IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

COMPOST QUALITY ASSESSMENT OF BERHAMPUR MUNICIPAL CORPORATION (BeMC), ODISHA, INDIA

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Abstract: India produces about 3000 million tons of MSW annually out of which 40 –50 % are compostable (Sharholy *et al.*, 2007). The quality of the compost is crucial to the commercial viability of MSW compost as it is examined for hazardous microorganisms, heavy metals, and fertilizing characteristics. In the current study, an analysis (both statistical and from the State Organic Fertilizer Testing Laboratory) of the MSW obtained from the 150TPD Municipal Solid Waste Management Plant under Berhampur Municipal Corporation, Berhampur, Odisha, has been done in an attempt to understand the quality of compost so formed by the windrow composting process. The quality of composts was determined using Quality Control Indices such as Fertilizing Index and Clean Index. After analysis, it was discovered that all of the metrics, including moisture content, pH, EC, TOC, Total Nitrogen, Total Phosphorus, Total Potassium, and C/N ratio, as well as heavy metals including zinc, copper, cadmium, nickel, lead, and chromium, were within the FCO's acceptable limits. 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. It was found that Sample I belonged to Class A category whereas Sample II belonged to Class C category based on the values of the Indices, which are used to determine the class to which the compost belongs. Therefore, from the perspective of composting, it is recommended that thorough solid waste segregation be done because combined trash degrades compost quality.

Key words - C/N ratio, Clean Index, City Compost, Heavy metals, MSW

I. Introduction

India is the world's second-highest-populated country after China, with a population of 1.21 billion, or 17.5% of the world's population, and a growth rate of 3.35% (2011 census). It is interesting to note that currently 1 out of 3 people lives in urban areas, and it is projected that as much as 50% of India's population will live in cities in the next 10 years. The management of Municipal Solid Waste (MSW) is still one of the most overlooked aspects of urban growth in India, despite substantial expenditures by civic bodies.

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 (Sharholy *et al.*, 2008). Poor collection and transportation are responsible for the accumulation of MSW at every nook and cranny (Vinod & Ravindernath, 2015). 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 (Rathi, 2006). 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 (Mor *et al.*, 2006; Siddiqui *et al.*, 2006; Raje *et al.*, 2001; MoEF, 2016 & Ahsan, 1990). 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 (Vij, 2002).

India produces about 3000 million tons of MSW annually out of which 40 –50 % are compostable (Sharholy *et al.*, 2007). 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 (CPCB, 2016). 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 (Vinod & Ravindernath, 2015).

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 the 150TPD Municipal Solid Waste Management Plant under Berhampur Municipal Corporation, Berhampur, Odisha, by its analysis (State Organic Fertilizer Testing Laboratory as well as statistical analysis), and the quality of composts was found out using Quality Control Indices such as Fertilizing Index and Clean Index.

II. STUDY AREA

Municipal Solid Waste Management (MSWM) is one of the major environmental problems in Indian megacities. It involves activities associated with the generation, storage, collection, transfer, transport, processing, and disposal of solid waste. Sufficient infrastructure, upkeep, and modernization are necessary for the effective handling of Municipal Solid Waste. The Municipal Solid Waste (Management & Handling) Rules, 2016 (MSW Rules) are applicable to every municipal authority responsible for the collection, segregation, storage, transportation, processing, and disposal of municipal solids.

Berhampur city is located at 19° 32' North Latitude and 84° 78' East Longitude, in the southern part of Odisha, with an altitude of 90 m above mean sea level. The population of Berhampur Municipal Corporation, as per the 2011 census, is about 3.55 lakh and spread over an area of 37 km_2.

Table 1: Salient features of Berhampur City

PARAMETERS	DESCRIPTION
Area (2008)	37 sq. km (included added area in 2011)
Population (2011)	3.55 lakhs (including population from added area)
Geographical Features	Altitude - 90 meter above mean sea level Latitude- 19° 16’ North Longitude – 78.03’ East
Climatic features	Winter Temperature: Min 15^{o}C, Max 26^{o}C Summer Temperature: Min 22^{o}C, Max 40^{o}C Rainfall: (June to September): 1250mm Best season: October to February
Regional significance	Berhampur is one of the Odisha’s largest municipal corporations. River Rushikulya is called the “Ganga” of Ganjam. It flows at a distance of about 30 kms from the city and discharges into the Bay of Bengal near Gopalpur port. Regionally, Berhampur lies on the convergence of National and state highways and trunk, air and rail routes. It is also recognized as the city of business of Southern Odisha.

