Telangana. Hyderabad is being located on the cross-roads of the rivers Krishna and Godavari in the Telangana. Regionally, Hyderabad lies on the convergence of National and state highways and trunk, air and rail routes. It is also recognized as the city of pearls and pearl ornament, silverware, lacquer bangles, Kalamkari paintings and artifacts.

Based on the population growth and waste generation quantities by the year 2012 the total waste estimated was around 5500 TPD, as shown in Table 2. The waste (around 2400 tons/day) after segregation is sent to RDF process; which is further utilized as feed stock to the proposed 48MW (in 2X24MW) Waste to Energy (W2E) power plant for power generation. Around 2040 TPD of -125mm size waste material is processed on the windrow platform for treating in the compost plant. The compost produced at this site as well as the vegetable compost produced on lab scale were collected and was subjected for Quality Analysis.

III. Materials and Methodology

The vegetable waste from Himayat Nagar area were collected in the month of April of 2014 and the collected waste sample which weighted around 5 kg were subjected for composting. Proper segregation and removal of plastic and non-biodegradable material was carried out before undergoing composting.

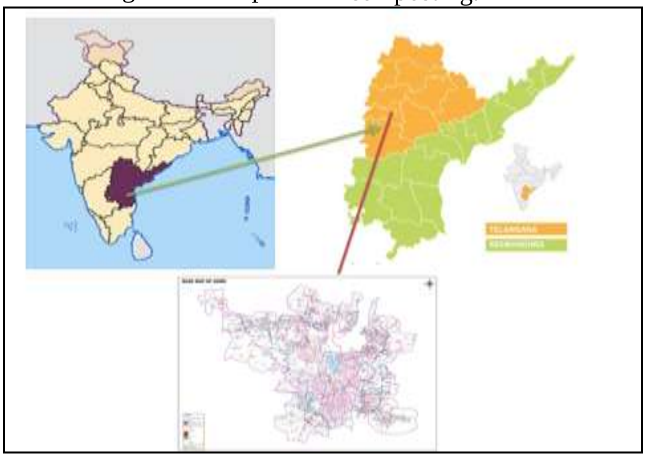

Figure1; Greater Hyderabad Municipal Corporation (GHMC) study area

Table 2: Total Waste generated

Sl. No	Type of Waste	Waste generated (MT/day)	% Waste Composition
1	Domestic Household waste	2268	41.24
2	Commercial Establishments waste	380	6.91
3	Hotels & Restaurants	400	7.27
4	Institutional waste	145	2.64
5	Parks and Gardens	108	1.96
6	Street sweeping waste	340	6.18
7	Waste from Drains	160	2.91
8	Markets	410	7.45
9	Temples	5	0.09
10	Chicken, Mutton, Beef, Fish stalls	250	4.55
11	Cinema halls	2	0.04
12	Function halls	90	1.64
13	Hospitals	142	2.58
14	Construction and Demolition waste	800	14.55
	Total	**5500**	**100.00**

The solid waste samples were kept in a plastic container (having small holes (around2 ½ mm diameter) at the bottom of the container for proper aeration throughout the sample and to let the excess water to drain out as leachate during the composting. The 5 kg of vegetable waste samples were mixed with 1kg of cow dung and was allowed to undergo composting with regular monitoring of temperature and moisture content of 50% - 60 % was maintained with proper mixing at the intervals of 2 days. The set up was kept for a period of 60 days till the final compost was produced. The final product was collected from the plastic containers were air dried and sieved using a 4mm sieve.

The compost obtained from lab scale experiments and sample from Jawahar nagar **w**ere allowed to undergo Laboratory Analysis of 15 different parameters. The composting samples were sent in an air tight plastic bag for the laboratory analysis of various parameters. The 15 parameters analyzed for the compost are: Moisture content, Total nitrogen, total phosphorous, total potash, organic carbon, organic matter, pH, Electrical Conductivity, C/N ratio, Carbon respiration and also heavy metals like; Zinc, copper, cadmium, lead, Nickel, chromium. Table 3 provides the standards for the organic contents prescribed and Table 4 shows the permissible limits of heavy metals in other countries as the organic content prescribed values remains same but the heavy metal values varies for different countries.

