

Municipal Corporation of Greater Mumbai
Solid Waste Management Department

e-Tender
for

Dumpsite Reclamation at Mulund Dumping Ground (MDG) in Mumbai by adopting suitable technology for existing garbage dump.

Bid No. :- 7100109494
Start Date :- 23.12.2017
End Date :- 18.01.2018

PART - I

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MUNICIPAL CORPORATION OF GREATER MUMBAI

Solid Waste Management Department

Ch.E./ 551 /SWM/ Project/dtd. 22.12.2017

CHAPTER – 1

e-TENDER NOTICE

Bid No. 7100109494

The Municipal Commissioner of Greater Mumbai invites the following online Global tender from eligible bidders qualified as per Eligibility Conditions (Criteria) in the Tender. The tender copy can be downloaded from MCGM's portal (<http://www.mcgm.gov.in>) under "Business ->Tenders & Quotations -> Tenders & Quotations ->Department->Solid Waste Management" and Business ->Tenders & Quotations -> Major Projects ->Department->Solid Waste Management."

All interested bidders, whether already registered or not registered in MCGM, are mandated to get registered with MCGM for e-tendering process & obtain Login Credentials to participate in the online bidding process on the above mentioned portal under "Tenders" tab.

For registration, enrollment for digital signature certificate & user manual, please refer to respective links provided in e-tendering tab on MCGM website. The bidders can get digital signature from any one of the Certifying Authorities (CA's) licensed by the controller of Certifying Authorities namely Safescrypt, IDRBT, National Informatics Centre, TCS, Customs, MTNL, GNFC and e-Mudhra CA.

MCGM has opened a help desk at the Dy.Ch.Engineer (SWM) New Projects office to help the bidders in this regard at following address.

Deputy Chief Engineer (Solid Waste Management) New Projects
2nd,3rd 4th floor, Bai Padmabai Thakkar Marg,
Kotwadi, Mahim(Shivaji Park)
Mumbai – 400016

e-mail :- newprojectswm.mcgm@gmail.com

Contact:-

Shri Chaudhari K.R.(Executive Engineer)- 09167725591

Shri Anerao R. N.(Assistant Engineer)- 09702850915

In case of any enquiry pertaining to e-tendering process (including User-ID, Password etc.), please contact IT Cell at Ground Floor, Worli Data Centre, 1Z Store Building, Dr.E. Mozes Road, Worli Naka, Mumbai-400018. Tel No. 022-24811275 from 11.30 AM to 5.00 PM on all working days of MCGM.

The technical and commercial bids shall be submitted **online** up to the Bid End Date & Time mentioned below:

Sr. No.	Name of the work	Earnest Money Deposit (Rs)	Period of Contract	e-Tender Price (Rs.)	Bid Start Date & time	Bid End Date & time
1	2	3	4	5	6	7
	Dumpsite Reclamation at Mulund Dumping Ground (MDG) in Mumbai by adopting suitable technology for existing garbage dump.	Earnest Money Deposit – 6.3 Crores	6 Years	7000/- plus 5.% GST i.e. 7350/-	23.12 .2017 After 11.00 AM	18.01.2018 Up to 04.00 PM

Note:- All the interested bidders shall submit their bid through online bidding process of MCGM. No bid will be accepted /received in physical or any other mode.

Pre – Bid Meeting

Date:- 03 / 01 / 2018 at 3.00 pm

Venue :- Conference Hall, 2nd Floor, Annexe Building
Municipal Head Office,
Mahapalika Marg, Fort, Mumbai -400 001

Place, Time & Date for opening of Tender:

Place: Office of
Chief Engineer (Solid Waste Management) Project
2nd, 3rd, 4th floor, Bai Padmabai Thakkar Marg,
Kotwadi, Mahim (Shivaji Park)
Mumbai – 400016

Time & Date: After 4.00 P.M. on 18/01/2018

The bidders shall have to pay the “Tender Procuring Charges” as mentioned in the above table through online payment gateway before downloading the tender documents, up to Bid End date & time.

All bidders shall pay Earnest Money Deposit (E.M.D) of 6.3 Crores of which Rs. 63 lacs to be paid online through Payment Gateway and balance amount (Rs.5.67 Cr.) in the form of Bank Guarantee from MCGM’s approved banks (Annexure 7A) which is to be uploaded in packet A.

Qualification Criteria:-

- A) The tenderer shall be either a natural person or legal person who can sue or can be sued in the court of law in Mumbai. They can be proprietor or partnership firms, a Private or Public Ltd Co. or Corporation. The tenderer shall have to submit the documents proving their legal status as a natural person or legal person in Packet ‘A’.

B) Financial Criteria:

- I. Bidders shall have average annual turnover during last three financial years i.e. 2014-15, 2015 -16 and 2016 -17 of an amount not less than Rs. 189 Crores. (Upload the attested copy of audited balance sheet along with turnover certificate issued by Statutory Auditor).

In case, audited balance sheet of financial year 2016-17 is not available, then audited balance sheet along with turnover certificate issued by Statutory Auditor of financial year 2013-14 will be considered.

(An escalation rate of 10% per annum shall be applied to annual Turnover for past years.)

In case of Joint Venture (JV), members of JV shall collectively fulfill the criteria as prescribed.

- II. Bidder/ Lead member (In case of JV) shall have positive net worth.

(Upload the attested copy of certificate from statutory auditor specifying the net worth of the Applicant, at the close of the preceding financial year).

C) Technical Criteria :-

Category-I:

Bidder/Joint Venture shall have scientifically reclaimed total 120,000 (**Aggregate**) metric tons or cubic meters of MSW from old dumpsite during last 15 years before date of publication of the tender in any Government / Semi-Government Organizations / Public Sector Undertakings or Private Organizations in India or abroad.

Bidder/Joint Venture shall have successfully completed the above work comprising **any two** of the following work components-

Component-1: Composting / Treatment

(“Composting” means a controlled process involving microbial decomposition of organic matter)

Component-2: Material Recovery Facility(MRF)/ Segregation / Recycling

Component-3: Sanitary Land Filling/Residual Solid Waste Management

In case, if the Bidder/Joint Venture does not have work experience of any two of the work components as specified above, then Bidder/Joint Venture shall have to submit the pre tender agreement/s with collateral warranty to provide technology for the remaining work components as specified above with such a company (Technology Provider) who has technical experience of MSW/ Residual Solid Waste Management for the remaining work component/s during last 15 years before date of publication of the tender.

(OR)

Category-II:

Bidder/Joint Venture shall have Composted / **Treated**/ Sanitary land filled/Securely land filled total 120,000 (**Aggregate**) metric tons or cubic meters of waste (MSW/**Hazardous waste**) during last 15 years before date of publication of the tender in any Government / Semi-Government Organizations / Public Sector Undertakings or Private Organizations in India or abroad.

and

In addition to the work component above, Bidder/ Joint Ventures shall have technical experience of one of the work components as specified in the table below or Bidder/ Joint Ventures shall have to submit the pre tender agreement with collateral warranty to provide technology for one of the work components as specified in the table below with such a company (Technology Provider) who has technical experience for that work component as specified in the table below.

Work component	Requirement
1. Composting / Treatment	Composting / Treatment experience of waste (MSW/Hazardous waste) during last 15 years before date of publication of tender
2. Material Recovery Facility(MRF)/Segregation/ Recycling	Material Recovery Facility(MRF)/Segregation/ Recycling experience of waste (MSW/Hazardous waste) during last 15 years before date of publication of tender
3. Sanitary Land Filling / Secured Land Filling / Residual Solid Waste Management	Sanitary Land Filling /Secured Land Filling/ Residual Solid Waste Management experience of waste (MSW/Hazardous waste) during last 15 years before date of publication of tender

For Category I & II , aggregate experience in any of the two work components of the respective category in any proportion of 1 20,000 metric tons or cubic meters of MSW/Hazardous waste/ Residual Solid Waste will be considered .

(Bidder / JV / Technology Provider shall submit & upload Work Experience Certificate from Statutory Auditor / Client as per Annexure -12 for the technology and the work components as specified above so as to fulfill the Technical Criteria .)

In case of any bidding subsidiary company they can claim experience of parent company or any other subsidiary company held by a parent company. However, such bidding subsidiary company has to provide Parent Company Guarantee as per Annexure-13.

In case of Joint Venture (JV), Lead member and other members of JV shall collectively fulfill the Qualification Criteria as prescribed.

Tenderer shall certify that the technology proposed to be used for the subject project has been operational for a period of three years anywhere in the world (Annexure-14).

Eligible Tenderers :-

(1) The eligibility criteria listed in this clause shall apply to the Tenderer, including all members constituting the Tenderer and identified in the Tenderer's Submission (the "Member" or "Members").

(a) A Tenderer may have the nationality of any country unless otherwise stated in the tender. A Tenderer shall be deemed to have the nationality of a country if the Tenderer is a citizen, or is constituted, incorporated or registered and operates in conformity with the provisions of the laws of that country, as evidenced by its articles of incorporation or documents of constitution, and its registration documents.

(b) A Tenderer shall be a private, public or government owned legal entity, or any combination of them in the form of a Joint Venture (JV). In the case where the Tenderer is a JV, it shall comply with the additional requirements as set out in the tender.

(c) Tenderers and all Parties constituting the Tenderer shall not have a Conflict of Interest as described in the tender. Tenderers shall have an obligation to disclose any situation of actual or potential conflict that impact their capacity to serve in the best interest of the Employer, or that may reasonably be perceived as having this effect. Failure to disclose said situations may lead to rejection of the Tender, or eventual termination of the Contract.

(d) Firms not eligible to submit tender:-

i) Any entity (including sole proprietary) which has been barred by the Central/ State Government, or any entity controlled by it, from participating in any project as on date of date of publication of the tender, shall not be eligible to submit a Tender.

(e) Deleted.

(f) Government entities shall be eligible only if they can establish that:

- (i) they are legally and financially autonomous, and
- (ii) they operate under commercial law, and

(iii) they are not a dependent agency of the Employer.

(2) Tenderers shall provide such evidence of their eligibility satisfactory to the Employer, as the Employer shall reasonably request.

D) Solvency:-

Original / attested copy of solvency certificate of Rs. 2.00 Crores from approved Bankers not more than one year old on the date of submission of e-tender, shall be scanned & uploaded.

E) Infrastructural set up :-

The bidder or in case of JV, any of its JV members should have their well established office within Greater Mumbai or MMR region. However, if the bidder/JV is not in Mumbai/MMR based and they happen to succeed in the bid, then they should open such office within 2 months of the receipt of the LOA/ work order.

F) Joint Venture (JV) :

In case, the tenderer wants to bid as a joint venture, he is allowed to do so. It is optional for Successful bidder or joint venture to form Special Purpose Vehicle (SPV) incorporated under the Indian Companies Act 1956/2013. In case successful bidder does not want to form SPV, then Special Purpose Vehicle (SPV) to be read as joint venture (JV) wherever applicable in the entire tender document. Consortium shall not be allowed for the tender.

However, the joint venture of maximum three firms / Companies, each having minimum 10% equity shall only be accepted. Exit from the JV is not allowed to any of the JV member for the entire contract period. Each tenderer shall submit only one tender either by itself or as a member of joint venture. Further, a company participating in the joint venture can not submit the tender separately in its own name. A tenderer who submits or participates in more than one tender shall summarily be rejected.

In any registered Joint Venture the share of the lead member shall be the highest. All members of JV shall be legally liable, jointly and severally, during the bidding process and for the execution of contract in accordance with the contract terms. Bids submitted by a joint venture of all firms as members shall comply with the following requirements.

- i. The bid shall include all the information regarding J.V. or all J.V. members.
- ii. The bid and, in case of a successful bid, the Agreement, shall be signed so as to be legally binding on all members in a form specified at Annexure/Proforma.
- iii. One of the members shall be nominated as being in charge, and this authorization shall be evidenced by submitting a power of attorney signed by legally authorized signatories of all the JV members as per the format provided in Annexure/Proforma.
- iv. The member in charge shall be authorized to incur liabilities and receive instructions for and on behalf of any and all JV members and the entire execution of the contract shall be done exclusively by the member in charge.
- v. All JV members shall be liable jointly and severally for the execution of the contract in accordance with the contract terms, and a statement to this effect shall be included in the bid and in the Agreement (in case of successful bid).
- vi. The joint venture agreement should indicate precisely the share holding of each of the JV in respect of work execution, and financing of the contract. This should not be varied / modified subsequently without prior approval of the MCGM.
- vii. The joint venture agreement should be registered in Mumbai so as to be legally valid and binding on all JV members and a copy of the joint Venture Agreement entered into by the members shall be submitted with the bid. Alternatively, a Letter of intent to execute a Joint Venture Agreement in the event of a successful bid shall be signed by

all JV members and submitted with the bid, together with a copy of proposed Draft Agreement.

The registered JV agreement shall be submitted by the successful tenderer within one month from the issue of letter of acceptance/work order.

Conflict of Interest :-

a) The tenderer shall not have a conflict of interest (the “Conflict of Interest”) that affects the Bidding Process. Any tenderer found to have a Conflict of Interest shall be disqualified. The tenderer shall be deemed to have a Conflict of Interest that affects the Bidding Process, if:

(i) The tenderer, its Member or Associate (or any constituent thereof) and any other tenderer, its Member or Associate (or any constituent thereof) have common controlling shareholders or other ownership interest; provided that this disqualification shall not apply in cases where the direct or indirect shareholding of the tenderer, its Member or an Associate thereof (or any shareholder thereof) having a shareholding of more than 25% (twenty five) percent of the paid up and subscribed share capital of such tenderer, Member or Associate (as the case may be) in the other Tenderer, its Member or Associate is less than 25% (twenty five) percent of the subscribed and paid up equity share capital thereof; provided further that this disqualification shall not apply to any ownership by a bank, insurance company, pension fund or a public institution referred to in section 4A of the Companies Act 1956. For the purposes of eligibility of tenderer, indirect shareholding held through one or more intermediate persons shall be computed as follows: (aa) where any intermediary is controlled by a person through management control or otherwise, the entire shareholding held by such controlled intermediary in any other person (the “Subject Person”) shall be taken into account for computing the shareholding of such controlling person in the Subject Person; and (bb) subject always to subclause (aa) above, where a person does not exercise control over an intermediary, which has shareholding in the Subject person shall be undertaken on a proportionate basis; provided however, that not such shareholding shall be reckoned under this sub-clause (bb) if the shareholding of such person in the intermediary is less than 26% of the subscribed and paid up equity share holding on such intermediary;

or

(ii) a constituent of such tenderer is also a constituent of another tenderer;

or

(iii) such tenderer receives or has received any direct or indirect subsidy, grant, concessional loan or subordinated debt from any other tenderer, or any Associate

thereof or has provided any such subsidy, grant, concessional loan or subordinated debt to any other tenderer, its Member or any Associate thereof;

or

(iv) Such tenderer has the same legal representative for purposes of this tender as any other tenderer;

or

(v) such tenderer, or any Associate thereof has a relationship with another tenderer, or any Associate thereof, directly or through common third party / parties, that puts either or both of them in a position to have access to each others' information about, or to influence the tender of either or each other;

or

(vi) such tenderer or any Associate thereof has participated as a consultant to the MCGM in the preparation of any documents, design or technical specifications of the Project.

b) The tenderer shall be liable for disqualification if any legal, financial or technical advisor of the MCGM in relation to the Project is engaged by the tenderer, its Member or any Associate thereof, as the case maybe, in any manner for matters related to or incidental to the Project. For the avoidance of doubt, this disqualification shall not apply where such advisor was engaged by the tenderer, its Member or Associate in the past but its assignment expired or was terminated 6 (six) months prior to the date of issue of this tender. Nor will this disqualification apply where such advisor is engaged after a period of 3 (three) years from the date of commercial operation of the Project.

Explanation: In case the tenderer is a Joint Venture, then the term tenderer as used in Clause 'Joint Venture' shall include each Member of such Joint Venture.

G) Every tenderer to note that his tender may be rejected if he-

a) Stipulates

- i. The validity period to be less than **180** days i.e. what is required in the bid documents.
- ii. Hedging condition / own conditions

b) Does not disclose.

- i. The full names, addresses, telephone Nos., Mobile Nos., E-mail ID of all his Partners in the case of partnership concern
- ii. Office address, phone Nos.
- iii. Status in the prescribed format

c) Does not scan and upload

- i. Duly filled in signed tender form, required declarations/undertakings etc.
- ii. Documents as specified for inclusion in Packet 'A' and Packet 'B'.
- iii. PAN CARD of his own in case he is retailer/dealer/supplier/distributor

in case of Company or firm –

in case of Proprietor / Ownership firm

in case of a Public/ Private Limited Co.

in case of a Partnership firm

in case of a Sanstha / Society or Trust registered under Public Trust Act 1950/ Registration Act 1860/ The Maharashtra Co-op Societies Registration Act 1960 (whichever is applicable). (However, in case of Semi Govt./Govt. Undertakings, no “PAN CARD” shall be insisted.)

in case of applicant is from a foreign country, no PAN CARD shall be insisted at the time of bidding. However, in case of successful bid, such applicant shall submit the PAN CARD within a period of 2 months from the date of letter of acceptance.