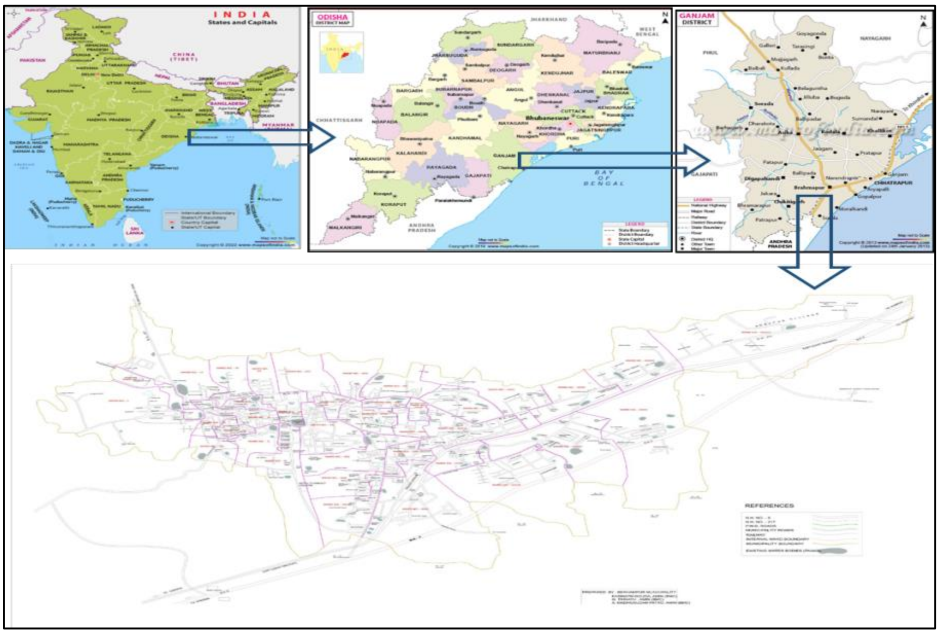

Figure 1: Berhampur Municipal Corporation Study Area

Based on population growth and waste generation quantities by the year 2011, the estimated total waste was around 138 TPD, as shown in Table 2. Around 138 TPD of 100-mm-size waste material is processed through the presorting section and the 35- and 16-mm-sized preparation section on the windrow platform for treatment in the compost plant. The compost produced at this site as well as the city compost produced on a lab scale were collected and subjected to quality analysis.

Table 1: Total Waste generated

SL. NO	TYPE OF WASTE	WASTE GENERATED (MT/DAY)	% WASTE COMPOSITION
1	Domestic Household waste	88	63.77
2	Commercial Establishments waste	15	10.87
3	Hotels & Restaurants	8.2	5.94
4	Institutional waste	0.5	0.36
5	Parks and Gardens	0.25	0.18
6	Street sweeping waste	1	0.72
7	Waste from Drains	3.1	2.25
8	Markets	12.75	9.24
9	Temples	2.3	1.67
10	Chicken, Mutton, Beef, Fish stalls	1	0.72
11	Cinema halls	0.2	0.14
12	Function halls	0.1	0.07
13	Hospitals	3.5	2.54
14	Construction and Demolition waste	2.1	1.52
	Total	**138**	**100**

Based on the total amount of garbage generated and the population of BMC in 2011, it is projected that per capita waste generation in Berhampur is 388g/person/day. According to MoUD's research, the amount of waste generated daily in Indian towns varies from 200 to 600 grams per person in cities with a population of 100,000 to 5,000,000. Therefore, for planning purposes and infrastructure assessment, a per capita waste generation rate of 390 grams per person per day has been considered (EIA Report for Integrated Solid Waste Management, Berhampur, Odisha, November 2014, Prepared by Global Experts C 23, BJB Nagar, Bhubaneswar).