Table 3: Quality Control parameters as per FCO Guidelines

Parameters	Compost Standards
Moisture Content	20% – 30%
pH	6.5 – 7.5
EC (dS/cm)	3.14
Total Organic Carbon	>16 (%dm)
Total N	>0.5
Total P	>0.22
Total K	>0.83
C:N Ratio	20:1

Fertilizing index and clean index are determined to grade the compost, which can be further used to find the methods required to obtained the best quality of compost from Municipal solid waste.

3.1. 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 5 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

Fertilizing index = $\Sigma i=1n\ S_i\ W_i\ /\ \Sigma i=1\ n\ W_i$ ….Eq. (1)

Where 'S_i' is score value of analytical data and 'W_i' is weighing factor. The values of S_i and W_i for fertilizing index are given in Table 5.

Table 4: Permissible limits of heavy Metals in Other Countries [30] and [31]

Heavy Metals (mg/Kg)	**FCO – India**	**MSW-2000**	**Finland Class A**	**Finland Class B**	**USA**	**EEC Organic Rule**	**EU Range**
Zinc as Zn2+	<1000	1000	200	75	2800	200	210-4000
Copper as Cu2+	<300	300	60	25	1500	70	70-600
Cadmium as Cd2+	<5	5	1	0.7	39	0.7	0.7-1.0
Lead as Pb2+	<100	100	100	65	300	45	70-1000
Nickel as Ni+	<50	50	20	10	420	25	20-200
Chromium as Cr3+	<50	50	50	50	1200	70	70-200
*FCO – The fertilizer (Control) order 1985, *MSW (2000) - Municipal Waste (Management & Handling) Rules, 2000, *EEC – European Economic Community Organic rules, *Finland Class A – Clean compost, Class B – Very Clean Compost, *EU Range - European Union Range							

Table 5: Score value of fertilizing Index

Score Value (S_i)	**5**	**4**	**3**	**2**	**1**	**W_i**
Total Organic C (% dm)	>20.0	15.1-20.0	12.1-15	9.1-12	<9.1	**5**
Total N (% dm)	>1.25	1.01-1.25	0.81-1	0.80-0.51	<0.51	**3**
Total P (% dm)	>0.60	0.41-0.60	0.21-0.40	0.11-0.20	<0.11	**3**
Total K (% dm)	>1.00	0.76-1.00	0.51-0.75	0.26-0.50	<0.26	**1**
C:N	<10.1	10.1-15	15.1-20	20.1-25	>25	**3**
Respiration activity (mgCO2-C/g VS d)	<2.1	2.1-6.0	6.1-10.0	10.1-15	>15	**4**

3.2. Clean index

The Clean Index was calculated based on the Score values which were given to each analytical value of the heavy metals as per scheme mentioned in Table 6. While assigning score values, the quality control limit values implemented by different European countries as well as those proposed by Saha et al., (2010) for India were taken into consideration. For each heavy metal a 'weighing factor' was allocated. 'Clean index' value was calculated by the following formula.

Clean Index = Σi=1 n S_j W_j / Σ i=1n W_j …..Eq. 2

Where 'S_j' is score value of analytical data and 'W_j' is weighing factor of the 'j' th heavy metal.

Table 6: Score values for Clean Index

S_i Value	**5**	**4**	**3**	**2**	**1**	**W_i**
Zn (mg/kg dm)	<151	151-300	301-500	701-900	>900	**1**
Cu (mg/kg dm)	<51	51-100	201-400	401-600	>600	**2**
Cd (mg/kg dm)	<0.3	0.3-0.6	1.1-2.0	2.0-4.0	>4.0	**5**
Pb (mg/kg dm)	<51	51-100	151-250	251-400	>400	**3**
Ni (mg/kg dm)	<21	21-40	81-120	121-160	>160	**1**
Cr (mg/kg dm)	<51	51-100	151-250	251-350	>350	**3**

On the basis of 'Fertilizing index', and 'Clean index' values of MSW composts, different classes of compost has been proposed (Table 7) for their use in different application areas as well as for their suitability as marketable product. The bases for such classifications are:

a) MSW composts graded under classes A, B, C and D should only be allowed to market. These composts must comply with the regulatory limit or statutory decree of the country in respect of all the heavy metal contents. The classes A and C have maximum fertilizing potential (Fertilizing index > 3.5); whereas, classes A and B pose minimum threat to environment from pollution (Clean index > 4.0).