- iv. Photographs of individual, proprietor or Min. two or all partners, as the case may be
- v. Latest partnership deed in case of partnership firm and R.C. & MOU in case of Private Ltd. Firm. Copy of the joint Venture Agreement entered into by the members.
- vi. Audited Balance sheets or Turnover Certificate issued by Statutory Auditor and Solvency Certificates issued by the approved bank.
- vii. Copy of Power of Attorney if tender documents are signed by holder of Power of Attorney.
- viii. Documentary proof in support of fulfilment of Eligibility Criteria
- ix. Declaration on stamp paper of Rs.200/- in respect of correctness and fulfilments of applicable conditions as above.
- x. Declaration about Litigation / Blacklisting as per Annexure-2, Point 11
- xi. Undertaking on Rs. 200/-Stamp paper, as per provisions **under ESIC Act 1948**
- xii. Annexure- 1 to 20
- xiii. Pro-forma ‘A’ to ‘L’
- xiv. Bank Guarantee of Balance amount of EMD (Rs. 5.67 Cr.)

Sd/-

Ch.E. (S.W.M.) Project

CHAPTER – 2

Qualification Criteria

The bidders in its name fulfilling the following criteria are eligible to bid for tender –

Qualification Criteria:-

- A) The tenderer shall be either a natural person or legal person who can sue or can be sued in the court of law in Mumbai. They can be proprietor or partnership firms, a Private or Public Ltd Co. or Corporation. The tenderer shall have to submit the documents proving their legal status as a natural person or legal person in Packet 'A'.

B) Financial Criteria:

- I. Bidders shall have average annual turnover during last three financial years i.e. 2014-15, 2015 -16 and 2016 -17 of an amount not less than Rs. 189 Crores. (Upload the attested copy of audited balance sheet along with turnover certificate issued by Statutory Auditor).

In case, audited balance sheet of financial year 2016-17 is not available, then audited balance sheet along with turnover certificate issued by Statutory Auditor of financial year 2013-14 will be considered.

(An escalation rate of 10% per annum shall be applied to annual Turnover for past years.)

In case of Joint Venture (JV), members of JV shall collectively fulfill the criteria as prescribed.

- II. Bidder/ Lead member (In case of JV) shall have positive net worth.

(Upload the attested copy of certificate from statutory auditor specifying the net worth of the Applicant, at the close of the preceding financial year).

C) Technical Criteria :-

Category-I:

Bidder/Joint Venture shall have scientifically reclaimed total 120,000 (Aggregate) metric tons or cubic meters of MSW from old dumpsite during last 15 years before date of publication of the tender in any Government / Semi-Government Organizations / Public Sector Undertakings or Private Organizations in India or abroad.

Bidder/Joint Venture shall have successfully completed the above work comprising **any two** of the following work components-

Component-1: Composting / Treatment

Component-2: Material Recovery Facility(MRF)/ Segregation / Recycling

Component-3: Sanitary Land Filling/Residual Solid Waste Management

In case, if the Bidder/Joint Venture does not have work experience of any two of the work components as specified above, then Bidder/Joint Venture shall have to submit the pre tender agreement/s with collateral warranty to provide technology for the remaining work components as specified above with such a company (Technology Provider) who has technical experience of MSW/ Residual Solid Waste Management for the remaining work component/s during last 15 years before date of publication of the tender.

(OR)

Category-II:

Bidder/Joint Venture shall have Composted / **Treated**/ Sanitary land filled/Securely land filled total 120,000 (**Aggregate**) metric tons or cubic meters of waste (MSW/**Hazardous waste**) during last 15 years before date of publication of the tender in any Government / Semi-Government Organizations / Public Sector Undertakings or Private Organizations in India or abroad.

and

In addition to the work component above, Bidder/ Joint Venture shall have technical experience of one of the work components as specified in the table below or Bidder/ Joint Venture shall have to submit the pre tender agreement with collateral warranty to provide technology for one of the work components as specified in the table below with such a company (Technology Provider) who has technical experience for that work component as specified in the table below.

Work component	Requirement
1. Composting / Treatment	Composting / Treatment experience of waste (MSW/Hazardous waste) during last 15 years before date of publication of tender
2. Material Recovery Facility(MRF)/Segregation/ Recycling	Material Recovery Facility(MRF)/Segregation/ Recycling experience of waste (MSW/Hazardous waste) during last 15 years before date of publication of tender
3. Sanitary Land Filling / Secured Land Filling / Residual Solid Waste Management	Sanitary Land Filling /Secured Land Filling/ Residual Solid Waste Management experience of waste (MSW/Hazardous waste) during last 15 years before date of publication of tender

For Category I & II , aggregate experience in any of the two work components of the respective category in a any proportion of 1 20,000 metric tons or cubic meters of MSW/Hazardous waste/ Residual Solid Waste will be considered .

(Bidder / JV / Technology Provider shall submit & upload Work Experience Certificate from Statutory Auditor / Client as per Annexure -12 for the technology and the work components as specified above so as to fulfill the Technical Criteria .)

In case of a any bidding subsidiary company they can claim experience of parent company or any other subsidiary company held by a parent company. However, such bidding subsidiary company has to provide Parent Company Guarantee as per Annexure-13.

In case of Joint Venture (JV), Lead member and other members of JV shall collectively fulfill the Qualification Criteria as prescribed.

Tenderer shall certify that the technology proposed to be used for the subject project has been operational for a period of three years anywhere in the world (Annexure-14).

Eligible Tenderers :-

- (1) The eligibility criteria listed in this clause shall apply to the Tenderer, including all members constituting the Tenderer and identified in the Tenderer's Submission (the "Member" or "Members").
 - (a) A Tenderer may have the nationality of any country unless otherwise stated in the tender. A Tenderer shall be deemed to have the nationality of a country if the Tenderer is a citizen, or is constituted, incorporated or registered and operates in conformity with the provisions of the laws of that country, as evidenced by its articles of incorporation or documents of constitution, and its registration documents.
 - (b) A Tenderer shall be a private, public or government owned legal entity, or any combination of them in the form of a Joint Venture (JV). In the case where the Tenderer is a JV, it shall comply with the additional requirements as set out in the tender.
 - (c) Tenderers and all Parties constituting the Tenderer shall not have a Conflict of Interest as described in the tender. Tenderers shall have an obligation to disclose any situation of actual or potential conflict that impact their capacity to serve in the best interest of the Employer, or that may reasonably be perceived as having this effect. Failure to disclose said situations may lead to rejection of the Tender, or eventual termination of the Contract.

- (d) Firms not eligible to submit tender:-
 - i) Any entity (including sole proprietary) which has been barred by the Central/ State Government, or any entity controlled by it, from participating in any project during last five years, shall not be eligible to submit a Tender.

- (e) Any Tenderer shall have n either failed to perform on any contract, as evidenced by imposition of a penalty by an arbitral or judicial Employer or a judicial pronouncement or arbitration award against the Tenderer as the case may be nor
 - i. has been expelled from any project or contract by any public entity
 - ii. have had any contract terminated by any public entity for breach by such Tenderer, or any Member constituting the Tenderer.

- (f) Government entities shall be eligible only if they can establish that:
 - (i) they are legally and financially autonomous, and
 - (ii) they operate under commercial law, and
 - (iii) they are not a dependent agency of the Employer.

(2) Tenderers shall provide such evidence of their eligibility satisfactory to the Employer, as the Employer shall reasonably request.

D) Solvency:-

Original / attested copy of solvency certificate of Rs. 2.00 Crores from approved Bankers not more than one year old on the date of submission of e-tender, shall be scanned & uploaded.

E) Infrastructural set up :-

The bidder or in case of JV, any of its JV member should have their well established office within Greater Mumbai or MMR region. However, if the bidder/JV is not in Mumbai/MMR based and they happen to succeed in the bid, they should open such office within 2 months of the receipt of the LOA /work order.

F) Joint Venture (JV) :

In case, the tenderer wants to bid as a joint venture, he is allowed to do so. Successful bidder or joint venture shall form an appropriate Company or an appropriate Special Purpose Vehicle (SPV), incorporated under the Indian Companies Act 1956/2013 within two months from Letter of Acceptance (LOA).

However, the joint venture of maximum three firms / Companies, each having minimum 10% equity shall only be accepted. Exit from the JV is not allowed to any of the JV member for the entire contract period. Each tenderer shall submit only one tender either by itself or as a member of joint venture. Further, a company participating in the joint venture can not submit the tender separately in its own name. A tenderer who submits or participates in more than one tender shall summarily be rejected.

In any registered Joint Venture the share of the lead member shall be the highest. All members of JV shall be legally liable, jointly and severally, during the bidding process and for the execution of contract in accordance with the contract term. Bids submitted by a joint venture of all firms as members shall comply with the following requirements.

- i. The bid shall include all the information regarding J.V. or all J.V. members.
- ii. The bid and, in case of a successful bid, the Agreement, shall be signed so as to be legally binding on all members in a form specified at Annexure/Proforma.
- iii. One of the members shall be nominated as being in charge, and this authorization shall be evidenced by submitting a power of attorney signed by legally authorized signatories of all the JV members as per the format provided in Annexure/Proforma.
- iv. The member in charge shall be authorized to incur liabilities and receive instructions for and on behalf of any and all JV members and the entire execution of the contract shall be done exclusively by the member in charge.

- v. All JV members shall be liable jointly and severally for the execution of the contract in accordance with the contract terms, and a statement to this effect shall be included in the bid and in the Agreement (in case of successful bid).
- vi. The joint venture agreement should indicate precisely the share holding of each of the JV in respect of work execution, and financing of the contract. This should not be varied / modified subsequently without prior approval of the MCGM.
- vii. The joint venture agreement should be registered in Mumbai so as to be legally valid and binding on all JV members and a copy of the joint Venture Agreement entered into by the members shall be submitted with the bid. Alternatively, a Letter of intent to execute a Joint Venture Agreement in the event of a successful bid shall be signed by all JV members and submitted with the bid, together with a copy of proposed Draft Agreement.

The registered JV agreement shall be submitted by the successful tenderer within one month from the issue of letter of acceptance.

CHAPTER – 3

OTHER TENDER CONDITIONS

Every tenderer to note that his tender may be rejected if he --

- a) Stipulates
 - i. The validity period less than **180** days i.e. what is required in the bid documents.
 - ii. Hedging condition / own conditions
- b) Does not disclose.
 - i. The full names, addresses, telephone Nos., Mobile Nos., E-mail ID of all his Partners in the case of partnership concern
 - ii. Office address, phone Nos.
 - iii. Status in the prescribed format
- c) Does not scan and upload
 - i. Duly filled in signed tender form, required declarations/undertakings etc.
 - ii. Documents as specified for inclusion in Packet 'A' and Packet 'B'.
 - iii. PAN CARD of his own in case he is retailer/dealer/supplier/distributor
in case of Company or firm –
in case of Proprietor / Ownership firm
in case of a Public/ Private Limited Co.
in case of a Partnership firm
in case of a Sanstha / Society or Trust registered under Public Trust Act 1950/
Registration Act 1860/ The Maharashtra Co-op Societies Registration Act 1960
(whichever is applicable).
In case, applicant is from a foreign country, no PAN CARD shall be insisted at the time of bidding. However, in case of successful bid, such applicant shall submit the PAN CARD within a period of 2 months from the date of letter of acceptance/work order.
 - iv. Photographs of individual, proprietor or Min. two or all partners, as the case may be
 - v. Latest partnership deed in case of partnership firm and R.C. & MOU in case of Private Ltd. Firm. Copy of the joint Venture Agreement entered into by the members.
 - vi. Audited Balance sheets or Turnover Certificate issued by Statutory Auditor and Solvency Certificates issued by the approved bank.
 - vii. Copy of Power of Attorney if tender documents are signed by holder of Power of Attorney.

- viii. Documentary proof in support of fulfilment of Eligibility Criteria
- ix. Declaration on stamp paper of Rs.200/- in respect of correctness and fulfilment of applicable conditions as above.
- x. Declaration about Litigation / Blacklisting as per Annexure-2, Point 11
- xi. Undertaking on Rs. 200/-Stamp paper, as per provisions **under ESIC Act 1948**
- xii. Annexure- 1 to 20
- xiii. Pro-forma 'A' to 'L'

CHAPTER - 4

SPECIAL INSTRUCTIONS TO TENDERERS

1. The contract period is SIX years from the placement of LOA/work Order.
2. The contractor shall abide with the provision of the Minimum Wages Act/ Workman Compensation Act and such other statutory obligations notified by the concerned Govt. depts. from time to time. The tenderer should specifically note that the successful tenderer shall have to get themselves registered with the relevant authorities as required under various labour laws and submit undertaking of compliance along with the first payment bill failing which the payment bill shall not be processed. They shall strictly comply with all the statutory requirements notified by the concerned Govt. depts. from time to time and indemnify the Corporation against any claim(s) whatsoever arising therefrom and the tenderer shall be solely responsible for consequences thereof.

Tenderers are requested to take cognizance of child Labour Act and take precaution not to deploy child Labourers. If Child Labourer is found to be deployed on the work, necessary action as deemed fit will be taken.

3. The contract period of SIX years is including period required for mobilization, erection, commissioning and period required for obtaining requisite regulatory/statutory permissions/NOCs etc. and shall be reckoned from the date mentioned in the LOA/work order.
4. The successful bidder has to obtain all required permissions/NOCs from various authorities like State Level Environment Impact Assessment Authority (SEIAA), Maharashtra Pollution Control Board (MPCB), Maharashtra Coastal Zone Management Authority (MCZMA), Ministry of Environment & Forest and Climate Change (MoEF & CC), clearance of land owner for disposal of rejects/inerts and any such requisite regulatory/statutory permissions etc. in order to process existing MSW dumped at MDG. MCGM may assist the Successful Bidder in obtaining these permissions.
5. The tenderer shall state their Vendor Registration Number and e-mail ID. The procedure for registration as vendor in the MCGM is outlined as below:-
 - a. Go to MCGM website <http://portal.mcg.gov.in> → tender → Manuals → Vendor Registration Form. Download this form, read all the instructions, dully fill it and submit the same physically to the office mentioned in it along with all required documents.
 - b. After scrutiny of your duly filled form, MCGM's Central Purchasing Department will register you with MCGM and you will get a Vendor code.
 - c. After getting Vendor code, you have to contact this office i.e. Dy.Ch.E.(SWM) New Projects department, the address for the same is given in the tender notice. After receipt of your written request, your Vendor code will be transferred on MCGM's SAP SRM module and you will get an email on your registered e mail ID, follow the steps in this mail. In case of further details go to MCGM website <http://portal.mcg.gov.in> → tender → Manuals → User Manuals for Vendors Registration Process . Just follow the steps and you will get user new ID and password.

- d. Read all the applicable manuals available at <http://portal.mcgm.gov.in> → tender → Manuals. These manuals will be helpful for browser setting, payment gateways, digital signature, etc.
 - e. This is a one time procedure, after this you can participate in any e tender of MCGM.
6. Firms with common proprietors / partner or connected with one another either financially or as Principal and Agent or as Master and Servant or with Proprietor/Partners closely related to each other such as husband / wife / father / mother and minor son / daughter and brother / sister and minor brother / sister shall not tender separately under the different names for the same contract.
 7. If it is found that firms as described in the direction vide Clauses 6 above, have tendered separately under different names for the same contract, all such tender shall stand rejected and tenderer(s) deposit shall be forfeited. Any contract entered into under such conditions will also be liable to be cancelled at any time during its currency and penal action including blacklisting such firms will be taken.
 8. The prices quoted shall be in Indian Rupees (INR) and shall be firm. During the contract, no other price variations shall be allowed under any circumstances.
 9. Tenderer should specifically state their residential addresses besides their official addresses along with the telephone and mobile number. The contractor or their partners and authorized representative shall be available on a given telephone number during any hours of the day.
10. DEPARTURE FROM SPECIFICATIONS:
No departure from scope of work shall be allowed under any circumstances.

Signature of the Tenderer

Rubber Stamp of the Firms

Witness
of

Trading under the style and Name
Contractors

Address.....
.....

Witness.....
Administrator
Address.....
Mumbai

Municipal C ommissioner /
for Greater

CHAPTER – 5

EARNEST MONEY DEPOSIT

1. Earnest Money Deposit – Rs. 6.3 Crores/-

2. Mode of Payment

All bidders shall pay Earnest Money Deposit (E.M.D.) of 6.3 Crores of which Rs. 63 lacs to be paid online through Payment Gateway and balance amount (Rs.5.67 Cr.) in the form of Bank Guarantee from MCGM's approved banks (Annexure 7A) which is to be uploaded in Packet A.

3. Forfeiture of EMD:

(1) Entire EMD of a tenderer / bidder shall be forfeited,

- i. if the tenderer /bidder withdraws or amends its tender or impairs or derogates from the tender in any respect within the period of validity of its tender.
- ii. if the successful tenderer/ bidder fails to furnish the required performance security within the specified period.