III. DATA COLLECTION & ANALYSIS

The Municipal Solid Waste from Berhampur Municipal Area was collected in the month of April 2022, and the collected waste sample, which weighted around 25 kg, was subjected to composting. Prior to composting, plastic and non-biodegradable materials were properly separated and removed. The solid waste samples were kept in a plastic container with small holes (around 2 ½ mm diameter) at the bottom of the container for proper aeration throughout the sample and to let the excess water drain out as leachate during the composting. The 25 kg of pure organic waste samples were mixed with 1kg of pistia and dry leaf and allowed to undergo composting with regular monitoring of temperature and moisture content of 50%–60%, which was maintained with proper mixing at intervals of 2 days. The setup was maintained for 60 days in order to generate the final compost. The final product was collected from the plastic containers; air dried, and sieved using a 4mm sieve.

The compost obtained from lab-scale experiments and a sample from the Integrated Solid Waste Management facility in Berhampur were allowed to undergo laboratory analysis of 15 different parameters in the State Organic Fertilizer Laboratory, Baramunda, Bhubaneswar, Odisha. The composting samples were transported in an airtight plastic bag so that various laboratory parameters could be examined. Moisture content, Total Nitrogen, Total Phosphorous, Total Potash, Organic Carbon, Organic Matter, pH, Electrical Conductivity, C/N ratio, Carbon Respiration, and heavy metals such as arsenic, mercury, zinc, copper, cadmium, lead, nickel, and chromium are among the 15 characteristics that were assessed for the compost. While the recommended values for organic content remain the same, the values for heavy metals vary depending on the country. Table 3 gives the requirements for the organic contents that are prescribed, and Table 4 displays the acceptable limits of heavy metals in various nations.

Table 2: Quality Control parameters as per FCO, 1985 Guidelines

PARAMETERS	COMPOST STANDARDS
Moisture Content	15% – 25%
Bulk Density (g/cm³)	<1.00
pH	6.5 – 7.5
EC (ds/cm)	<4.00
Total Organic Carbon(%dm)	>12
Total N(%dm)	>0.8
Total P(%dm)	>0.4
Total K(%dm)	>0.4
C:N Ratio	20:1
Pathogen	Nil

Table 3: Permissible limits of heavy Metals in Other Countries

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
Arsenic As2+	<10	10	10	10	32	10	10

Mercury as Hg+	<0.15	0.15	0.15	0.15	17	0.7 - 10	0.7 - 10
***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**							

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

Fertilizing index: According to the categories listed in Table 5, each analytical data point that influences the fertilizing value (which enhances soil productivity) of compost, such as the overall C, N, P, and K contents as well as the C: N ratio and respiration activity, is given a "score" value. Each of these fertility standards was given a "weighing factor" based on scientific information regarding their contribution to enhancing soil productivity. The following formula is used to calculate the "Fertilizing index" of the MSW compost

Fertilizing index $FI = \sum_{i=1}^{n} S_i W_i / \sum_{i=1}^{n} W_i$…………………………………………………………………. Eq. (1)

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

Table 4: 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 VSd)	<2.1	2.1-6.0	6.1-10.0	10.1-15	>15	4

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 $= \sum_{i=1}^{n} S_j W_j / \sum_{i=1}^{n} W_j$ ………………………………………………………………………..Eq. 2

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

Table 5: Score values for Clean Index

S_J VALUE	5	4	3	2	1	W_J
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 have 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 canbe 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 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.

Table 6: Classification of MSW compost for their Marketability and Different uses

Class	Fertilizing Index	Clean Index	Quality Control Compliance	Remark
A	>3.5	>4.0	Complying for all heavy metal parameters	Best Quality. High manorial value potential and low heavymetal 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 metalcontent
C	>3.5	3.1-4.0	Complying for all heavy metal parameters	Good quality. High fertilizing potential and medium heavymetal 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

IV. RESEARCH METHODOLOGY

DETERMINATION OF pH

The pH value was determined by the Electrometric method. The pH value of the filtrate was measured using a pH meter, which is obtained by filtering the compost suspension through Whatman No. 1 or equivalent filter paper under vacuum using a Buchner funnel.