(b) The compost samples, which either do not comply regulatory limits with respect to heavy metal contents or do not have enough fertilizing value (Fertilizing index < 3.1) are not suitable for marketing and are placed under restricted use (RU) category. MSW compost samples graded under class RU-1 (FCO - QC standards), though comply regulatory limits with respect to heavy metal contents, and should not be allowed for selling due to their inferior fertilizing potential. However, these can be used unrestrictedly as soil conditioner.

(c) MSW compost samples graded under class RU-2, score high 'Clean index' values (>4.0) but fail to meet regulatory limits with respect to heavy metal contents due to having at least one of the heavy metals beyond the permissible limit. Such composts with high 'Fertilizing index' value (>3.5) can be used for growing non-food crops (including fodder crops) with periodic monitoring of soil quality if used repeatedly.

(d) Composts (graded under class RU-3) with enough fertilizing limits for fertilizing parameters should play an advisory role in-value ('Fertilizing index' > 3.0), but having high heavy metal may be allowed for one time application under In this direction, the classification (a first proposal for discus-restricted condition like developing lawns/gardens, afforestation , rehabilitation of degraded land etc. Compost samples, which do not belong to any of the above classes, may be diverted to landfill area (Saha et al., 2009).

Table 7: Classification of MSW compost for their Marketability and Different uses[31].

Class	**Fertilizing Index**	**Clean Index**	**Quality Control Compliance**	**Remark**
A	>3.5	>4.0	Complying for all heavy metal parameters	Best Quality. High manurial value potential and low heavy metal content and can be used for high value crops like in organic farming
B	3.1-3.5	>4.0	Complying for all heavy metal parameters	Very good quality. Medium fertilizing potential and low heavy metal content
C	>3.5	3.1-4.0	Complying for all heavy metal parameters	Good quality. High fertilizing potential and medium heavy metal content
D	3.1-3.5	3.1-4.0	Complying for all heavy metal parameters	Medium quality

RU-1	<3.1	-	Complying for all heavy metal parameters	Should not be allowed to market due to low fertilizing potential. However, these can be used as soil Conditioner
RU_2	>3.5	>4.0	Not Complying for all heavy metal parameters	Should not be allowed to market. Can be used for growing non-food crops. Requires periodic monitoring of soil quality if used repeatedly
RU- 3	>3.0	-	Not Complying for all heavy metal parameters	Restricted use. Should not be allowed to market. Can be used only for developing lawns/gardens (with single application), rehabilitation of degraded land

IV. Results and discussion

Both the samples (Sample I from Lab scale studies and sample II from Jawahar Nagar dumping yard) were analyzed for their physico-chemical parameters and following results were obtained:

The Lab analytical data from Table 8, showed that Moisture content in Sample I was less than the prescribed value of 20% - 30%. This might be due to air drying of the finished compost. The pH and EC of the sample I was found to be 9.28 and 5.53 ds/m respectively; which are higher than the values prescribed by FCO. The compost was found to alkaline and hence there is a possibility of having a good amount of organic content in the sample, due to the addition of cow dung which has a pH of 8 and presence of salts in food waste in the feed stock. High pH can affect the plant growth. It should be stabilised before its use in agriculture. The EC value itself explains the presence of salts in higher amount in the sample. The TOC value of the vegetable compost sample was also found to be 44.21 % dm.

The major plant nutrients such as Total N, P, K is the important fertilizing parameters. According to FCO guidelines the composts should have at least 1 % each. The Total N, P, K content analyzed was found to be 1.15% dm, 2.56% dm and 5.75%dm respectively. From the data obtained it can be concluded that the fertility of the compost, which can be observed by N, P and K values, is very high and the quality of compost might be good. The potash content in the compost is found to be very high.

The C:N Ratio, which measures the stability of compost as it immobilizes the Nitrogen content and its higher value indicates large amount of carbonatious matter, was found to be 38.44. The organic matter is found to be 76.22 %dm. Carbon respiration, which indicates that the CO_2 evolution from the compost was found to be 0.2.