(2) If bidder fails to submit the necessary physical copies of documents uploaded in Packet A & B, if required by MCGM within stipulated period, his tender may be treated as non-responsive. Further in such a case, MCGM reserves the right of forfeiture of 10% EMD.

(3) If bidder fails to submit clarification within the stipulated period his tender may be treated as non-responsive. Further in such a case, MCGM reserves the right of forfeiture of 10% EMD.

(4) No rejections and forfeiture shall be done in case of curable defects. For non-curable defects the 10% of EMD may be forfeited and bid will be liable for rejection.

Note:

i) Curable Defect shall mean shortfalls in submission such as: -

a. Non-submission of following documents,

i. Valid Registration Certificate

ii. Valid Bank Solvency

iii. Sales Tax Registration Certificate (VAT)

iv. Certified Copies of PAN documents and photographs of individuals, owners, etc

v. Partnership Deed and any other documents

vi. Undertakings as mentioned in the tender document.

b. Wrong calculation of Bid Capacity,

c. No proper submission of experience certificates and other documents, etc.

ii) Non-curable Defect shall mean shortfalls in submission such as:-

- a. In-adequate submission of EMD/ASD amount,
- b. In-adequacy of technical and financial capacity with respect to Eligibility criteria as stipulated in the tender.

4. Exemption of EMD:

All bidders shall pay EMD as specified above and there is no provision of exemption of EMD.

5. Refund/Adjustments :-

EMD furnished by all the tenderers shall be returned to them without any interest, as follows:-

- In case of non-responsive bidders: After passing of D.L. in the standing committee.
- In case of responsive bidders :
 - ✓ Except first three lowest, immediately after Tender Committee recommendations.
 - ✓ In case of successful bidder: either refund it after furnishing the Performance Security Deposit required under the Contract or convert it into Performance Security Deposit as per bidder's desire.
 - ✓ In case of other two bidders: refund it immediately after approval of competent authority to award contract.

Entire amount of EMD or part thereof can be adjusted/recovered/ forfeited for any of the lapses on the part of the tenderer mentioned in the tender documents.

CHAPTER-6

EVALUATION CRITERIA

It shall be as mentioned in PART-II, CHAPTER-I, GENERAL CONDITIONS OF CONTRACT (GCC), 15) Evaluation of bids, and mentioned elsewhere: _

CHAPTER -7

INFORMATION TO THE BIDDERS

7-A) PRE – BID MEETING

Pre-bid Meeting:

- 1) A pre-bid meeting will be conducted with a view to clarify issues and to answer questions on any matter that may be raised by the prospective tenderer in respect of the tender documents.
- 2) The Tenderer or his authorized representative may attend a pre-bid meeting as per the date, time and venue mentioned in the tender notice.
- 3) The purpose of the meeting is to clarify issues and to answer questions on any matter that may be raised by the prospective tenderer at that stage.
- 4) Any tenderer requiring clarification about the content of the tender document and/ or the works / specifications etc. may submit in writing, at least 2 days before the meeting, to the Dy.Ch.E.(SWM) New Projects department the points on which clarification is needed. The MCGM will not be bound to respond to the queries received after permitted period mentioned above.
- 5) Points raised by the bidders shall be clarified in the Pre-bid meeting. Any modifications / additions / alteration of the tendering documents, which may become necessary as a result of the pre-bid meeting, shall be made by the MCGM by recording the minutes of the Pre Bid Meeting. Such modifications in the Tender Documents shall be published on the MCGM portal so as to make it known to all the prospective bidders so also by communicating to the bidders seeking clarification.
- 6) Non-attendance at the pre-bid meeting shall not be a cause for disqualification of a tenderer.
- 7) Any change in venue, date and time shall be communicated in the same manner in which other changes would be intimated.

7-B) CONTENTS OF EACH PACKET

Contents of Packets:

Tenderers should note that the tender is to be filled in and uploaded by following three Packet systems.

Packet - 'A':-

All documents as required under Mandatory Conditions mentioned in Part-I, Chapter 3 submission of which is mandatory shall be under **Packet 'A'**.

Packet – 'B':-

- a. Documents under this Packet are related to technical, financial, machinery and personnel capacity as well as fulfilment of other requirements such as certificates / licenses, literatures, pamphlets, etc. from different authorities.
- b. Proposed plan and methodology for the project comprising entire technical documentation.
- c. Annexures & Proformas.
- d. Signed copy of the Addendum / Corrigendum if any.

Packet – 'C':-

11. This Packet will be generated by the system itself. Bidder has to fill in the rate he desires to quote as per the requirement of the tender.
12. This Packet shall therefore contain only financial offer of the bidder and nothing else.

Above three Packets i.e. 'A', 'B' and 'C' form part of e-tendering process.

Tenderers shall note that they shall not disclose / quote the rates of any item in Packet 'A' or 'B'. Any such indication / attempt by the tenderer shall amount to disclosure of rate in advance and his tender would be rejected outright.

7-C) RATES, TAXES, VALIDITY PERIOD

A) Taxes and Duties (applicable only for processing of MSW):-

- 1) All rates shall be inclusive of applicable taxes and duties.

Chapter X XI-Miscellaneous, section 171(1) of GST Act, 2017 governs the 'Anti Profiteering Measure'(APM).

As per the provision of this section, 'Any reduction in rate of tax on any supply of goods or services or the benefit of input tax credits shall be passed on to the recipient by way of commensurate reduction in prices'

Accordingly, the contractor should pass on the complete benefit *accruing to him on account of reduced tax rate or additional input tax credit*, to MCGM.

Further, all the provisions of GST Act, 2017 and its amendments/circulars from time to time will be applicable to the tender.

- 2) G.S.T. and other state levies/cess which are not subsumed under GST will be applicable. The tenderer shall quote inclusive of all taxes. It is clearly understood that MCGM will not bear any additional liability towards payment of any Taxes & Duties.

Wherever the services to be provided by the Tenderers, falls under Reverse Charge Mechanism, the Price quoted shall be exclusive of GST, but inclusive of Taxes/Duties/ Cess other than GST, if any.

Rates accepted by MCGM shall hold good till completion of work and no additional individual claim shall be admissible on account of fluctuations in market rates; increase in taxes/ any other levies/ tolls etc. except that payment / recovery for overall market situation shall be made as per Price Variation.

- 3) All the applicable taxes for processing of MSW under this contract such as service tax and other taxes shall be borne by the contractor.
- 4) However, % or rate of each tax applicable for processing of MSW shall be shown separately with their prevailing rate of percentage as per the Annexure-15. Where no specific mention of the taxes chargeable is made by the tenderer, it shall be understood that these taxes are either not applicable being already paid at source by the tenderers, or it shall be borne by him. Subsequent claim from the successful tenderer for payment of these taxes shall not be entertained.

B) Rates and validity period:

- 1) Tenderers shall quote firm offer and shall not quote more than one rate for the same item. Conditional offers shall not be considered and shall be treated as non-

responsive. The offer with discount for prompt payment, bonus etc. shall not get weightage at the stage of evaluation.

- 2) Alternate Offers submitted by the tenderers shall not be considered. If submitted, offer for that item shall be rejected.
- 3) Validity of the offer should not be less than **180** days from the date of opening of tender. Any period quoted lesser than this will amount to conditional offer and shall be rejected. In exceptional circumstances, prior to expiry of the original time limit, the Municipal Commissioner may request the tenderer to extend the period of validity for a specified additional period. The request and the tenderer's responses shall be made in writing. A tenderer may refuse the request to extend the validity period. A tenderer agreeing to extended validity period shall not be permitted to modify terms & conditions of the tender.
- 4) Tenderers shall not quote any conditions outside the conditions included in these documents. Such offers would be treated as conditional offers and would be rejected outright.
- 5) The rates quoted should be firm for the entire contract period and no change on any account shall be allowed.
- 6) The rate offered shall be for the whole work as described in scope of work attached hereto based on the Bill of Quantities.
- 7) The Tenderer shall fill / upload the item rate in figures in the Financial Bid.

7-D) SIGNING AND SUBMISSION OF TENDERS

1) Filling in the form, signing and sealing:

Tenderers shall be advised to fill in the tender documents by observing the following:

- (i) Tender shall be written in English only.
- (ii) Before filling in the tender documents tenderers are requested to go through all terms and conditions to be fulfilled and the steps to be followed in uploading the tender documents.
- (iii) The tenderers are requested to sign and put the official seal of the company on the last page of the tender form.
- (iv) The tender must be submitted in the tender form / item schedule of the Corporation and should be free from erasures. Any tender containing corrections or alterations shall be rejected.
- (v) The rate must be typed on schedule rate copy. Rate presented on any other sheet of the paper, covering letter etc. shall not be considered. All the columns must be filled in carefully.
- (vi) Tenderers are informed that they should score off or write 'NIL' on each blank sheet of items, which are not tendered for.
- (vii) The tenderers are requested to fill the tender carefully after noting the items and specifications, quantity mentioned for each article in the schedule. They are informed that no variation in rates shall be allowed on any ground such as clerical mistake or misunderstanding etc. after tender has been submitted.
- (viii) Who should sign-
 - a) If the e-tender is made by an individual, it shall be signed by him with his full name and current address.
 - b) If the e-tender is made by a proprietary firm it shall be signed by the proprietor with his name and the name of his firm with its current address.
 - c) If the e-tender is made by firm in partnership, it shall be signed by all the partners of the firm with their full names and current address or by a partner holding the Power of Attorney for the firm for signing the tender. In this case, a certified copy of the Power of Attorney shall be uploaded. A certified copy of the partnership deed shall also be uploaded.
 - d) If the e-tender is made by a limited company or a limited corporation or Joint Venture, it shall be signed by a duly authorized person holding the Power of Attorney for signing the tender in which case a certified copy of the Power of Attorney shall be uploaded.

- e) If the e-tender is made by a co-operative society or any charitable institute or any other sanstha it shall be signed by a duly authorized person and copy of resolution and the Registration certificate shall be uploaded.
- f) If the person signing the tender is other than the individual or the Proprietor, then tender shall upload a certificate copy of Power of Authority authorizing the signatory.

2) Submission of Tender:

A. Tender Document:

Each tenderer shall submit only one tender document. Tender document is not transferable. Tenderers are requested to read carefully the following directions, terms and conditions of the contract and sign the form of tender, annexure, specifications and bill of quantities and rates etc. after making appropriate entries wherever necessary. All entries should be in clear writing and legible. Any corrections made by the tenderer in his entries must be attested by the signatory. Tenders containing erasures or alterations not so attested or written in illegible form are liable to be rejected. This is an e-Tender & shall be submitted by e tender process only. Contents of the tender documents are:

1. e-Tender Notice
2. Eligibility Criteria
3. Special Instructions to the Tenderers
4. Mandatory Conditions
5. Earnest Money Deposit
6. Evaluation Criteria
7. Information to the Bidders
8. General Conditions of Contract (GCC)
9. Undertaking on Rs.200/- Stamp paper, as per provisions **under ESIC Act 1948**
10. Special Instructions to Bidders Participating in e-Tendering of MCGM
11. Technical Specification & Scope of Work
12. Schedule/Bill of Quantities and Rates (BOQ)
13. Instructions to Bidders
14. Annexure- 1 to 20
15. Proforma 'A' to 'L'

- B.** All tenders shall be submitted as per procedure stated in “SPECIAL INSTRUCTIONS TO BIDDERS PARTICIPATING IN e-TENDERING OF M.C.G.M.” on due date & time. Tenders must be submitted by way of uploading the entire offer document including Article of Agreement Document, completely filled in and digitally signed by a authorized signatory prior to time & date mentioned in the e-Tender Notice. Tenders received after the stipulated time and date will not be considered. Telegraphic tenders will not be accepted under any circumstances.

3) Interpretation of Tender Document:

Tenderer(s) shall examine the tender document and acquaint themselves with all conditions and matters affecting the cost of the supply. If any tenderer(s) finds discrepancies or omissions in the document or if any doubt about their meaning, he should immediately address a query to the office of Dy. Ch. Eng. (SWM) New Projects prior to the date of submission.

Any resulting interpretation of the tender document will be published on MCGM website for prospective Tenderer(s) as an addendum in addition to written reply to the particular Tenderer. Oral clarification obtained from any source shall not be binding on the Corporation.

No tenderer(s) shall amend the text of any document except as may be necessary to comply with any addendum.

4) Cost of Tendering:

The Corporation will not defray expenses incurred by any tenderer(s) in tendering and will not be bound to accept the lowest or any tender.

5) Tenderer are requested to submit the tender in time on the stipulated day so as to avoid rush at the closing hour.

6) Responsibility for uploaded Documents:

- 1) The responsibility to produce original and authenticated documents in respect of documents uploaded rests with the Tenderer. If any document is found to be forged, bogus etc. the tender shall be rejected and the EMD will be forfeited. Any contract entered into under such conditions shall be liable to be terminated at any time during its currency and in addition for further penal action like criminal prosecution, blacklisting against the said contractors and / or the partners.
- 2) If the certificates issued by any state authority are in a language other than English, Hindi or Marathi, then translated copy in one of the languages mentioned above, duly certified by the official translator, shall have to be uploaded, along with a copy of the original certificate.

7) Amendment to Tender documents:

- 1) Before the deadline for uploading / submission of tender offer, the MCGM may modify any tender condition included in the tender document and issue addendum / corrigendum / clarification by publishing in the newspapers and on the portal. MCGM may also adopt e-mail facility or may display such amendment on the notice board of the department issuing the tender also.
- 2) Such addendum/corrigendum/clarification so issued shall form part of the tender documents. All tenderers shall digitally sign such addendum / corrigendum / clarification and upload it in Packet 'B'.

- 3) With a view to give sufficient time to the prospective tenderers to consider any such addendum / corrigendum / clarification, MCGM may, if considered necessary, extend the due date of submission / uploading of the offer and accordingly re-schedule the further activities.

PART -II

CONTENTS

SR.NO.	DESCRIPTION	PAGE NO.
1.	Chapter-1 “ General Conditions of Contract (GCC)”	
2.	CHAPTER – 2 “SPECIAL INSTRUCTIONS TO BIDDERS PARTICIPATING IN e-TENDERING OF MCGM”	

CHAPTER -1
General Conditions of Contract (GCC)

A Booklet containing Standard General Conditions of Contract for Construction Works 2016 (GCC-2016) is available on website for downloading to intending bidder along with other bid documents. It shall form part of contract documents. All the GCC-2016 will be applicable for the contract except conditions at Section-A: General- 4(a), 4(c), 4(f), 4(g), 5(a), 5(c), 5 (f), 5(h), 5(i), 5(m), 5(v), 5(x), 8(c), 12(a), 12(b), 13(g) which will not be applicable and for these conditions relevant conditions of this tender will apply. The conditions of this tender prevail over GCC-2016.

1) Award of Contract:

- i) M.C.G.M.'s right to accept any Tender and to reject any Tender or all Tenders.

Notwithstanding anything stated herein, M.C.G.M. reserves the right to accept full or part of the tender or reject any tender, and to cancel/annul the tendering process and reject all tenders at any time before the award of the Contract, without assigning any reason and thereby without incurring any liability to the affected tenderer or Tenderers or any obligation to inform affected Tenderer's of the ground for M.C.G.M.'s action / decision.

- ii) Notification of Award

After the evaluation of the tenders, the offer of responsive lowest Bidder will be recommended for acceptance. The successful Tenderer will be notified accordingly.

- iii) Notification to Tenderer

Notification of the award by M.C.G.M. will be issued in writing to the successful tenderer prior to the expiration of the period of validity of the proposal, by hand delivered letter/registered letter or by fax/email. Notification of award will constitute the formation of contract as mentioned in MMC Act. This letter (hereinafter the " Letter of Acceptance") shall direct the tenderer in consideration of the execution, completion and maintenance of the work as prescribed by the Contract (hereinafter the "Contract Cost") in accordance with Payment Terms mentioned in the relevant clause. The Tenderer shall acknowledge in writing, the receipt of the Letter of Acceptance and shall send his acceptance to enter into the Contract within five (5) days from the receipt of the Letter of Acceptance.

- iv) Signing of agreement/contract

Pursuant to the Tenderer acknowledging the Letter of Acceptance, MCGM will issue the Work Order to the successful bidder. The successful bidder and MCGM shall promptly and in no event later than 30 days from the date of acknowledgement of the LOA/Work

Order, sign the Contract. This shall be subject to submission of the Performance Security Deposit as stated in clause herein below. MCGM shall have the right and authority to negotiate certain terms with the successful Tenderer before signing of the Contract. The signing of the Contract shall amount to a ward of the Contract and the Tenderer shall initiate the execution of the work as specified in the Contract.

v) Discharge of E.M.D.