DETERMINATION OF MOISTURE CONTENT

The measurement of moisture content relies on the weight difference before and after drying the sample. This measurement helps composters monitor and adjust the moisture levels to ensure proper composting, preventing issues like excessive dryness or excessive moisture that can hinder the decomposition process.

Calculation:

$$100\ (B-C)/B-A$$

Where,

A= Weight of the Petri dish

B= Weight of the Petri dish plus material before drying

C= Weight of the Petri dish plus material after drying

DETERMINATION OF BULK DENSITY

The bulk density of compost refers to the mass of compost per unit volume, and it is determined by the Volumetric method. Calculation:

Weight of the sample taken (W2 - W1)/Volume of Sample (V2-V1)

DETERMINATION OF ELECTRICAL CONDUCTIVITY

The Electrical Conductivity (EC) value was determined by a conductivity probe.

DETERMINATION OF ORGANIC CARBON

The dichromate oxidation method was used to quantify the organic carbon in compost.

Calculate:

Total Organic matter % = Initial wt. – final wt. X 100 /wt. of sample taken

Total C% = total organic matter”/1.724

DETERMINATION OF TOTAL NITROGEN

The Total Nitrogen value was determined by the Kjeldahl method, which involves digesting the compost with sulfuric acid to convert the organic nitrogen into ammonium sulfate. The total nitrogen content is calculated based on the volume of acid used in the titration. This method provides an accurate and reliable measure of the total nitrogen content in compost.

Calculation:

Nitrogen% by weight = 1.401(V1N1-V2N2) -(V3N1-V4N2) x df /W

Where,

V1 = Volume in ml of standard acid taken in receiver flask for sample

V2 = Volume in ml of standard NaOH used in titrating standard acid in receiver flask after distillation of test sample

V3 = Volume in ml of standard acid taken in receiver flask for blank

V4 = Volume in ml of standard NaOH used in titrating standard acid in receiver flask after distillation in blank

N1 = Normality of standard acid

N2 = Normality of standard NaOH

W = Weight in gm of sample taken, df = Dilution factor of sample

DETERMINATION OF TOTAL PHOSPHORUS AS P2O5

The measurement of Total Phosphorus in compost involves determining the total amount of phosphorus present in the compost sample. This was achieved through the Gravimetric Method using quinoline phosphomolybdate.

DETERMINATION OF TOTAL POTASH AS K2O

The Total Potash content in compost involves a simple and widely used principle known as titration. Total Potash value was determined by the titrimetric method**.**

Calculation:

Potash (K) %by weight = R X 20 X diluting factor

Where,

R= ppm of K in the sample solution (obtained by extra plotting from standard curve).

DETERMINATION OF CADMIUM, COPPER, CHROMIUM, LEAD, NICKEL AND ZINC

The measurement of cadmium, copper, chromium, lead, nickel, and zinc in compost involves several principles. Firstly, a representative sample of compost was collected and prepared for analysis. Then, various instrumental techniques, such as atomic absorption spectroscopy (AAS), inductively coupled plasma optical emission spectroscopy (ICP-OES), or inductively coupled plasma mass spectrometry (ICP-MS), are utilized.

Measured the metal concentrations of Cd, Cu, Cr, Fe, Pb, Ni, Zn by flaming the standard solution and samples using Atomic Absorption Spectrophotometer (AAS) as per the method given for the instrument at the recommended wavelength for each element.

RESULTS AND DISCUSSION

Both samples (Sample I from lab-scale studies and Sample II from the Integrated Solid Waste Management Plant, Berhampur, Odisha) were analyzed for their physico-chemical parameters and following results were obtained:

The lab analytical data from Table 8 showed that the moisture content in Samples I and II was less than the prescribed value of 15%–25%. This might be due to the air drying of the finished compost. The pH and EC of Samples I and II were found to be 7.15 and 7.28 ds/m, respectively, which are in between those prescribed by FCO. The compost was found to be alkaline, and hence there is a possibility of having a good amount of organic content in the sample due to the addition of dry leaf and pistia, which have a pH of 8, and the presence of salts in pure organic waste in the feed stock. High pH can affect plant growth. It should be stabilized before use in agriculture.