Table 8: Physical and Chemical Analysis data for Sample I

Sl. No	Test parameters	Unit of measurement	Results obtained
1	Moisture as Received basis	% by mass	5.7
2	Total Nitrogen as N	% by mass	1.15
3	Total Phosphorus as P_2O_5	% by mass	2.56
4	Total Potash as K_2O (on Dry Basis)	% by mass	5.75
5	Organic Carbon (Loss on Ignition)	% by mass	44.21
6	Organic matter	% by mass	76.22
7	pH (of 5% aqueous extract)	---	9.28
8	Electrical conductivity (of 5% aqueous extract)	ds/m	5.53
9	C/N ratio	---	38.44
10	Carbon Respiration	(mg CO2 – C g Vs d)	0.2
Heavy Metals :			
1	Zinc as Zn, mg/kg	Ppm	94
2	Copper as Cu, mg/kg	Ppm	87
3	Cadmium as Cd, mg/kg	Ppm	< 1
4	Lead as Pb, mg/kg	Ppm	17
5	Nickel as Ni, mg/kg	Ppm	7
6	Chromium as Cr, mg/kg	Ppm	7

The heavy metals present in the compost sample I are found to be within the permissible limits prescribed by the FCO India, MSW 2000 (handling) rule, Finland Compost standards, USA bio solids standards and EEC organic rule. The value of Zinc (Zn^{2+}) was found to be 94 ppm, Copper (Cu^{2+}) was found to be around 87 ppm, Cadmium (Cd^{2+}) less than 1, Lead (Pb^{2+}) was 17ppm, Nickel (Ni^{+}) was 7 ppm and Chromium was found to be 7 ppm. From the above values it can be stated that no heavy metals are present in excess and the heavy metals concentration in the Sample I are acceptable.

The Fertilizing Index and the Clean Index values were estimated to be 4.2. From the calculated values of Fertility Index (4.2) and Clean Index (4.2) the compost of sample I is categorized to class A.

The Moisture content, pH and the EC content in the Sample II was 29.82 % dm, 7.75 and 2.29 ds/m respectively. Hence it can be seen that all the three values are within the permissible limits prescribed by FCO India. The organic content of the sample II were also identified as shown in Table 9.

Table 9: Physical and Chemical Analysis data for Sample II

Sl. No	Test parameters	Unit of measurement	Results obtained
1	Moisture as Received basis	% by mass	29.82
2	Total Nitrogen as N	% by mass	0.78
3	Total Phosphorus as P_2O_5	% by mass	0.62
4	Total Potash as K_2O (on Dry Basis)	% by mass	0.39
5	Organic Carbon (Loss on Ignition)	% by mass	23.46
6	Organic matter	% by mass	40.45
7	pH (of 5% aqueous extract)	---	7.75
8	Electrical conductivity (of 5% aqueous extract)	ds/m	2.29
9	C/N ratio	---	30.08
10	Respiration Activity		0.2
Heavy Metals :			
1	Zinc as Zn, mg/kg	ppm	269
2	Copper as Cu, mg/kg	ppm	247
3	Cadmium as Cd, mg/kg	ppm	< 1
4	Lead as Pb, mg/kg	ppm	59
5	Nickel as Ni, mg/kg	ppm	17
6	Chromium as Cr, mg/kg	ppm	37

Parameters like TOC (which determines the organic carbon content), total N, P, K (which is useful in determining the fertility of the compost and its potential), C/N ratio (which indicates the compost maturity) were analyzed and it was found that all the parameters lies within the permissible limits of FCO India. The values of TOC, N, P,K, C:N were found to be 23.46 % dm, 0.78 %dm, 0.62 %dm, 0.39 % dm, 30.08 respectively. The N, P, and K values in sample II is found to be near to the lower limit as prescribed by FCO. Hence these can be increased by adding N, P and K components externally like by using some Low grade phosphorous rocks, etc. The respiration activity explains about the CO_2 evolution and it is found to be 0.2. All the heavy metal concentrations are within the range provided in the FCO guideline.

The fertility index value is estimated as 4.2 and the Clean Index value was found out as 3.6. The determined values of Fertility Index and Clean Index of the compost Sample II indicates that the compost belongs to Class C, and hence it can be said that the compost sample obtained from the Jawahar Nagar dump site has high fertility potential and medium Heavy metal concentration. Table 10 shows a short description about the various values obtained from the two samples.

Table 10: Quality control Indices for sample I and sample II

Sr. No	Sample	Fertilizing Index	Clean Index	Class	Quality
1	Sample I	4.2	4.2	A	Best Quality
2	Sample II	4.2	3.6	C	Good quality

V. Conclusion

The solid waste collected from a commercial area of Hyderabad City (Himayat Nagar) was allowed to undergo the composting process (April 2014-May 2014.) in a 10 liter plastic container containing approximately 2 mm diameter holes on the walls of the container. 5 to 6 numbers of holes were pierced on the container so that a proper circulation of air and removal of leachate through these holes are regulated. Initially 5 kg of solid waste was mixed with 1 kg of cow dung. During composing initially there was a rise in temperature because of exothermic reactions taking place. A continuous monitoring of temperature and moisture content was done to maintain stable condition for the bacteria's which are helpful in undergoing composting. It took around 45 to 60 days for the compost (Sample I) to produce. The compost from Jawahar Nagar Dump yard (Sample II) was collected directly in the air tight plastic bags.