Within a period of 30 days from date of acknowledgement of the Letter of Acceptance, the successful Tenderer shall deliver to the MCGM a Performance Security Deposit as stated in Clause herein below. Upon submission of the Performance Security Deposit by the successful Tenderer, MCGM shall notify the other Tenderers that their Tenders have been unsuccessful and shall discharge the E.M.D. to unsuccessful Tenderer pursuant to relevant Clause.

vi) Expenses for the Contract

All incidental expenses of the execution of the Contract shall be borne solely by the successful Tenderer and such amount shall not be refunded to the successful Tenderer by the MCGM.

vii) Failure to abide by the Contract

The conditions stipulated in the Contract shall be strictly adhered to and violation of any of these conditions shall entail termination of the Contract without prejudice to the rights of MCGM with such penalties as specified in the Tender Document and the Contract.

2) Stamp Duty, Legal Charges and Stationery Charges:

The successful tenderer shall pay stamp duty on the contract and legal & Stationery charges for preparation of the contract agreement. The contract agreement shall be adjudicated for payment of stamp duty by successful tenderer on contract, advance or BG as the case may be.

Stamp Duty

- 1) As per the provision made in Article 63, Schedule I of Maharashtra Stamp Duty Act 2015, stamp duty is payable for “works contract” that is to say, a contract for works and labour or services involving transfer of property in goods (whether as goods or in some other form) in its execution and includes a sub-contract, as under :-

Where the amount or value set forth in such contract does not exceed rupees ten lakhs	Five hundred rupees stamp duty
Where it exceeds rupees ten lakhs	Five hundred rupees plus 0.1% of amount or value above rupees ten lakh subject to the maximum of rupees twenty five lakh stamp duty

- 2) For all the charges which are paid in the form of Bank Guarantee (BG), the successful bidder shall pay stamp duty of 0.5% of BG amount.

- 3) The successful bidder shall enter into a contract agreement with M.C.G.M. within 30 days from the date of acknowledgement of the LOA/Work Order and the same should be adjudicated for payment of Stamp Duty by the successful bidder.
- 4) Further shortfall if any, in amount of stamp duty paid as against prescribed amount for the documents executed in Mumbai City & Mumbai Suburban District be recovered from the concerned work contractors and to deposit the deficit or unpaid Stamp Duty and penalty by two separate Demand Draft or Pay Order in favour of “Superintendent of Stamp, Mumbai” within 15 days from intimation thereof.
- 5) All legal charges and incidental expenses in this respect shall be borne and paid by the successful tenderer.

Legal charges & Stationery Charges

The successful tender shall pay the legal charges & Stationery charges for preparation of the contract agreement. The combined legal charges & Stationery charges at present are as under:

Contract value	Legal Charges & Stationery charges
Up to Rs. 3,00,000/-	NIL
From Rs. 3,00,001/- to Rs. 20,00,000/-	Rs. 660/-
From Rs. 20,00,001/- to Rs.1,00,00,000/-	Rs. 2,670/-
From Rs. 1,00,00,001/- to any amount	Rs. 6,660/-

However, contractor should pay the legal charges/stationary charges prevailing at the time of award of the contract.

3) Penalty & Liquidated damages:

Without prejudice to the different conditions prescribed for timely completion of work, supply, delay in completing project/supply, short supply etc. for which penalty clauses are included under GCC as well as separately in the tender, following conditions shall apply for the lapses which are not covered separately in the tender-

- i. Subject to force majeure, if the Contractor fails to perform any or all of the services within the time period(s) specified in the contracts, the department shall, without prejudice to its other remedies under the contract deduct from the contract price, as liquidated damages, a sum equivalent to 0.5% of the unperformed services for each week of delay until actual performance, up to a maximum deduction of 10% of the Services contract price. Once the maximum is reached the department may consider termination of the Contract.
- ii. All such work as is not in accordance with the direction of the Engineer or other officer aforesaid or is composed of materials disapproved by him or the workmanship whereof is disapproved by him shall be taken down and removed by the Contractors at his/their own risk and expense within twenty four hours after receipt by him / them of a notice to that effect signed by the Engineer or other officer aforesaid shall be at liberty at the risk and expense of the Contractors to take down and remove the same and to cause such

work to be executed by any person or persons at such rates and prices as the Engineer may think proper and cost of expense thereby incurred including 15 per cent supervision charges on the works and also such penalty as the Engineer may impose for such wrongful conduct of the contractor with penalty the Engineer shall be competent to impose against the imposition of which or the amount thereof by the Engineer an appeal shall lie only to the Commissioner within seven days of the order in that behalf of the Engineer and the decision of the Commissioner on which shall be final and binding upon the contractors may be deducted from any money due or to become due to the contractors under this or any other contract between the contractors and the said Corporation.

- iii. Contractor will be levied for defects and lapses observed at first instance Rs 5,000/- to Rs 10,000/- and so on. After defects and lapses are notified to the CONTRACTOR & if same are not rectified by the contractor in time a note will be taken in Ephemeral Register.
- iv. The competent authority keeps the right reserved to make any change, amendment, addition/deletion and enhancement in the penalty clause in duration of a agreement period etc.
- v. If it is observed that the Contractors carrying out the work fail to comply with the instructions given by the Higher Authorities viz. Additional Municipal Commissioner/ Municipal Commissioner level during execution of work twice, the work will be terminated and will be carried out at risk & cost of the Contractor and a penal action will be taken against them. The decision will not be arbitrable at all.

4) Exceptional Risks

4.1 Exceptional Risks

An exceptional risk is a risk arising from an Exceptional Event which includes, but is not limited to:

- (a) war, hostilities (whether war be declared or not), invasion, act of foreign enemies;
- (b) rebellion, terrorism, revolution, insurrection, military or usurped power, or civil war, within the Country;
- (c) riot, commotion or disorder within the Country by persons other than the Contractor's Personnel and other employees of the Contractor and Subcontractors;
- (d) strike or lockout not solely involving the Contractor's Personnel and other employees of the Contractor and Subcontractors;

(e) munitions of war, explosive materials, ionising radiation or contamination by radio-activity, within the Country, except as may be attributable to the Contractor's use of such munitions, explosives, radiation or radio-activity; and

(f) natural catastrophes such as earthquake, hurricane, typhoon or volcanic activity which are Unforeseeable or against which an experienced contractor could not reasonably have been expected to have taken adequate preventative precautions.

4.2 Notice of an Exceptional Event

If a Party is or will be prevented from performing any of its obligations under the Contract due to an Exceptional Event, then it shall give Notice to the other Party of such event or circumstance and shall specify the obligations, the performance of which is or will be prevented. The Notice shall be given within 14 days after the Party became aware, or should have become aware, of the event or circumstance constituting an Exceptional Event.

The Party shall, having given Notice, be excused performance of such obligations for so long as such Exceptional Event prevents it from performing them.

4.3 Duty to Minimise Delay

Each Party shall at all times use all reasonable endeavors to minimise any delay in the performance of the Contract as a result of an Exceptional Event. A Party shall give Notice to the other Party when it ceases to be affected by an Exceptional Event.

4.4 Consequences of an Exceptional Event

If the Contractor is prevented from performing any of his obligations under the Contract due to an Exceptional Event of which Notice has been given under Sub-Clause 4.2 [*Notice of an Exceptional Event*] and suffers delay and/or incurs cost by reason of such Exceptional Event, the Contractor shall be entitled to:

- (a) an extension of time for any such delay, if completion is or will be delayed, and
- (b) if the event or circumstance is of the kind described in sub-paragraphs (a) to (e) of Sub-Clause 4.1 [*Exceptional Risks*] and, in the case of sub-paragraphs (b) to (e), occurs in the Country, payment of any such Cost. If the Exceptional Event occurs during the Operation Service Period, sub-paragraph (a) of this Sub-Clause 4.4 will not apply.

After receiving this Notice, the Employer's Representative shall proceed to agree or determine these matters.

4.5 Optional Termination, Payment and Release in case of Exceptional Risks

If the execution of substantially all the Works in progress is prevented for a continuous period of 84 days by reason of an Exceptional Event of which Notice has been given under Sub-Clause 4.2 [*Notice of an Exceptional Event*], or for multiple periods which total more than 140 days due to the same notified Exceptional Event, then either Party may give to the other Party a Notice of termination of the Contract. In this event, the termination shall take effect 7 days after the Notice is given, and the Contractor shall proceed to terminate the Work and Removal of Contractor's Equipment.

Upon such termination, the Employer's Representative shall determine the value of the work done and issue a payment certificate which shall include:

- (a) the amounts payable for any work carried out for which a price is stated in the Contract;
- (b) any other Cost or liability which in the circumstances was reasonably incurred by the Contractor in the expectation of completing the Works;
- (c) the Cost of removal of Temporary Works and Contractor's Equipment from the Site and the return of these items to the Contractor's works in his country (or to any other destination at no greater cost); and
- (d) the Cost of repatriation of the Contractor's staff and labour employed wholly in connection with the Works at the date of termination.

4.6 Release from Performance under the Law

Notwithstanding any other provision of this Clause, if any event arises outside the control of the Parties (including, but not limited to, an Exceptional Event) which makes it impossible or unlawful for either or both Parties to fulfil its or their contractual obligations or which, under the law governing the Contract, entitles the Parties to be released from further performance of the Contract, then upon Notice by either Party to the other Party of such event:

- (a) the Parties shall be discharged from further performance, without prejudice to the rights of either Party in respect of any previous breach of the Contract; and
- (b) the sum payable by the Employer to the Contractor shall be the same as would have been payable under Sub-Clause 4.5 [*Optional Termination, Payment and Release*] if the Contract had been terminated under that Sub-Clause.

5) Secrecy:

The Contractor shall take all reasonable steps necessary to ensure that all persons employed in any work in connection with the Contract, who obtains in the course of the execution of the Contract, any information whatsoever, which would or might be directly or indirectly of use to any person not connected with the contract should treat it as secret and shall not at any time communicate it to any person.

6) Compliance with Security Requirements:

The Contractor shall strictly comply with the Security Rules of the MCGM in force and shall complete the required formalities including verification from Police and other authorities, if any, and obtain necessary prior permission for entry into the premises.

7) Confidential Information:

The drawings, specifications, prototype, sample and such other information furnished to the Contractor relating to the supply/works/sub-system/equipment etc. shall be treated as confidential and shall not be divulged to any third party. It shall remain as the property of MCGM. If, during the process of execution of the Contract, any improvement, refinement or technical changes and modifications are effected by the Contractor, such changes shall not affect the title to the property and all the information, specifications, drawings etc. including the improvement/modifications effected by the Contractor shall continue to be the property of the MCGM.

8) Laws governing the Contract and Jurisdiction:

The Contract shall be governed by the laws & procedures prescribed by the laws prevailing and in force in India, within the framework of applicable legislation and enactment made from time to time concerning such commercial dealings/processing. In case of any claim, dispute or difference arising in respect of this contract, the cause of action thereof shall be deemed to have arisen in Mumbai and all legal proceedings in respect of any such claim, dispute or difference shall be referred to the Competent Court in the city of Mumbai.

9) Indemnity:

The prices stated in the contract shall be deemed to include all amounts payable for the use of patents copy right, registered charges, trademarks and any other industrial property rights. The Contractor shall at all times indemnify the MCGM against all claims including claim by any third party which may be in respect of stores for infringement of any rights protected by patent registration of design or trademarks and shall take all risks of accident or damage which may cause a failure of the supply from whatever cause arising and entire responsibility for the sufficiency of all the means used by him for the fulfillment of the Contract.

This tendering process is covered under Information Technology Act and Cyber Laws as applicable.

10) Site Visit :

Prior to online submitting and uploading his tender for the work prospective bidder shall visit and examine the site of works and its surroundings at his own expenses and obtain and ascertain for himself, his own responsibility and risk, all information, technical data, etc. that may be necessary for preparing his tender and entering into a contract including inter-alia, the actual conditions regarding the nature and conditions of site, availability of materials, labour, probable sites for chowky/stores etc. and the extent of lead and lift required for the execution of the work over the entire duration of the contract, after taking into consideration local conditions, traffic restrictions, obstructions in work if any, allow all such expenses that are likely to be incurred due to any such conditions, restrictions, obstructions, etc. in the quoted and uploaded contract price for the work. Any claim/dispute subsequently in regard to site conditions will not be entertained.

11) Extension of Tender Opening Date:

Sometimes, situations may arise necessitating modification of the tender documents already put on sale. Also, after receiving the documents, a bidder may point out some genuine mistakes necessitating a amendment in the tender documents. Tender inviting department may also feel necessity of amending it. In such a situation, it is necessary to amend / modify the tender documents suitably prior to the date of submission of bids. Any change by way of

amendments / modifications in the tender documents, change in respective dates etc. shall be made known to all bidders by way of corrigendum /addendum on the MCGM's website only.

12) Amendments / Modifications to bids by the bidder:

In the light of corrigendum issued, the bidder, after submitting the bid, may alter or modify his offer and upload, before revised due date & time of receiving tenders, his modified offer. In that case, he shall delete his original offer.

13) Late Tender:

Under e-tendering process the question of late submission of tender would not arise as the site blocks any submission on expiry of due date and time.

14) Opening of Tenders:

At a predetermined time tender opening process shall start. At that time one representative of each tenderer shall be allowed to remain present on production of letter of authorization in the format as per Annexure-5.

15) Evaluation of bids:

There are four steps viz.

- (a) Preliminary scrutiny,
- (b) Detailed scrutiny,

(a) Preliminary Scrutiny:

The tenderer to note that following are some of the basic points for which bid may be treated as non-responsive:-

- i) Conditional Bid,
- ii) Validity quoted is less than the required period,
- iii) Non submission of documents as required.
- iv) Non agreeing to some essential conditions in the bid document / quoting his own condition,
- v) Non submission of authority letter from the manufacturer,
- vi) Not agreeing to the payment schedule.
- vii) Quoting for goods manufactured by a different firm without the required Authority letter from the manufacturer.
- viii) Not agreeing to give the required security deposit/performance security.
- ix) Quoting for part supply instead of entire requirement as specified in the tender condition.

Based on the conditions, all tenders shall be scrutinized and those non-responsive shall be kept out of consideration. Those responsive shall be considered for further evaluation purpose.

(b) Detailed Scrutiny:

During detailed scrutiny of Packet 'A' & 'B', the MCGM may, if necessary, call for submission of all the documents uploaded in Packet A & B physically and additional documents if required for further clarification by giving specific time limit in respect of the documents submitted by the bidders. The eligibility of the bidder shall be determined on the basis of the documents submitted/uploaded and further clarifications sought in accordance with parameters for evaluation of technical bids as specified in Annexure-11. Those responsive bidders scoring minimum 60% marks in technical evaluation shall be considered for opening of Packet 'C'.

If bidder fails to submit the necessary physical copies of documents uploaded in Packet A & B, if required by MCGM and also further clarification sought within the stipulated period his tender may be treated as non-responsive. Further 10% EMD of the bidder may be forfeited.

After opening of Packet 'C' (Price Bid) the financial proposal of the bidders will be ranked on the basis of the amount payable by MCGM.

16) Errors and Discrepancies in Tender:

If tender contains errors such as computing mistakes, incorrect transfers etc., the Engineer will inform the tenderer(s) of such errors or discrepancies and rectify the errors or discrepancies and will re-total the amount of bill of quantities. The foregoing procedure may be applied at any time prior to award of contract and the Engineer is not liable for any error or discrepancy which was not discovered during scrutiny of the tender.

17) Rejection of Tenders:

In the ordinary course, Municipal Commissioner does not pledge himself to accept the lowest or any tender and reserves the right to reject any or all the tenders without assigning any reason.

There are however, some contingencies under which offers received are required to be cancelled or rejected –

- (i) There has been a material change in the basic specifications after receipt of tenders.
- (ii) The offers received do not conform to specifications in important respects.
- (iii) Prices quoted are unreasonably high.
- (iv) Lack of competition.
- (v) Lowest responsive tenderer withdraws the offer.**

18) Warranty:

Manufacturer's warranty shall be given for all the spare parts.

19) Guarantee and repairs during the guarantee period:

The Contractor/s shall for a period of one year after acceptance and satisfactory installation and commissioning of the equipments, maintain, uphold and keep them in thorough repairable and working order at their own cost and expense and to the entire satisfaction of the purchasing Officer. Contractor shall also be responsible for and be liable under the provisions of this clause to make good any defect that may, during that period, develop in the normal and proper working of the Machinery/Equipment/Furniture. In case of repair of Machinery/Equipment which is not manufactured in India, the manufacturer/Agent during the guarantee/warranty period, shall be ar all the taxes, custom duties, levies, t o & fro cost of transporting etc. of the Machinery/Equipment till the same is returned to India duly repaired by the Manufacturer. During the entire period of guarantee the contractor shall replace the equipment and or parts of the equipment, on its breakdown / non functional, at his own cost which shall include also the labour charges, transport charges etc. During the period of guarantee, if the equipment fails to perform as per the norms already decided, the guarantee period shall stand extended by such period during which the equipment remains defective.

20) Demonstrations:

Where needed, the tenderer, at his cost, should arrange for the demonstration of the equipment quoted for in the tender within 15 days from the date of intimation of the request for demonstration.

21) Execution of work at the risk and cost of contractor:

In the event of successful contractor failing to fulfill the contractual obligations, work shall be carried out at the risk and expenses of the successful contractor.