The EC value is within the permissible limits prescribed by FCO India. The TOC value of the vegetable compost sample was also found to be 44.21 % dm and 42.22 % 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, 5.75% dm, 1.77% dm, 1.85% dm, and 0.41% dm, respectively. Based on the data collected, it is possible to conclude that the compost has good quality and a very high level of fertility, as indicated by the N, P, and K values.

The C:N ratio was determined to be 38.44 and 23.85, which shows a considerable amount of carbonatious matter. This ratio measures the stability of compost since it immobilizes the nitrogen content. The organic matter is found to be 67.50% dm and 76.22% dm. The CO_2 evolution from the compost was determined to be 0.2, as indicated by carbon respiration.

Table 7: Physical and Chemical Analysis data

SL. NO	TEST PARAMETERS	UNIT OF MEASUREMENT	RESULTS OBTAINED	
			NABL CERTIFIED LAB-WBWML SAMPLE-I	STATE ORGANIC FERTILIZER TESTING LAB, GOVT OF ODISHA SAMPLE-II
1	**Moisture as Received basis**	% by mass	24.13	15.7
2	**Total Nitrogen as N**	% by mass	1.77	1.15
3	**Total Phosphorus as P_2O_5**	% by mass	1.85	2.56
4	**Total Potash as K_2O (on Dry Basis)**	% by mass	0.41	5.75
5	**Organic Carbon (Loss on Ignition)**	% by mass	42.22	44.21
6	**Organic matter**	% by mass	67.50	76.22
7	**pH (of 5% aqueous extract)**	---	7.15	7.28

SL. NO	TEST PARAMETERS	UNIT OF MEASUREMENT	RESULTS OBTAINED	
			NABL CERTIFIED LAB-WBWML SAMPLE-I	STATE ORGANIC FERTILIZER TESTING LAB, GOVT OF ODISHA SAMPLE-II
8	Electrical conductivity (of 5% aqueous extract)	ds/m	3.8	3.53
9	C/N ratio	---	23.85	38.44
10	Carbon Respiration (mg CO2 – C g Vs d)		0.2	0.2
	HEAVY METALS :			
1	Zinc as Zn, mg/kg	ppm	160	110
2	Copper as Cu, mg/kg	ppm	114.93	89
3	Cadmium as Cd, mg/kg	ppm	3.9	1.3
4	Lead as Pb, mg/kg	ppm	11.97	17
5	Nickel as Ni, mg/kg	ppm	0.437	5.5
6	Chromium as Cr, mg/kg	ppm	18.19	8.9

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 biosolids standards, and EEC organic rule. As per Table No. 8, no heavy metals are present in excess, and the heavy metal concentrations in Sample I are acceptable.

PARAMETER	CITY COMPOST (SI)		WEIGHING FACTOR (WI)	FW FERTILITY (SIWI)	
	NABL CERTIFIED LAB-WBWML	STATE ORGANIC FERTILIZER TESTING LAB, GOVT OF ODISHA		NABL CERTIFIED LAB-WBWML	STATE ORGANIC FERTILIZER TESTING LAB, GOVT OF ODISHA
Total Organic C (% dm)	5	5	5	25	25
Total N (% dm)	4	4	3	12	12
Total P (% dm)	1	1	3	3	3
Total K (% dm)	5	5	3	15	15
C:N	2	5	1	2	5

Calculation:

1. Fertilizing Index (FI) = 57/15 =3.8 based on the result from NABL Certified Lab-WBWML
2. Fertilizing Index (FI) = 60/15 =4 based on the result from State Organic Fertilizer Testing Lab, Govt. of Odisha

PARAMETER	CITY COMPOST (SJ)		WEIGHING FACTOR (WJ)	CITY FERTILITY (SJWJ)	
	NABL CERTIFIED LAB-WBWML	STATE ORGANIC FERTILIZER TESTING LAB, GOVT OF ODISHA		NABL CERTIFIED LAB-WBWML	STATE ORGANIC FERTILIZER TESTING LAB, GOVT OF ODISHA
Cr	5	5	3	15	15
Zn	4	5	1	4	5
Cu	3	4	2	6	8
Cd	1	2	5	5	10
Pb	5	5	3	15	15
Ni	5	5	1	5	5

1. Clean Index (CI) = 50/15 =3.3 based on the result from NABL Certified Lab-WBWML
2. Clean Index (CI) = 58/15 =3.9 based on the result from State Organic Fertilizer Testing Lab, Govt. of Odisha

The Fertilizing Index and the Clean Index values were estimated to be 3.8 & 3.3 from Analysis Report of Sample I.