The two compost samples (Sample I from lab scale setup and Sample II from Jawahar Nagar Dump yard) were further subjected to understand the quality of a compost sample. Laboratory work was carried out to find various physical and chemical parameters for Sample I and Sample II. Parameters like Moisture content, pH, Electrical Conductivity, Total organic Carbon, Total Nitrogen, Total Phosphorous, Total Potassium, C/N ratio, and heavy metals like Zinc, Copper, Cadmium, Nickel, Lead, and chromium were analyzed. These are the major and basic parameters required to monitor the fertility and applicability of the compost. These 15 parameters were compared with FCO 2007 standards. It was found that all the parameters are within the permissible limits prescribed by FCO.

The laboratory results were further processed and Quality control Indices like fertility index and clean index was determined. Fertility Index is estimated depending on few organic parameters like TOC, N, P, K whereas Clean Index is calculated by using Heavy metals concentration. It was found that both the samples had a fertility index value of 4.2 and clean index value of 4.2 for sample I and 3.6 for Sample II was determined.

These Indices values are used to find out the class to which the compost belongs to; and hence it was found out that sample I which has a Fertilizing Index and Clean Index value as 4.2 and 4.2 respectively belonged to Class A category whereas Sample II had a value of 4.2 and 3.6 as Fertilizing Index and Clean Index which is categorized to Class C category. The classes A and C have maximum fertilizing potential (Fertilizing index > 3.5); and Class A has a minimum environmental threat, but the class C has little environmental threat as it has large amount of heavy metals.

Hence it can be recommended that proper segregation of the solid waste is important from composting point of view because mixed waste affects the quality of compost whereas addition of low grade phosphorous rock to the feed stock can improve the phosphorous content in the finished compost.

References

[1] Khurshid S and Sethuraman S In New India All Roads Lead to City. *Hindustan Times, New Delhi* (2011, July 31) pp 10.

[2] Sharholy, M., Ahmad, K., Mahmood, G., Trivedi, R. C., 'Municipal Solid waste management in Indian cities – A review', *Waste Management, 28, 2008*, pp 459-467.

[3] Sharma, S., Shah, K.W. Generation and disposal of solid waste in Hoshangabad. In: *Book of Proceedings of the Second International Congress of Chemistry and Environment, Indore, India, 2005* pp. 749–751.

[4] Central Pollution Control Board (CPCB). Management of Municipal Solid Waste. *Ministry of Environment and Forests, New Delhi, India, 2004*

[5] Shekdar, A.V., Krshnawamy, K.N., Tikekar, V.G., Bhide, A.D. Indian urban solid waste management systems – jaded systems in need of resource augmentation. *Journal of Waste Management* 12 (4) 1992, 379–387.

[6] Rathi, S. Alternative approaches for better municipal solid waste management in Mumbai, India. *Journal of Waste Management* 26 (10) 2006, 1192–1200.

[7] Sharholy, M., Ahmad, K., Mahmood, G., Trivedi, R.C. Analysis of municipal solid waste management systems in Delhi – a review. In: *Book of Proceedings for the second International Congress of Chemistry and Environment*, Indore, India,2005, pp. 773–777.

[8] Ray, M.R., Roychoudhury, S., Mukherjee, G., Roy, S., Lahiri, T. Respiratory and general health impairments of workers employed in a municipal solid waste disposal at open landfill site in Delhi. *International Journal of Hygiene and Environmental Health* 108 (4) 2005, 255–262.

[9] Jha, M.K., Sondhi, O.A.K., Pansare, M., 2003. Solid waste management – a case study. *Indian Journal of Environmental Protection* 23 (10), 1153–1160.

[10] Kansal, A. Solid waste management strategies for India. *Indian Journal of Environmental Protection* 22 (4) 2002, 444–448.

[11] Kansal, A., Prasad, R.K., Gupta, S. Delhi municipal solid waste and environment – an appraisal. *Indian Journal of Environmental Protection* 18 (2) 1998, 123–128.