22) Product Support:

In respect of purchases requiring periodic post purchase attendance, it shall be ensured that the recommended bidder is well equipped to provide the following-

- a. Assured supply of information on product/technological improvement, modification and upgrades.
- b. Obsolescence management and life time purchase
- c. An illustrated spares price catalogue with base price and pricing mechanism for long term.

23) Clarification on Tenders:

1. To assist in the examination, evaluation and comparison of Tenders, the tender scrutiny officers may, at their discretion, ask any Tenderer for clarification of the Tenderer's tender, including breakdowns of the prices in the Bill of Quantities. The request for clarification and the response shall be in writing or by cable, but no change in the price or substance of the Tender shall be sought, offered or permitted except as required to confirm the correction or arithmetic errors discovered by the officers in the evaluation of the tender.
2. The Tenderer will not be permitted to change the substance of his tender or to replace the document after tenders have been opened.

24) Acceptance , Rejection, Splitting:

1. The Municipal Commissioner reserves the right to accept any e-tender and / or split the work for award and / or to annul the tendering process and / or reject all the e-tenders at any time prior to award of the contract, without incurring any liability to the affected tenderer or tenderers or any obligation to inform the affected tenderer or tenderers on the grounds for the MCGM's action.
2. When more than one work is covered under any tender, the Municipal Commissioner reserves the right to allot one work to one tenderer depending on the least cost basis.

25) Disqualification:

1. Without prejudice to other conditions disqualifying the bidders they shall note that even though the tenderers meet the qualifying criteria, they are liable to be disqualified, with forfeiture of E.M.D., if they have:
 - a) Made misleading or false representations in the forms, statements and attachments submitted online, in proof of the qualification requirements, and/or
 - b) Record of poor performance such as abandoning the works, not properly completing the contract, inordinate delays in completion or financial failures etc. and / or
 - c) Participated in the previous tendering for the same work and had quoted unreasonably high tender prices and could not furnish rational justification to the Corporation, or
 - d) Not uploaded details of ongoing works / commitments.
 - e) Adopted any "corrupt practice" by offering, giving, receiving or soliciting of anything of value to influence the action of a public official in the procurement process or in contract execution or adopted any "fraudulent practice" means, misrepresentation of facts in order to influence a procurement process or the execution of a contract including collusive practice among tenderers (prior to or after tender submission).
2. No tenderer shall contact the Municipal Commissioner on any matter relating to its tender from the time of the tender opening to the time of the contract is awarded. If the tenderer wishes to bring additional information to the notice of Municipal Commissioner, he should do so in writing. Any effort by the tenderer to influence

the Municipal Commissioner in tender evaluation, tender comparison or contract award decision, may result in the rejection of the tenderer's tender.

3. Tender shall be termed to be under consideration from the opening of the tenders, until such time an official announcement of award of the tenders is made. While tenders are under consideration, tenderers and their representatives or other interested parties are advised to refrain from contact, by any means, the Corporation's personnel or representatives on matters related to the tenders under consideration.
4. Staff involved in short listing and bid evaluation should resist itself from accepting business gifts and hospitality. Code of Conduct sets out certain guidelines in this respect. The motive of donors may be different and objectionable from the eyes of third party. If any staff member believes that gift offered is with an ulterior motive he must report such incident to his superiors. Bid offer of such a bidder shall be straight way rejected.

26) Performance Security Deposit:

1. Period for Furnishing Performance Security Deposit:

Within 30 days of the receipt of the acknowledgement of the Letter of Acceptance from MCGM, the successful Tenderer shall furnish a Performance Security Deposit for an amount equivalent to 5% of the Contract Cost in accordance with the conditions of the Contract, in the form of a Bank Guarantee or Demand Draft / Bank Pay Order from a Nationalized / Scheduled Commercial Bank approved by MCGM, drawn in favour of "Municipal Corporation of Greater Mumbai", payable at Mumbai. If such Performance Security Deposit is in the form of a Bank Guarantee, then such Bank Guarantee shall be in a form acceptable to the MCGM as per Annexure 7. The Performance Security Deposit shall be retained by the MCGM till the end of the term as defined in the Contract.

However Contractor has the option of reducing the performance security deposit proportionately after accomplishment of each milestone as mentioned in table 2.1.1 (Part III, Chapter 1).

- 1) **Annulment of Award**
Failure of the successful Tenderer to comply with the terms and conditions set out in the Tender Document shall constitute sufficient ground for the annulment of the award of Contract and forfeiture of the E.M.D., in which event M.C.G.M. may make the award to the next lowest evaluated Tenderer or call for new tenders.
- 2) The Performance Security Deposit etc. shall be refunded to the contractor only after finalization of final bill, settlement of accounts of work by the contractor in all respects or after completion of the contract whichever is later.
- 3) The banks with their branches in Greater Mumbai and upto Virar and Kalyan have been approved for the purpose of accepting Banker's Guarantee. (Please see the list enclosed herewith in Annexure 7-A).
- 4) The bankers guarantee issued by branches of Approved Bank beyond Kalyan and Virar can be accepted only if the Banker's Guarantee is countersigned by the Manager of a Branch of the same Bank within the Mumbai city limit Categorically endorsing there on that the said Banker's Guarantee is binding enforced against the said Branch of the bank in case of default by the tender / supplier furnishing the banker's guarantee.

- 5) Failure of the successful Tenderer to comply with the requirements of Performance Security Deposit shall constitute sufficient grounds for cancellation of the award and forfeiture of the E.M.D., and any such other remedy the Municipal Commissioner may take under the Contract, and the Municipal Commissioner may resort to awarding the contract to the next ranked Tenderer.
- 6) Mode of payment:
The mode of payment of Performance Security Deposit shall be as under :
Sum amounting to five percent of the contract sum shall be paid within 30 days after receipt of Letter of Acceptance of tender. It is optional to the Contract to make the contract deposit in one or the other form mentioned below:
 - i. Wholly in cash by way of DD in favour of the Municipal Corporation of Greater Mumbai
 - ii. By way of Bank Guarantee issued on behalf of the Contractors by the Bank on approved list of the Municipal Corporation, in the prescribed format.
- 7) Refund of Performance Security Deposit:
Performance Security shall be refunded to the contractor without any interest, whatsoever, after faithful and satisfactory compliance of the contract in all respects and completion of all such obligations under the contract.
Before refund of Performance Security due care shall be taken to ascertain the provisions under GCC regarding refund of Performance Security Deposit as also defect liability period etc. with amendments from time to time.
- 8) Forfeiture of Performance Security:
Performance security shall be forfeited in the event of a breach of contract by the contractor, in terms of the relevant contract conditions.

27) **Signing of Agreement:**

- i. At the time of notifying the successful Tenderer that his Tender has been accepted, M.C.G.M. will make available the Tenderer the agreement in the form provided in the Tender documents, incorporating all conditions agreed between the parties.
- ii. Within 30 days of receipt of Letter of Acceptance, the successful Tenderer will pay the requisite legal & stationery charges, sign the Agreement and deliver it to the Municipal Commissioner, together with the required Performance Security Deposit.

28) **Redressal of Grievances:**

Any bidder having grievance in respect of specifications, eligibility criteria, evaluation criteria or actual evaluation and selection of a responsive bidder may seek redressal of his grievances by following procedure explained under Chapter on the Redressal of Grievances as per Annexure-10.

29) **Dispute Resolution & Arbitration :-**

29.1 If any dispute, difference or claim arises by either Party to any matter arising out of this contract, the aggrieved party may refer such dispute within a period of 7 days to the concerned Additional Municipal Commissioner, who shall constitute a committee comprising of three officers i.e. concerned DMC or Director (E.S.&P), Chief Engineer

other than the engineer of contract and concerned Chief Accountant. Concerned DMC or Director (E.S.&P) will be the chairman of this committee and other officers will be members of this committee. The committee shall give its decision within 60 days. Appeal from the order of the committee may be referred to Municipal Commissioner within 7 days. The decision given by the Municipal Commissioner shall be final and binding upon the parties.

29.2 Arbitration

Any Dispute which is not resolved amicably as provided in Clause 29.1, shall be resolved in accordance with Indian Arbitration and Conciliation Act, 1996. The Arbitral Tribunal shall comprise only one arbitrator appointed upon mutual consent of the parties. Payment of arbitrator shall be equally shared by the parties. The venue of such arbitration shall be Mumbai, and the language of arbitration proceedings shall be English.

29.3 The courts within the local limits of Mumbai only shall have jurisdiction to deal with and decide any matter arising out of this Contract.

30) Termination of Contract:

30.1 Save as otherwise provided in this Contract, in the event that any of the defaults specified below shall have occurred, and the contractor fails to cure the default within the given time period, or where no time period is specified, then within a period of 60 (sixty) days, the contractor shall be deemed to be in default of this Contract, unless the default has occurred solely as a result of any breach of this Contract by the MCGM or due to Force Majeure. The defaults referred to herein shall include:

- a) the Contractor does not achieve the latest outstanding project milestone due in accordance with the provisions of the contract and continues to be in default for 180 (one hundred and eighty) days or more;
- b) the Contractor abandons or manifests intention to abandon the construction or operation of the Project Facility without the prior written consent of the MCGM;
- c) Project is not Completed within the period specified in the contract;
- d) the Contractor fails to comply with performance standards set out in this tender and continues to default despite being cautioned by the MCGM
- e) The Contractor accepts and disposes of waste supplied by any third party into the processing plant.
- f) the Contractor is in breach of the Operation & Maintenance Requirements or the Safety Requirements as per Good Industry Practice, as the case may be;
- g) the Contractor fails to make the required payment to the MCGM within the period specified in this Contract;
- h) a breach of any of the Contract condition by the Contractor has caused a Material Adverse Effect;
- i) the Contractor creates encumbrances in violation of the Contract conditions;
- j) the Contractor repudiates this Contract or otherwise takes any action or evidences or

- conveys an intention not to be bound by the Contract;
- k) a change in constitution of Company/SPV has occurred without MCGM's prior approval;
 - l) there is a transfer, pursuant to law either of (i) the rights and/or obligations of the Contractor under the contract, or of (ii) all or part of the assets or undertaking of the Contractor, and such transfer causes a Material Adverse Effect;
 - m) the Contractor is a judged bankrupt or insolvent, or if a trustee or receiver is appointed for the Contractor or for the whole or material part of his assets which has a material bearing on the Project;
 - n) the Contractor has been, or is in the process of being liquidated, dissolved, wound-up, amalgamated or reconstituted in a manner that would cause, in the reasonable opinion of the MCGM, a Material Adverse Effect;
 - o) a resolution for winding up of the Contractor is passed, or any petition for winding up of the Contractor is admitted by a court of competent jurisdiction and a provisional liquidator or receiver is appointed and such order has not been set aside within 180 (ninety) days of the date thereof or the Contractor is ordered to be wound up by Court except for the purpose of a amalgamation or reconstruction; provided that, as part of such amalgamation or reconstruction, the entire property, assets and undertaking of the Contractor are transferred to the amalgamated or reconstructed entity and that the amalgamated or reconstructed entity has unconditionally assumed the obligations of the Contractor under this Contract and the Project Contract; and provided that:
 - i. the amalgamated or reconstructed entity has the capability and operating experience necessary for the performance of its obligations under this Contract and the Project Contract;
 - ii. the amalgamated or reconstructed entity has the financial standing to perform its obligations under this Contract and the Project Contract and has a credit worthiness at least as good as that of the Contractor as at the appointed date; and
 - iii. each of the Project Contract remains in full force and effect;
 - p) any representation or warranty of the Contractor herein contained which is, as of the date hereof, found to be materially false or the Contractor is at any time hereafter found to be in breach thereof;
 - q) the Contractor submits to the MCGM any statement, notice or other document, in written or electronic form, which has a material effect on the MCGM's rights, obligations or interests and which is false in material particulars;
 - r) the Contractor has failed to fulfill any obligation, for which Termination has been specified in this Contract.

30.2 Without prejudice to any other rights or remedies which the MCGM may have under this Contract, upon occurrence of a Contractor Default, the MCGM shall be entitled to terminate this Contract by issuing a Termination Notice to the Contractor; provided that before issuing the Termination Notice, the MCGM may by a notice inform the Contractor of its intention to issue such Termination Notice and grant 30 (thirty) days to the Contractor to make a representation, and may after the expiry of such 30 (thirty) days, whether or not it is in receipt of such representation, issue the Termination Notice.

30.3 If contract is terminated upon occurrence of a contractor's default as mentioned above, MCGM will recover the liquidated damages from the Performance Security Deposit

and action deemed fit will be initiated.

30.4 Other rights and obligations of the MCGM

Upon Termination for any reason whatsoever, the MCGM shall:

- a) be deemed to have taken possession and control of the Project Facility forthwith;
- b) take possession and control of all materials, stores, implements, construction plants and equipment on or about the Site;
- c) be entitled to restrain the Contractor and any person claiming through or under the Contractor from entering upon the Site or any part of the Project;
- d) have the right to execute the said project through any other contractor at risk & cost of the Concessionaire.

30.5 MCGM shall have the right to terminate the contract without assigning any reason to the Concessionaire.

31) Documents forming part of Contract:

Following documents shall form part of the Contract:

- i. All Original Bid Documents submitted at the time of bidding,
- ii. Letter of Acceptance,
- iii. Power of Attorney in favour of authorized signatory on behalf of the contractor,
- iv. Performance Security
- v. All the tender documents duly incorporating the amendments effected through addenda.
- vi. Accepted financial offer (Financial Bid submitted by contractor along with Negotiation letter, if any, wherein the contractor had amended his offer).
- vii. Copy of Standing Committee Resolution, General Conditions of Contract (GCC – 2016)

32) Contract Labour & other Acts :

- 1) Contract Labour (Regulation and Abolition Act 1970) : The tenderer should specifically note that the successful tenderer shall have to strictly comply with all the statutory requirement under the provision of the Contract Labour (Regulation and Abolition) Act, 1970 and with the Maharashtra State Contract Labour (Regulation and Abolition) Rules 1971 and indemnify the Corporation against any claim(s) whatsoever.
- 2) The tenderer should specifically note that the successful tenderer shall have to strictly comply with all the statutory requirement under the provision of the Contract Labour Act, Minimum Wages Act, Workmen's Compensation Act, Child Labour Act, Provident Fund Act or any other enactment of the State or Central Government applicable to the employees engaged by him and indemnify the Corporation against any claim(s) whatsoever.

33) ESIC Act.1948

As per circular under no. **CAF/FRD/ on e/ 65 dated 30.03.2013** the tenderer shall comply as per the provisions under **ESIC Act 1948** as follows:-

(The English version of contents of circular is for understanding, the Devnagari (Marathi) version of Circular are given below):-

The ESIC Act 1948 are applicable to those:

1. ज्या जागी 10 किंवा त्याहून अधिक व्यक्ती नोकरीला आहेत आणि कुठल्याही भागामध्ये उर्जेच्या मदतीने उत्पादन प्रक्रीया चालते.

(The place or factory or an establishment where production process is carried out with the aid of power and there 10 or more nos. of employees are employed)

OR किंवा

2. ज्या जागी 20 किंवा त्याहून अधिक व्यक्ती नोकरीला आहेत आणि जिच्या कुठल्याही भागामध्ये उर्जेच्या मदतीशिवाय प्रक्रीया चालते अशा संस्थांनाच ईएसआय कायदा लागू होतो.

(The place or factory or an establishment where production process is carried out without aid of power and there 20 or more nos of employees are employed)

“ उपरोक्त तदतूदी ज्या आस्थापनांना लागू होतात त्यांनी राज्य कामगार विमा योजना कायदा 1948 च्या अंतर्गत नोंदणी प्रमाणपत्र सादर करणे आवश्यक आहे. जर उपरोक्त अनुक्रमांक 1 खाली येणा-या आस्थापनांमध्ये 10 पेक्षा कमी कामगार / व्यक्ती असतील किंवा अनुक्रमांक 2 खाली येणा-या आस्थापनांमध्ये 20 पेक्षा कमी कामगार / व्यक्ती असतील , तर निविदाकाराने रुपये 100/- एवढ्या रकमेच्या स्टॅम्प पेपरवर तशा आशयाचे लिखित प्रतिज्ञापत्र सादर करणे आवश्यक आहे“ .

(The tenderer shall submit the Registration Certificate to those the above provisions of ESIC Act 1948 is applicable.

The Tenderer shall submit the undertaking on Rs.200/- stamps paper, stating the reason that the above provisions of ESIC Act 1948 is not applicable to them)

34) Insurance :-

Successful tenderer shall provide insurance for all the manpower & machinery deployed in the contract for executing the work and submit relevant documents to MCGM as and when required. The vehicles must have been insured with Comprehensive Insurance.