The Fertilizing Index and the Clean Index values were estimated to be 4.0 & 3.9 from Analysis Report of Sample II.

From the calculated values, the compost of sample I & sample II is categorized to class C & Class C respectively.

Hence, it can be said that the compost sample obtained from the integrated Solid Waste Management Plant has high fertility potential and medium heavy metal concentration. Table 9 shows a short description about the various values obtained from the two samples.

Table 8: Quality control Indices for sample I and sample II

SL. NO	SAMPLE	FERTILIZING INDEX	CLEAN INDEX	CLASS	QUALITY
1	**Sample I**	3.8	3.3	C	Good quality
2	**Sample II**	4.0	3.9	C	Good quality

Figure 2: Visit during sampling

Figure 4: Sample-I

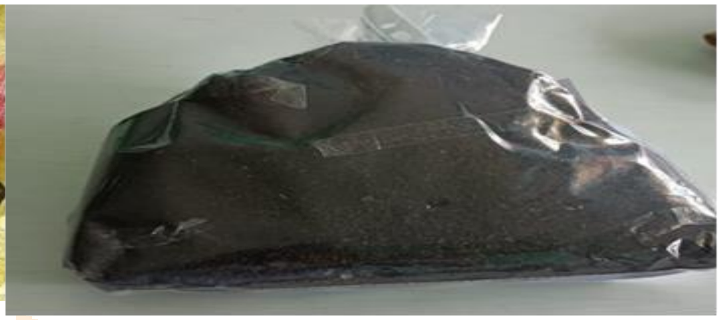

Figure 4: Sample-II

V. CONCLUSION

The solid waste collected from Berhampur Municipal Corporation was allowed to undergo the composting process (April 2022–May 2022.) in a 10-litre plastic container containing approximately 2 mm-diameter holes on the walls of the container. Five to six holes were pierced in the container so that the proper circulation of air and the removal of leachate through these holes were regulated. Initially, 5 kg of solid waste was mixed with 1 kg of pistia and dry leaf. During composition, initially, there was a rise in temperature because of exothermic reactions taking place. To keep the conditions steady for the bacteria that aid in composting, constant monitoring of the temperature and moisture content was carried out. It took around 45 to 60 days for the compost (Sample I and Sample II) to be produced. The two compost samples (Sample I and Sample II from Berhampur Municipal Corporation Area) were further subjected to analysis to understand the quality of the compost sample. Laboratory work was carried out to find various physical and chemical parameters for Sample I and Sample II. Assessment was done on parameters such as moisture content, pH, Electrical Conductivity, Total Organic Carbon, Total Nitrogen, Total Phosphorus, Total Potassium, and the C/N ratio. Heavy metals such as zinc, copper, cadmium, nickel, lead, and chromium were also evaluated. These are the major and basic parameters required to monitor the fertility and applicability of the compost. These 15 parameters were compared with FCOn 1985 standards. Each parameter was found to be within the FCO-mandated acceptable bounds.

Quality control Indices such as the Clean index and Fertility index were calculated after further analysis of the laboratory data. While the Clean Index is determined using the concentration of heavy metals, the Fertility Index is computed based on a few organic indicators such as TOC, N, P, and K. It was found that both samples had a fertility index value of 3.8 and a clean index value of 3.3 for sample I and 4.0 and 3.9 for sample II, respectively.

Sample I was determined to have a Fertilizing Index, since these Indices values are utilized to determine the class to which the compost belongs, and a Clean Index value of 3.8 and 3.3, respectively, belonged to the Class C category, whereas Sample II had a value of 4.0 and 3.9 as Fertilizing Index and Clean Index which is categorized to the Class C category. The class C has maximum fertilizing potential (Fertilizing index > 3.5), but the class C has little environmental threat as it has less heavy metals.

RECOMMENDATION

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

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