[12] Singh, S.K., Singh, R.S. A study on municipal solid waste and its management practices in Dhanbad–Jharia coalifield. *Indian Journal of Environmental Protection* 18 (11) 1998, 850–852.

[13] Gupta, S., Krishna, M., Prasad, R.K., Gupta, S., Kansal, A. Solid waste management in India: options and opportunities. Resource,

Conservation and Recycling 24, 1998, 137–154.

[14] Mor, S., Ravindra, K., Visscher, A.D., Dahiya, R.P., Chandra, A. Municipal solid waste characterization and its assessment for potential methane generation: a case study. *Journal of Science of the Total Environment* 371 (1) 2006, 1–10.

[15] Siddiqui, T.Z., Siddiqui, F.Z., Khan, E., 2006. Sustainable development through integrated municipal solid waste management (MSWM) approach – a case study of Aligarh District. In: Proceedings of National Conference of Advanced in Mechanical Engineering (AIME- 2006), Jamia Millia Islamia, New Delhi, India, pp. 1168–1175.

[16] Raje, D.V., Wakhare, P.D., Despande, A.W., Bhide, A.D., 2001. An approach to assess level of satisfaction of the residents in relation to SWM system. *Journal of Waste Management and Research* 19, 12–19.

[17] Ministry of Environment and Forests (MoEF), 2000. The Gazette of India. Municipal Solid Waste (Management and Handling) Rules, New Delhi, India.

[18] Ahsan, N. Solid waste management plan for Indian megacities. *Indian Journal Of Environmental Protection* 19 (2) 1999, 90–95.

[19] Vij, D. 'Urbanization and Solid waste Management in India: Present practices and future challenges', International Conference on Emerging Economies – prospects and Challenges (ICEE- 2012), Social and Behavioral Sciences, 37 2002, pp 437-447.

[20] Sharholy, M., Ahmed, K., Vaishya, R.C., Gupta, R.D.Municipal Solid Waste Characteristics and Management in Allahabad, India. *Journal of Waste Management* 27 (4) 2007, 490-496.

[21] CPCB, 2000, Status of Solid Waste Generation, Collection, Treatment and Disposal in Metrocities, Series: CUPS/46/1999–2000.

[22] Khan, R.R., 1994. Environmental management of municipal solid wastes. *Indian Journal of Environmental Protection* 14 (1), 26–30.

[23] Gupta, P.K., Jha, A.K., Koul, S., Sharma, P., Pradhan, V., Gupta, V., Sharma, C., Singh, N. Methane and Nitrous Oxide Emission from Bovine Manure Management Practices in India. *Indian Journal of Environmental Pollution* 146 (1) 2007, 219–224.

[24] Sharholy, M., Ahmad, K., Mahmood, G., Trivedi, R.C. Development of prediction models for municipal solid waste generation for Delhi city. In: Proceedings of National Conference of Advanced in Mechanical Engineering (AIME-2006), Jamia Millia Islamia, New Delhi, India, pp. 2006, 1176–1186.

[25] Srivastava, P.K., Kushreshtha, K., Mohanty, C.S., Pushpangadan, P., Singh, A. Stakeholder-based SWOT analysis for successful municipal solid waste management in Lucknow, India. *Journal of Waste Management* 25 (5) 2005, 531–537.

[26] Malviya, R., Chaudhary, R., Buddhi, D. Study on solid waste assessment and management – Indore city. *Indian Journal of Environmental Protection* 22 (8) 2002, 841–846.

[27] Reddy, S., Galab, S., 1998. An Integrated Economic and Environmental Assessment of Solid Waste Management in India – the Case of Hyderabad, India.

[28] Dayal, G. Solid wastes: sources, implications and management. *Indian Journal of Environmental Protection 14 (9)* 1994, 669–677.

[29] Rao, K.J., Shantaram, M.V. Physical characteristics of urban solid wastes of Hyderabad. *Indian Journal of Environmental Protection 13 (10)* 1993, 425–721.

[30] Briton, W.F., (2000). Compost Quality Standards and Guidelines. Final Report. Woods End Research Laboratory, Inc., USA. <http://compost.css.cornell.edu/Brinton.pdf> (accessed 26.11.12.).

[31] Saha JK, Panwar N, Singh MV (2010). An assessment of municipal solid waste compost quality produced in different cities of India in the perspective of developing quality control indices. *Waste Manag 7(11):2009–2013.*