35) CHANGE IN LAW

- a) Change in Law shall mean the occurrence or coming into force of any of the following, after the date of execution of this Agreement:
 - i. enactment of any new Indian law;
 - ii. repeal, modification or re-enactment of any existing Indian law;
 - iii. a change in the interpretation or a application of any Indian law by a court of record; and
 - iv. any order, decision or direction of a court.
- b) Subject to Change in Law resulting in Material Adverse Effect and subject to Contractor taking necessary measures to mitigate the impact or likely impact of change in Law on the Project, if as a direct consequence of a change in Law, Contractor is obliged to incur Additional costs, MCGM shall either : (i) subsequently reimburse to the Contractor one hundred percent (100 %) of such Additional costs; or (ii) agree to amend this Agreement as per the proposals of Contractor in order to make the

continued implementation of the Project viable, provided such Additional Cost is not less than Rupees Ten Lakhs (Rs 10,00,000/-)

- c) Upon occurrence of a Change in Law, Contractor may, notify MCGM of the following:
- i. the nature and the impact of Change in Law-on the Project
 - ii. the estimate of the Additional Cost likely to be incurred by Contractor on account of Change in Law;
 - iii. the measures, which Contractor has taken or proposes to take to mitigate the impact of Change in Law, including in particular, minimizing the Additional Cost; and
 - iv. the relief sought by Contractor,
- d) Upon receipt-of the notice of Change in Law issued by Contractor pursuant to preceding sub-clause, MCGM and Contractor shall hold discussions and take all such steps as may be necessary including determination/certification by a duly qualified independent person who is acceptable to both MCGM and Contractor, of the quantum of the Additional Cost to be borne and paid by MCGM.
- e) MCGM shall within thirty (30) days from the date of determination of quantum of Additional Cost, provide relief to Contractor in the manner as mutually agreed upon by the Parties.

36) INSPECTION

- 1)MCGM shall have rights to inspect the supply and / or test the goods at any stage during the continuance of the contract.
- 2)Contractor is required to do all such works, which are pointed out during the inspection to meet the M.C.G.M.'s requirement as per specifications free of cost.
- 3)Contractor shall have to bear all the cost of inspection, whenever inspection is required.
- 4)Finish goods shall be offered for inspection and testing to MCGM by the contractor prior to its dispatch / delivery.

37) Right To Information Act:-

- (1) Tenderers are advised that the MCGM is subject to the requirements of the *Right to Information Act 2005* (the "Act"). If a Tenderer considers that any of the informations supplied with their e-Tender Submission is either commercially sensitive or confidential in nature, this shall be highlighted and the reasons for its sensitivity specified. In such cases, the relevant material shall, in response to a request under the Act, be examined in the light of the exemptions provided for in the Act.
- (2) The MCGM will consult with the Tenderer about any such sensitive information before making a decision on any freedom of information request received.
- (3) In the event that the MCGM determines that it must release, in accordance with the Act, particular information relating to the e-Tender Submission which has been identified as sensitive, the Tenderer will have the option of appealing this determination. Tenderers are advised to obtain advice with respect to the Act, and if no information is identified by the Tenderer as sensitive, with supporting reasons, then it is likely to be released in response to a request under the Act.
- (4) The Tenderers shall note that the MCGM may make public the amount of all e-Tender Submissions and may publish the name of the successful Tenderer.

CHAPTER – 2
SPECIAL INSTRUCTIONS TO BIDDERS PARTICIPATING IN e-TENDERING OF
MCGM

E-Tendering :-

1. The Municipal Commissioner for and on behalf of the Municipal Corporation of Greater Mumbai, hereinafter referred to as 'the Commissioner', invites online e-tenders from eligible bidders Qualified as per Eligibility Conditions (Criteria) in the Tender for the Supply / Work as detailed in the tender documents. This invitation is open to any tenderer subject to fulfillment of eligibility criteria prescribed. Prospective bidders can download the blank tender copy from MCGM's portal (<http://portal.mcg.gov.in>) on payment of prescribed charges by adopting e-tendering process under section "Payment of Tender Fees".
2. Tenderers should note that the word bidder is an alternative word for tenderer and bid is an alternative word for the tender and that the meaning of both these words are the same. Also the word 'vendor' is used for the word 'prospective bidder/tenderer'.
3. All interested tenderers, whether already registered or not registered with MCGM, are mandated to get registered with MCGM for e-tendering process and obtain login credentials to participate in the online bidding process. The details of the same are available on the above mentioned portal under 'e-Tenders' tab.
4. Please read carefully the document 'Article of Agreement, Instructions to the Tenderers, General Conditions of Contract' available in e-Procurement section of the respective tender on MCGM Portal. As MCGM switched to e-Tendering, all the references in this document to traditional bidding process like packets A, B, C etc. may please be ignored. All documents that are required to be submitted as part of technical bid need to be uploaded and commercial bid need to be filled online.
5. This document (Instructions to Bidders) and the 'Article of Agreement, Instructions to the Tenderers / General Conditions of Contract' of the respective tender, which are available in 'MCGM documents' of e-Tendering section of MCGM Portal, are part of all tender documents unless stated otherwise in the tender document.
6. Affixing of digital signature at any one place in the bid document while submitting the bid shall be deemed to mean acceptance of the terms and conditions contained in the tender document as well as confirmation of the bid/bids offered by the Bidder which shall include acceptance of special directions/terms and conditions if any, incorporated.

All documents uploaded for online submission must be digitally signed and self-attested by the person duly authorised to digitally sign on behalf of the Tenderer. All documents submitted in hard copy must be signed by the person duly authorised to sign on behalf of the Tenderer. Each page of the Tender shall be initialled by the person duly authorised to sign on behalf of the Tenderer. Failure to comply with these requirements shall result in disqualification of the Tenderer.
7. All the documents and data submitted by bidder online will be digitally signed by the system by prompting for digital signature certificate. Thus, it is mandatory for the Bidders willing to participate in e-Tendering to procure digital signature certificate of class-2 /class-3 and 'Company' Type.
8. For registration enrollment for digital signature certificates and user manual, tenderers shall refer to respective links provided in e-tendering tab. They can get digital signature from any one of the Certifying Authorities (CA)'s licensed by Controller of Certifying Authorities namely Safescrypt, IDRBT, National Informatics Center, TCS, CUSTOMS, MTNL, GNFC and e-Mudhra CA.

9. In order to participate in an e-Tender, the registered vendors need to follow the steps given below:-

- a) Open the e-Tendering application by clicking the link available in 'e-Tendering' section of MCGM portal.
- b) Download the 'Browser Settings' document and carry out the necessary settings and root certificates installation as mentioned in the document. Please note that the computer user should have administered rights to be able to work with e-Tendering application.
- c) Login to the application with your credentials and follow the instructions given in the document 'User Manual for Vendors – Bidding Process' which is available in the 'e-Procurement' section of MCGM Portal.
- d) Make payment of tender fee online and download the tender document.
- e) Please refer to FAQs in the e-Procurement section of MCGM portal for additional information.
- f) Note that entire set of bid documents is available on making payment as stated in e-tender notice.
- g) Note that all documents requiring physical signature are to be modified to digital signature now.
- h) Note that no manual offers sent by post / Fax or in person shall be accepted, and that if any such offer happened to have been delivered would be treated as invalid and rejected without assigning any other reason.
- i) Note that bidder has to download all the documents, take out the print, fill up the required information and sign, scan them and upload the same in folder named "Bidders Documents".
- j) Verifying correctness of the documents uploaded by downloading the same, and again uploads properly.
- k) Submit the commercial bid by filling in the values on the screen itself. All the inputs given on this screen need to be digitally signed.
- l) Submit technical and commercial bids only in the bidder's folder online and before the date and time mentioned for submission of bids.
- m) Note that bid can be modified till the end date and time for bid submission.
- n) Delete the old version, if a new version of a document is to be uploaded.
- o) Ensure that your bid is submitted by verifying the 'Bid Status' of the bid in the initial bids listing screen is 'Bid submitted'.
- p) Note that it is bidder's responsibility to maintain computer used for submitting his bid free of viruses.

10. In e-tendering process some of the terms and their meaning are to be read as under wherever reflected in online tendering process –

- a) Start Date read as "Sale Date".
- b) End Date read as "Submission Date".
- c) Supplier read as "Contractor/bidder".
- d) Vendor read as "Contractor/bidder".
- e) Vendor Quotation read as "Contractor's Bid/Offer"
- f) Percentage Variation read as "Percentage Quoted".
- g) Authority/Employer read as "MCGM".

11. No tender submission is possible after the deadline prescribed as system will automatically close the acceptance of tender.

12. It is the responsibility of the vendors to maintain their computers, which are used for submitting their bids, free of viruses, all types of malware etc. by installing appropriate anti-virus software and regularly updating the same with anti-virus etc.

13. Intimations about shortfalls in submission will be informed to Bidders/Contractors by e-mail on their mail ID. The bidders should also send information in reply by e-Mail to respective offices where the bid is being scrutinized.

14. The tenderers shall bear all costs associated with the downloading, preparation and uploading of his Tender, and the M.C.G.M. will in no case be responsible and liable for those costs.

15. MCGM has opened a help desk at

Deputy Chief Engineer (Solid Waste Management) Project
2nd, 3rd, 4th floor, Bai Padmabai Thakkar Marg, Kotwadi,
Mahim (Shivaji Park) Mumbai – 400016.
e-mail :- newprojectswm.mcgmg@gmail.com

Contact:-

Shri Chaudhari K.R. (Executive Engineer)- 09167725591

Shri Anerao.R N. (Assistant Engineer)- 09702950915

In case of any enquiry pertaining to e-tendering process (including User-ID, Password etc.), please contact IT Cell at Ground Floor, Worli Data Centre, 1Z Store Building, Dr.E. Mozes Road, Worli Naka, Mumbai-400018. Tel No. 022-24811275 from 11.30 AM to 5.00 PM on all working days of MCGM.

16. All documents as per 3 packet system mentioned in Chapter 7-B of Part-I shall be uploaded by the bidders in the folder named “Bidders Documents” in the online e-Tender. If the information, data, design to be uploaded by tenderer in e-tender submission is of more than 10 MB size, the files (information, data, design) shall be split into 10 MB or lesser size and uploaded serially to form a sequence of the understandable document.

18. After satisfying that all the pre-requisite conditions are fulfilled and the required documents are attested and inserted in their respective cover, intending tenderer must upload them in the vendor folder only as per the guidelines given in the tender documents.

19. Tenderers are requested to submit and upload the tenders in time on or before stipulated day so as to avoid rush at the closing hours. MCGM will not be responsible for poor connectivity of network/internet services/connectivity of servers/snag in system/breakdown of network/or any other interruptions. If any online information uploaded but not received by Bid Creator (MCGM) within stipulated time limit, MCGM will not be held responsible at any cost and such bids cannot be validated. Any online intimation/information asked to be submitted by Bidders/Contractors or sent to Bidders/Contractors, if not received or bounced back at the receiving end due to any problem in server or connectivity, MCGM will not be held responsible. Intimation about shortfalls in submission may be informed to Bidders/Contractors by e-mail on their mail ID.

20. Schedule of Program:

Program related to the Tender shall be as under or mentioned elsewhere.–

- a) Blank tender documents available for download from –
- b) Time and date of Pre-bid meeting –
- c) Time and date for uploading tender offers –
- d) Time and date for opening of Packet ‘A’ – 22.09.2017 after 3.00pm
- e) Time and date for opening of Packet ‘B’ – 22.09.2017 after 3.00pm
- f) Time and date for opening of Packet ‘C’ – 05.10.2017 after 3.00pm

21. If there are any changes in the dates or there is any addendum/corrigendum to this tender, the same will be given publicity by uploading on MCGM portal as well as publishing in the local newspapers and displaying on notice board of the office of Deputy Chief Engineer (Solid Waste Management) Project, 2nd, 3rd, 4th floor, Bai Padmabai Thakkar Marg, Kotwadi, Mahim (Shivaji Park) Mumbai – 400016. Prospective bidders shall take note of such changes.

PART - III

CONTENTS

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2.	CHAPTER – 2 “SCHEDULE (BILL) OF QUANTITIES AND RATES”	

MUNICIPAL CORPORATION OF GREATER MUMBAI
(Solid Waste Management Department)

CHAPTER-1

TECHNICAL SPECIFICATION & SCOPE OF WORK

Sub : Dumpsite Reclamation at Mulund Dumping Ground (MDG) in Mumbai by adopting suitable technology for existing garbage dump

1. Introduction:-

The Municipal Corporation of Greater Mumbai (the “MCGM”) is responsible for providing municipal and civic services to the citizens of Greater Mumbai, including collection, transportation, processing and disposal of Municipal Solid Waste (MSW) generated within its jurisdiction. Towards this, the MCGM has decided to invite open competitive bids for ‘Dumpsite Reclamation at Mulund Dumping Ground (MDG) in Mumbai by adopting suitable technology in respect of the existing garbage dump’ by way of deploying viable and sustainable technologies as Solid Waste Management Rules 2016 (SWM Rules 2016) and other applicable Rules as amended from time to time.

MCGM receives waste to the tune of 9500 TPD including C&D Waste from the 24 municipal wards of Mumbai. This waste is transported and managed at Deonar, Mulund and Kanjur landfills. MCGM now intends to recover the land at Mulund Dumping Ground (MDG) in Mumbai by adopting suitable technology in respect of the existing garbage dump.

Mulund dumpsite is spread over around 24 Ha and is operational for more than the past forty years. Waste dump heaps ranging from 8 to 30 Mts height have been created at the site as well as spilled over the adjoining areas. As per contour survey carried out in September 2015, total volume of existing MSW at MDG is approximately 5.35 Million Cu.M including C&D waste as shown in Annexure-18 (Volume of section ‘L’ is not considered). Considering the average density of 1 MT/Cu.M, the weight of this entire MSW is estimated to be approximately 5.35 Million Metric Ton. Considering the continuous intake of MSW till commencement of the project, the quantity assumed for the subject project is 7 Million MT (i.e. Equivalent to Volume of 7 Million Cubic Meter).

2. Scope of Work:

Objective of the proposed project is:-

Objective of the proposed project is to recover the entire municipal waste dump land at the Mulund Dumping Ground up to its original ground level. The level of exit gate of neighbouring Mulund Octroi Check Naka which is 29.29 Mtrs from MSL has been taken as the original ground level.

2.1 The Scope of the work for the project will broadly include :-

1. The successful bidder has to set up processing facilities to dispose off seven Million MT of existing MSW from the Mulund Dumpsite through scientific processing within six years from the date of LOA/work order (including mobilization & construction period of one year) by way of deploying suitable and sustainable technology in accordance with Solid Waste Management Rules 2016 (SWM Rules 2016) and other applicable rules & norms as amended from time to time. Waste composition analysis in 2007 and IIT Mumbai report dt. 23.05.2016 on “Waste Sampling, its Characterization & Analysis at Mulund Dumpsite” are provided as background information along with the tender document.

Entire area of existing dump shall be divided into 100m x 100m grids. Mining of existing dump will be done grid-wise as per the action plan submitted by successful bidder and as approved by the MCGM which will be reviewed periodically and will be subject to changes. The contractor has to provide suitable fencing arrangement to the entire dumpsite area once the LOA/Work order is issued to the contractor. Temporary net cadding is recommended above fencing to capture/ contain light weight RDF flight because of wind flow.

Contractor has to carry out contour survey every month for monitoring volumetric reduction of existing dump and contour survey reports shall be submitted along with every monthly bill clearly showing monthly volumetric reduction of existing dump.

Payment will be made to the contractor every month on the basis of weight of incoming waste to the processing plant set up by the contractor for the purpose of this project.

Milestones :-

Milestones required to be achieved within the given timeframe are as mentioned below. Penalties will also be levied accordingly depending upon the Milestones to be achieved.

Table 2.1.1

Milestones to be achieved for the Project

Sr. No.	Activity to be completed	Time Period for completion
1.	Obtaining all the clearances required for the project.	6 months from the date of LOA/work order
	<p>Note :- It shall be the responsibility of the successful bidder to make the required applications within the shortest possible period and also to respond to any queries within the shortest possible time so as to ensure that this deadline is met. Period for obtaining clearances can be extended by not more than 6 months in case reasons are thoroughly justifiable and with express approval of Hon. MC. It is successful bidder's responsibility to obtain all the clearances required for installation and operation of processing plant at MDG area as well as for the land found by the successful bidder to dispose off the inerts & rejects. Agreement between contractor & the land owners shall clearly mention that land shall be used for the purpose of disposal of inerts/rejects of this project. MCGM may assist to obtain these clearances.</p>	
2.	Construction & erection of the plant.	12 months* from the date of LOA/work order
	<p>* If period for obtaining all the clearances is extended with express approval of Hon.MC, period for construction & erection of the plant will be extended further accordingly by that period.</p>	
3.	To dispose off 11,20,000 MT (16%) of existing waste from Mulund Dumpsite through scientific processing	Second year (11,20,000 MT)
4.	To dispose off 12,60,000 MT (18%) of existing waste from Mulund Dumpsite through scientific processing	Third year (Cumulative: 23,80,000 MT)
5.	To dispose off 14,00,000 MT (20%) of existing waste from Mulund Dumpsite through scientific processing	Fourth year (Cumulative: 37,80,000 MT)
6.	To dispose off 15,40,000 MT (22%) of existing waste from Mulund Dumpsite through scientific processing	Fifth year (Cumulative: 53,20,000 MT)
7.	To dispose off 16,80,000 MT (24%) of existing waste from Mulund Dumpsite through scientific processing	Sixth year (Cumulative: 70,00,000 MT)

1. Weighment & Vehicle Tracking System :-

(i) Weighment System :-

The successful bidder has to set up two weighbridges of required capacity or any other suitable system for weighment as approved by MCGM for measurement of MSW to be processed and for outgoing material after processing. One weighbridge

for weighing of incoming waste to the processing plant and other weighbridge for weighing of outgoing material from the processing plant.

This weighing system should meet following conditions:-

- a. It should be fully online electronic, automatic system equipped with the latest technology along with backup server facility. Data of weighing system shall be maintained properly for the entire contract period with back up server facility and shall be provided as & when required by MCGM officials and competent authorities.
- b. It should be operated in CCTV surveillance with data storage of entire contract period. For CCTV surveillance High Definition IP based cameras in adequate numbers (as directed by MCGM) shall be provided by the contractor with following specifications, but not limited to,
Speed-30 fps, Resolution-Full HD, Infrared-supported, Automatic number plate recognition.

These IP cameras should capture static images of the vehicles clearly showing vehicle numbers.

- c. CCTV Recordings of operation of weighing system shall be provided as and when required by MCGM officials and competent authorities.
- d. All the data acquisition of weighing system comprising weighing of MSW to be processed shall be done online on website in public domain in view of the transparency of project operations. Dedicated connectivity for both MCGM users and citizens shall be provided by the contractor.
- e. The vehicles used for transportation of waste within site shall be registered with R.T.O. Mumbai and fulfill all rules & regulations of Mumbai R.T.O. in force. Also, these vehicles shall be equipped with Radio Frequency Identification (RFID).
- f. Any malfunctioning in operation of weighing system will be the responsibility of contractor.
- g. In case any malfunction/technical problem in the functioning of weighing system, the same shall be rectified by the contractor within period of 24 hrs. During this period of failure, weighing of MSW shall be carried out at private weighbridge located outside which should be approved by MCGM at contractor's cost and no additional charges will be paid by MCGM.

- (ii) Vehicle Tracking System (VTS) : - Online Vehicles Tracking System will be provided by the contractor for all the vehicles deployed for transportation & disposal of inerts/rejects from the plant. The real time data shall be connected to MCGM server with adequate data storage capacity of 6 months for live data and backup data of entire contract period.
- (iii) Server & connectivity requirements for data of Weighment system, VTS system are as below:-
- a. Weighment system application, VTS application, database, other software licenses, server with adequate capacity and required configuration shall be provided by contractor. The server facilities like server room, rack, power supply, UPS & air conditioning shall be provided by contractor. It will be hosted at MDG site and location of which will be notified by MCGM.
 - b. Server should have back up storage of all the data of weighment system , VTS and all other required data.
 - c. Dedicated connectivity for MCGM authorities and citizens shall be provided by the contractor.
 - d. All the facilities i.e. weighment system application, VTS application, database, other software licenses, server facilities shall be property of MCGM after end of contract period.
 - e. Administrative privileges of the server related to all data of weighment system, CCTV and VTS shall be with MCGM.
 - f. Any technical errors/malfunctioning of server data shall be rectified by the contractor at his own cost.
 - g. MCGM may audit any of the softwares used for the project at any time during the contract period.
2. Successful bidder has to provide CCTV surveillance covering the entire area of the Mulund Dumpsite. Adequate number of CCTV surveillance High Definition IP based cameras have to be installed at site.
 3. Also contractor has to ensure power back up for the smooth operation of weighbridge, critical electrical system, security & surveillance system and for all other required equipments/systems etc.
 4. The successful bidder shall set up & operate treatment plant for effluents etc. if required. All the facilities required by applicable law and to meet scope & conditions of this contract shall be set up by the contractor.
 5. Initial land required for setting up processing plant and machineries admeasuring up to maximum 4 Ha shall be made cleared by the contactor at his own cost. Contactor may shift the waste within the site for clearing this land.

6. If additional land is required for future expansion of the processing plant, operator can use the land that is recovered after processing the MSW up to maximum 4 Ha with prior approval of Municipal Commissioner.
7. The land area which will be cleared and cleaned will remain with MCGM except as mentioned in Sr.No. 5 (if required) which can be used till completion of project period and after termination of contract it will remain with MCGM.
8. It is the sole responsibility of the contractor to dispose off the rejects/inerts generated during the process. ("Reject" means Residual Solid Waste as per SWMRules 2016) Byproducts from such processing viz recyclables, enriched soil, compost, gas, energy etc will be the property of the contractor. It is expected that e-waste, hazardous waste and recyclables such as the plastic, glass, metal etc. does not any way form the part of inert waste. Every effort shall be made to recycle or reuse the rejects to achieve the desired objective towards zero waste going to landfill.

Contractor can make any useful building material from the waste lying at MDG at Karvale site or any other suitable place possessed by the contractor. The inert and non-biodegradable waste shall be used for building roads or filling-up of appropriate areas on hills/quarries. In case of constraints in finding adequate land in hilly areas/quarries and for road-laying, waste not suitable for road-laying or filling up shall be disposed off at MCGM's Karvale site or at any other site possessed by the contractor

9. The inert waste disposal plan shall also be proposed by the bidder which will include identification of an inert waste disposal area / site to be approved by relevant competent authorities. The said land shall be in lawful possession of the bidder and a agreement between contractor & the land owner shall clearly mention that land shall be used for the purpose of disposal of inerts/rejects of this project. Alternatively if bidder requires, MCGM's land maximum up to 20 Ha (200,000 Square Meter) at village Karvale near Talaja (Survey No. 26A, 26B, 29/1, 29/2, 29/3, 29/4, 29/5, 29/6, 29/7, 31, 40) will be allotted for the disposal of inerts/rejects of this project. The land may not be contiguous and contractor has to fill and level the land using inerts/rejects at Talaja as directed by MCGM.

Bidder has to give requirement of land maximum up to 20 Ha while submitting the bid. No extra land would be provided in future in addition to the land requirement given while submitting the bid. As per the land requirement, Bidder also has to pay premium for disposal of inerts/rejects on the land at village Karvale as mentioned below. Rate of the land per square meter would be Rs. 1000. Premium amount for the use of MCGM's land will be deducted from the monthly bill proportionately with quantity of work done and land requirement. It Contractor's responsibility to obtain all the required clearances/permissions for the land at Karvale .

Disclaimer: MCGM shall be completely absolved from any litigation/agitation by public regarding the land of Karvale which may arise subsequently. MCGM will do all possible efforts to provide the land but ultimately it is contractor's responsibility to dispose of inert/rejects of this project as per applicable norms and make his own arrangement for the same. Also there will be no lease of the land to the contractor and hence the question of creation of encumbrances on the land does not arise.

10. Contractor to ensure that maximum quantity of inert/rejects going to the Karvale landfill is not exceeding 20% of the total quantity of waste of the project.
11. A comprehensive plan covering activities like Removal, Segregation, Processing, Transportation, Disposal in a scientific manner will be submitted along with the technical proposal of the bidder.
12. The successful bidder has to obtain all required permissions/NOCs (For entire project activities i.e. For MDG area as well as for inert/rejects disposal area) from various authorities like State Level Environment Impact Assessment Authority (SEIAA), Maharashtra Pollution Control Board (MPCB), Maharashtra Coastal Zone Management Authority (MCZMA), Ministry of Environment & Forest and Climate Change (MoEF & CC), clearance of land owner for disposal of rejects/inerts and any such requisite regulatory/statutory permissions etc. in order to process existing MSW dumped at MDG. MCGM may assist the Successful Bidder in obtaining these permissions.

List of clearances required for the project may be as below, but not limited to:-

Sr.	Clearance	Authority
a.	Environmental Clearance / EIA for the project	MoEF/MCZMA/SEIAA
b.	Authorization under SWM Rules 2016	MPCB
c.	Consent to establish/ Consent to operate	MPCB
d.	CRZ clearance / EIA	MoEF/MCZMA
e.	Any other clearance	Competent Authority

13. Environmental Standards :-

- (i) Contractor has to follow the Environmental Standards as mentioned below (Annexure-3):-
 - a. Air Quality Monitoring: As per Solid Waste Management Rules 2016 (SWM Rules 2016) or amendments thereafter with respect to baseline site parameters.
 - b. Noise Monitoring – As per Noise Pollution Rules 2000 or amendments thereafter with respect to baseline site parameters.
 - c. Leachate Treatment – As per Solid Waste Management Rules 2016 (SWM Rules 2016) or amendments thereafter with respect to baseline site parameters.

- d. Odour Monitoring – As per CPCB guidelines ‘ Odour Pollution & Its Control May 2008’ or amendments thereafter with respect to baseline site parameters.
 - e. Water Quality Monitoring - As per Solid Waste Management Rules 2016 (SWM Rules 2016) or amendments thereafter with respect to baseline site parameters.
- (ii) Environmental parameters shall be monitored and recorded as per SWM Rules 2016 and other applicable Rules and their amendment from time to time. Monitored parameters to be displayed for the public view.
- (iii) Contractor may appoint a professional agency approved by MoEF/NABET to achieve these standards.

14. Hazardous waste:-

- a. The contractor will be responsible for the disposal of hazardous waste [as defined in Hazardous Waste (Management, Handling and Trans-boundary Movement) Rules, 2008] if existing/generated and shall dispose off the same at MPCB’s approved sites in accordance with Hazardous Waste (Management, Handling and Trans-boundary Movement) Rules, 2008 or amendments thereafter.
- b. Required charges for disposal of hazardous waste are required to be paid by the contractor.
- c. Contractor has to submit documentary evidence regarding disposal of hazardous waste at the MPCB’s approved sites.

15. After completion of contract period (6 years or extended period as the case may be), within 3 months, contractor has to completely remove the plant, machineries and equipment from the site and clear the project area. Performance security of the contractor will be released only after the entire project site has been handed over to MCGM without encumbrances. If the plant and machinery are not removed within the stipulated period, the same shall be removed and disposed off by MCGM. In such case Performance Security shall qualify for refund only after appropriating the cost of dismantling, removing and disposing off the plant and machinery.

16. It is the sole responsibility of the operator to abate the odour and fire nuisance on site. Operator has to use enzyme/herbal based products which will help to abate the odour and flies nuisance. Necessary fire fighting vehicles shall be arranged to abate the fire nuisance. However, in case of major fire incidence, MCGM may assist by providing fire fighting vehicles according to availability at that time.

Necessary safety gears shall be provided by the operator to all the staff working as per the good industry practice.

17. Contractor shall ensure that material which is to be transported for disposal after scientific processing is not dumped at MDG. He can make necessary arrangement like fencing or any other suitable arrangement as directed by MCGM authorities to prevent such events.

2.2 Special conditions:-

1. There will be no lease of land to the contractor. He will only set up the plant on MCGM's land for scientifically treating the garbage and operate it without any interest in land whatsoever. However, MCGM will provide necessary assistance to lenders/bankers/financial institutions funding the project in terms of granting right to entry if there is a need. Such right of entry however will be restricted to the plant and machinery set up by the contractor and will under no circumstances be extended to the land. As specified above, there will be no lease of land to the contractor and hence the question of creation of encumbrances on the land does not arise. Format of comfort letter to lenders/bankers/financial institutions is attached at Proforma-J.
2. The bidders should familiarize themselves with the site conditions and also carry out necessary site visits, surveys, studies / testing, analysis of the existing MSW with due diligence at their own cost prior to the bidding. Bidders will be allowed to take bores at site to ascertain density at different levels and to carry out analysis of strata. All the data/information/maps provided in the tender are indicative only. Contractor shall not bring any dispute regarding any data provided in the tender, variation in quantity and characteristics of MSW as he is expected to do his own studies.
3. All documents & technical proposal submitted shall be part of contract. The same plan shall be adhered for implementation. No change in the plan is allowed without the approval of MCGM.
4. All the plant design, equipments submitted in technical proposal should be reflected in the financial proposal. If any discrepancy is observed in the financial proposal with rate analysis and is not justified satisfactorily by the bidder, the bid may be rejected.
5. Team Leader of the successful bidder should not be changed without prior approval of MCGM.
6. MCGM shall be absolved from any litigation which will arise subsequently due to violation of the contract and any applicable norms/rules.

2.3 Water and Electricity:-

Arrangement of water and electricity required for the project will be the responsibility of the contractor. Necessary assistance may be provided by the MCGM.

2.4 The contractor has to follow in principle the method for Dumpsite Reclamation as per GoI, Ministry of Urban Development(MoUD), CPHEEO, SBM MSW Management Manual

Dumpsite reclamation involves sorting out mixed municipal waste according to material size (oversized material, intermediate sized waste and soil or humus) by using a trommel. The size and type of screens used depend on the end use of the recovered material. Dumpsite reclamation typically consists of two basic operations: excavating waste and screening waste.

A. Excavation:-

The old waste dump contains leachate at different layers and various gases and odor-causing substances. Before starting excavation, it is necessary to vent out the gases and drain out the leachate. Ventilation systems for application to such situations have been developed. Basically, it comprises blowing or sucking air from designated areas for 2 days before breaking open the dump for excavation. The exhaust air is passed through filters (preferably bio-filter) to trap the harmful gases. Excavation of waste material from the dump is then initiated. A front-end loader then organizes the excavated materials into manageable stockpiles and separates oversized or bulky material.

B. Screening:-

Waste screening begins with the segregation of excavated material into discrete streams. An electromagnet is used to segregate ferrous material from the main stream of waste. The nonferrous fraction is processed through an air classifier that separates light materials from heavy organics. A trommel or vibrating screen or vibrating screen separates soil from soil waste. Trommel screens are more effective than vibrating screens.

The sizes and types of screens used depend on the end use of the recovered material. For example, if the reclaimed soil is used as landfill cover, a 50mm screen is used for separation. If, however, the reclaimed soil is sold as construction fill or for another end use requiring fill material with a high fraction of soil content, a smaller mesh screen is used to remove small pieces of metal, plastic, glass, and paper. Operation costs can be retrieved by the sale or reuse of the recovered materials such as recyclables, soil, and waste.

Material recovery depends on the composition of waste, effectiveness of mining technology, and efficiency of mining technology. The material recovery ranges from 50% to 90%, while average soil fraction in recovered municipal waste from landfill tends to be around 50%-60%. However, it can vary between 20% and 80% depending on moisture content and decomposition rate.

It is to be noted that dumpsites which are subject to repeated burning, spontaneous or not, will have minimal potential for reclamation and recovery of material. Unless the recovered organic material is proved to be free from contamination (items indicated in Fertilizer Control Order [FCO], 2009 and 2013), it should not be used as manure for food crops.

Management of the project and methodology required to be adopted for handling existing solid waste at MDG may include but not limited to the following :-

1. The contractor should ensure regulated and continuous removal of waste from dump site with utmost safety and under standard hygienic conditions.
2. The waste removed from the dump sites is to be safely transferred to the treatment facility erected at the site. The contractor will prepare a layout clearly showing the area required for treatment of the garbage along with allied activities.
3. The treatment plant should be provided with necessary infrastructure like security and access control/s, camera monitoring and recording features etc by the contractor.
4. A separate first aid facility will be provided at the treatment plant within 100 mts. of the treatment facility.
5. Contractor may plan to work in three shifts
6. The hardware and technology to be adopted may include but not limited to the following:
 - i. Size reduction machineries.
 - ii. Magnetic separator for ferrous metals & scraps, also solution for non ferrous metals removal.
 - iii. Size reduction & Screening
 - iv. Effective segregation of non-biodegradables mass like plastics, inert material (construction / demolition waste), etc.
 - v. Collection of biodegradable and organic matter followed by scientific processing.
 - vi. In case excess power is generated the same may be supplied to grid, upon obtaining appropriate approvals from concerned agencies by the bidder at his own cost.
 - vii. Transfer and disposal of metal scrap and other recyclable mass like glass and plastics to primary producer industry either directly or through approved vendors / contractors.

- viii. The disposal site identified by the bidder to dump the rejects/ inerts after treatment shall be in lawful possession of the bidder and is required to be approved by the relevant competent authorities.
- ix. By-products from such processing like recyclables, RDF, gas, energy etc will be the property of the contractor.
- x. Deploying of all requisite inputs viz., MSW collection & handling equipment and vehicles, conveyors, JCB, dumpers etc. will be contractor's responsibility.
- xi. The plant and machineries necessary for each of the above steps will be part of the proposal submitted to MCGM for approval.
- xii. The plan proposed should be comprehensive in terms of providing a source to end solution.

2.5 Provision for building ancillary facilities:

In case contractors are required to set up ancillary facilities at site like Fuel storage, DG set etc. MCGM may assist the contractor in getting the same installed at site for period of contract only. However the necessary permissions required are to be obtained by contractor at his cost.

All handling of explosives, including storage, transport shall be carried out as per the applicable rules of "Explosives Department of the Government".

2.6 Submissions of plan and methodology for the project:-

Bidders will submit the following documents along with the technical bid:-

- i. Detailed plan and methodology including monsoon period.
- ii. Sample plant flow charts
- iii. Typical drawing of the structure to be erected as treatment plant
- iv. Details of site laboratory
- v. Documentary evidences for the parameters for evaluation of the Technical Bid specified in the Annexure 11.

2.7 Mobilization & Construction period and commencement of the project:- Construction and erection of the plant and creation of other allied facilities should be completed within 12 months from the receipt of LOA/work order. This will include the mobilization period and time period required for getting necessary statutory clearances/permissions. After completion of construction and erection of the plant, operation of the plant shall commence which will be considered as Commercial Operation Date (COD) of the project.

2.8 Dumping of fresh MSW:-

No fresh MSW will be dumped at MDG by the MCGM after issuance of Letter of Acceptance (LOA)/Work Order except in case of natural calamities. After issuance of Letter of Acceptance (LOA)/Work Order, successful bidder has to take charge of the site in

all respect and shall keep his own security at site so as to avoid unauthorized dumping, fire etc. Successful bidder has to also take contour survey after issuance of LOA/Work Order so as to monitor the progress of work.

3. Contract Period :-

Contract period will be six years from the date of LOA/Work Order (including mobilization & construction period of one year and monsoon period) to dispose off Seven Million MT of existing MSW from the Mulund Dumpsite through scientific processing.

4. Terms of Payment:-

- i. Payment will be made on the basis of weighment of incoming waste to the processing plant set up by the contractor for the purpose of this project. Payment will be released after ensuring that waste is processed as per the applicable rules in force and removed from the site for further disposal. If any malpractice is observed in this, heavy penalty as mentioned in the clause 5.3 of Chapter 1 in Part-III shall be imposed. If malpractice observed second time, Municipal Commissioner may even cancel the contract & initiate legal action against the contractor which may also include blacklisting.

ii. Bill submission:

As per circular no CA/FRD/I/06 dtd 02.05.2012, the contractor has to submit the bill for the work carried out within 15 days and the same will be paid within 30 days from the receipt after satisfactory completion of works and due certification of the same by MCGM officials.

If these contractual agencies fail to submit their bills to concerned executing department for the completed work/running bill within 15 days, penalty or action as shown below will be taken for each delayed bill:-

1.	After 15 days from the date of completion/running bill up to certain date, up to next 15 days i.e. up to 30 days.	Equal to 5% of bill amount
2.	Next 15 days up to 45 days From the date of Completion/running bill up to Specified date.	Equal to 10% of bill amount
3.	If not submitted within 45 Days from the date of Completion/R.A. bill.	Bill will not be admitted for Payment.

iii. Retention from monthly bill :

5% of the amount from each monthly bill will be retained till the completion of the contract. The retention money shall be refunded to the contractor only after finalization of final bill, settlement of accounts of work by the contractor in all respects or after completion of the contract whichever is later.

- iv. Escalation:-** Escalation will be given to the contractor as per the Annexure-19 on the rate quoted in the BOQ from the second year of COD of the project. The applicable escalation will be given after every six months. However, this escalation will be applicable as per the yearly time period and accomplishment of cumulative milestones as specified in table 2.1.1 only and will not be given on the backlog quantity processed & cleared.

For the backlog quantity, escalation applicable during the first month for the particular milestone year of which backlog is pending would be considered.

Maximum escalation admissible during the entire contract period will be 10% of the contract cost.

- v. Advance Mobilization loan of 10% of contract cost but not exceeding 25% of plant & machinery cost will be given as per usual terms & conditions of GCC of MCGM against the Bank Guarantee by modifying the clause. Portion of modified clause as follows:-**

The Corporation will make advance to the contractor for the works in two installments. The first installment shall be equal to 5% of contract cost or 12.5% of plant & machinery cost as the case may be and will be paid after submission of plant and machinery invoices copies. The payment of the first installment of advance shall be due after (i) execution of the form of agreement by the parties thereto. (ii) payment of Security Deposit by the Contractor and (iii) Submitting the Bank Guarantee by the Contractor in the form of a Bank specified in the tender for an amount equal to 7% of the contract cost or 17.5% of plant & machinery cost as the case may be (with includes 2% extra for the interest charges). The first installment of advance shall be paid to the Contractor within 28 days after fulfilling all the above requirements under sub items (i) to (iii) Payment of second instalment of the mobilization advance up to 5% of contract cost or 12.5% of plant & machinery cost as the case may be will be due within a period of 28 days from erection of plant and machinery, preliminary site establishment works such as construction of access roads to site, Engineer's office, Contractor's site office, Stores, Workshop sheds, etc. to the satisfaction of the Engineer. After certification by the Engineer that the preliminary works are completed

satisfactorily, the second installment will be released after the Contractor submits the Bank Guarantee from a Bank acceptable to the Corporation for an amount equal to 7% of the contract cost or 17.5% of of plant & machinery cost as the case may be (with includes 2% extra for the interest charges). Bank Guarantee shall be submitted in the approved prescribed form. The Bank Guarantee/s for the Mobilization Advance should be valid till the full recovery advance is made. The Contractor shall use the advance payment only towards expenses for plant and machinery, preliminary site establishments works, and to meet expenses required specifically to carry out the works. The above advance shall bear simple interest at 12% per annum. The interest on the amounts paid as advance is chargeable from the date the amount is paid. The contractor shall produce all quotations, invoices, vouchers and accounts or receipts in connection with expenditure in respect of plant and machinery cost.

RECOVERY OF ADVANCE : Recovery of advance paid and interest against it aforesaid, shall be made by deductions from the on account of payments referred to in condition no.12 (b) of GCC-2016 in suitable percentage in relation to the progress as fixed by the Engineer so that all sums with interest shall be fully recovered by the time the work amounting to nearly 80 percent of the contract is completed. If the amount payable under any interim bill is not sufficient to cover all deductions to be made on this account and other sums deductible therefrom the balance outstanding shall be deducted from subsequent bills as may be necessary.

- vi. Monsoon Period : - During the monsoon period (June to September), considering moisture content, 90% of weightment of incoming waste to the processing plant shall be considered for payment.
- vii. As per the land requirement given by the bidder, Contactor has to pay premium for disposal of inert/rejects on the land at village Karvale as mentioned below:
Rate of the land per square meter would be Rs. 1000.
Premium amount for the use of MCGM's land will be deducted from the monthly bill proportionately with quantity of work done and land requirement given by the bidder.

5. Penalty :-

Penalties will be applicable as mentioned below. The powers to relax/condone the penalties fully or partially shall vest with the Commissioner. The Commissioner shall decide each case on merits.

Sr No.	Description	Penalty Amount.
1.	Delay in commencement of the project after completion of mobilization & construction period i.e. 12 months from the date of LOA/work order.	Rs. 20,000/- per day

2.	Violation Solid Waste Management Rules 2016 (SWM Rules 2016) or other applicable environmental norms notified by competent authorities	Rs.5,000/- per incident per day in addition to action taken by concerned authority.
3.	Tampering of records at weighbridge or submission of manipulated records or any malpractice which will affect quantity & quality of work done.	50% of the value of bills certified for three preceding months from the month of incidence noticed + Loss incurred to MCGM due to such event
4.	Malfunction/technical problems in weighment system is not rectified within 24 hrs	Rs. 2000 per hour starting after 24 hrs of permissible repairing time.
5.	Processing less quantity of waste than designed for a particular stage. (Will be calculated on yearly basis)	5% of the rate as quoted in BOQ* Yearly shortfall in MT
6.	If fire at site is not stopped within 72 hrs.	Rs. 25000 per hr.
7.	Safety measures not taken as per standard practices	Rs.100 per fault per incident

6. Incentives :-

Incentive (7% of the rate quoted in BOQ) will be given, if quantity processed is more than the quantity which is to be processed as per the milestones set out in table 2.1.1. Incentive will be calculated as below:-

$$\text{Incentive} = \left(\frac{7\% \text{ of the rate quoted in BOQ}}{\text{BOQ}} \right) \times (\text{Additional quantity processed in a particular year})$$

However, this incentive will be applicable as per the time period and quantity specified in the table 2.1.1 only and will not be given on the backlog quantity processed & cleared.

Contactors have to first clear the backlog quantity and then start the next year's milestone.

MUNICIPAL CORPORATION OF GREATER MUMBAI

CHAPTER-2

SCHEDULE/BILL OF QUANTITIES AND RATES (BOQ)

Note: This format is for information purpose only and shall not be filled and submitted in physical form & not in Packet A & B. Actual rates to be filled online in price bid i.e. Packet C.

Sub: Dumpsite Reclamation at Mulund Dumping Ground (MDG) in Mumbai
by adopting suitable technology for existing garbage dump

ITEM CODE	ITEM DESCRIPTION	Total Quantity	Rate in Rs./MT
1	Scientific processing and disposing off existing waste from the Mulund dumpsite.	7 Million MT	Rate should be quoted online in the Packet C.

Note - Bidders shall submit the rate analysis within two days from opening of Packet-C or within stipulated time period as prescribed by MCGM. If the bidders fails to submit the rate analysis , his bid shall be rejected and in such a case, selection of the bidder will be done amongst the other remaining bidders.

PART -IV

List of Annexure

Annexure	Subject
1	Tender form. It covers declaration regarding:- <ul style="list-style-type: none"> • Acceptance of terms and conditions. • Keeping the offer valid for the required period.
2	Declaration/ Affidavit by the Tenderer regarding:- <ul style="list-style-type: none"> • Common partners • Best price. • Forfeiture of EMD • Carrying out work / effecting supply pending sanction of appropriate authority • Debarment / Litigation etc. • Correctness of Documents/ Information.
3	Environmental Standards
4	Status of Tenderer.
5	Authorization letters for attending <ul style="list-style-type: none"> • Pre-bid meeting • Tender opening
6	Form of contract for Civil /Mechanical works. (Existing)
7	Form of Banker's Guarantee (Existing)
8	Letter of Acceptance
9	Form of Integrity Pact
10	Grievance Redressal Mechanism
11	Mandatory fulfillment and Technical Evaluation of Technical Bid
12	Work Completion Certificate from the Statutory Auditor/Client regarding work experience criteria/technical capacity
13	Parent Company Guarantee
14	Self-Certification by the Tenderer regarding technology
15	Taxes and Duties
16	Deleted
17	Map of Mulund Dumping Ground (MDG)
18	Map of MDG with volume statement
19	Price Adjustment
20	Irrevocable Undertaking

Annexure:-1
Tender Form

To
The Municipal Commissioner
Municipal Corporation of Greater Mumbai

Subject:- E-Tender No.:..... Due date:.....

Sir,

I / We.....(full name in capital letters starting with surname), the Proprietor /Managing Director / Holder of the business for the establishment / firm / registered company named herein below do hereby state that I / We have read, examined and understood the contents of following documents relating to

- 1) e-Tender Notice.
 - 2) Eligibility Criteria.
 - 3) Special Instructions to the Tenderers.
 - 4) Mandatory Conditions
 - 5) Earnest Money Deposit.
 - 6) Evaluation Criteria.
 - 7) Information to the Bidders.
 - 8) General Conditions of Contract (GCC).
 - 9) Undertaking on Rs.200/- Stamp Paper, as per provisions under ESIC Act-1948
 - 10) Special Instructions to Bidders participating in e-Tendering of MCGM.
 - 11) Technical Specification & Scope of Work
 - 12) Schedule/Bill of Quantities and Rates (BOQ)
 - 13) Instructions to Bidders
 - 14) Annexure 1 to 20.
 - 15) Proforma 'A' to 'L'.
 - 16) Minutes of pre bid meeting, if any.
 - 17) Addendum/ Corrigendum, if any.
2. I / We have examined the details/ specifications of supply to be made/ work to be carried out and noted all the terms and conditions and accordingly hereby e-tender for execution of the works/ supply referred to in the aforesaid documents, at the rate quoted in the form of price proposal and appendix to price proposal and signed by me / us. (Strike out the portions which are not applicable).
3. I/ We have paid the Earnest Money Deposit (E.M.D.) online dated..... for
INR..... We are aware that this EMD shall not bear any interest till it is with MCGM.
4. I / We also agree to keep this e-tender open for acceptance for a period of **150 days** from the date for opening the same and not to make any modifications in its terms and conditions which are not acceptable to the Corporation.
5. I/We hereby further agree to execute agreement in the prescribed proforma and shall bear all the charges of whatsoever nature in connection with the preparation, Stamp Duty and execution of the said contract.
6. I/ we have offered our rates in the prescribed format and uploaded it along with the bid document.
7. I/We further state that I/We have separately furnished an undertaking / declaration in the form of Affidavit on the stamp paper of Rs.200/- (Rupees Two Hundred only) with regards to agreeing to the

terms and conditions incorporated in the bid documents and various declarations as per requirement of MCGM and I/We shall abide by them, in all respect throughout the period of contract.

.....
.....
.....
.....

Full Names and Residential Address of all
the partners constituting

The firm :

1.
.....
.....
2.
.....
.....
3.
.....
.....
4.
.....
.....

Yours faithfully,

Address :

Signature of the Tenderer / Partners

1.
2.
3.
4.
5.

Annexure:-2

Declaration by the Tenderer

(To be filled in and signed by the tenderer and to be submitted on non judicial stamp paper of Rs, 500/-duly notarized by Notary Public / First Class Magistrate.)

AFFIDAVIT

To
The Municipal Commissioner
Municipal Corporation of Greater Mumbai

Subject:- E-Tender No..... Due date.....

Sir,
I/ We.....(full name in capital letters starting with surname), the Proprietor /Partner/Managing Director/Holder of Power of Attorney of.....

.....
.....
the business, establishment / firm / registered company do hereby, in continuation of the terms and conditions underlying the Tender Form and agreed to by me/us, give following undertaking:-

1. I / we hereby confirm that I / we will be able to carry out the work/supply/ installation/commissioning offered by me /us at the quoted rates and as per specifications/drawings indicated in the tender after compliance of all the required formalities within the specified time.
2. I/We do hereby state and declare that I/We, whose names are given herein below in detail with the addresses, have not filled in this e- tender under any other name or under the name of any other establishment/ firm or otherwise, nor we are in any way related to or concerned with the establishment/ firm or any person, who have filled in the e- tender for the aforesaid work.
3. I/We also admit that if the relevant conditions forbidding submission of tender under different names of the firm is found violated, the Municipal Commissioner is at liberty to take necessary action against me/us.
4. I /We do hereby undertake that we have offered best price for the subject supply /work as per the present market rates and that I/We have not offered less price for the subject supply/work to any other outside agencies including Govt. / Semi Govt. agencies and within MCGM also, in similar conditions.
5. I / We hereby request you not to enter into a contract with any other person/s for the execution of the works/supply until notice of non-acceptance of this e-tender has first been communicated to me/us, and in consideration of your agreeing to refrain from so doing I/We agree, not to withdraw the offer constituted by this e-tender before communicating me/us the decision of the MC/ Mayor/ Standing Committee or of the Education Committee, as may be required under Mumbai Municipal Corporation Act.
6. I / We agree to comply with and fulfill the requirements of all labour laws or other enactments applicable to this supply /work and abide them throughout the period of contract.

- 7.** I / We accept the right of MCGM to stop any supervising staff/ labour employed by me / us from entering in the MCGM premises if it is felt that the said person is an undesirable element or is likely to create nuisance. MCGM will not be required to assign any reason while exercising this right and I/We shall abide by such decision being binding on us.
- 8.** I / We shall not sublet the work to any agency without prior approval of the MCGM.
- 9.** I / We understand and accept that our e-tender/contract is liable for rejection/ termination and EMD paid by me/us shall be liable for forfeiture by the MCGM if-
- a)** I / We fail to keep the e-tender open as aforesaid,
 - b)** I / We fail to execute the formal contract or make payment of contract deposit when called upon to do so,
 - c)** I / We do not commence the work/supply on or before the date specified by officer/ engineer in his work order/indent,
 - d)** I / We fail to produce required information, testimonials or a letter in original whenever called upon to do so or I/We fail to give satisfactory reason for non- production of such information testimonials, letter etc. within a period of one week from receipt of such demand.
- 10.** I/We hereby agree to execute the additional work/ supply to the extent of 50% over and above the office estimates at the quoted rate and terms and conditions of contract, but within the contract period as and when called upon by the Municipal Commissioner, Additional Municipal Commissioner, Director or Dy. Municipal Commissioner to do so.
- 11.** I/We hereby further state and declare that-
I/We are ...
- not declared insolvent any time in the past.
 - not debarred or blacklisted for tendering of bids by the Corporation or any other Govt./ Semi Govt. organizations.
 - not convicted under the provision of IPC or Prevention of Corruption Act., nor any case is pending against me/us in any court of law.
- 12.** The acceptance of this tender by M.C.G.M. shall constitute a binding contract between me / us and M.C.G.M.
- 13.** I / We have filled in the accompanying e-tender with full knowledge of liabilities and therefore we will not raise any objections or disputes in any manner relating to any action including forfeiture of deposit and blacklisting for giving any information, which is, found to be incorrect and against the instructions and directions given in this e-tender.
- 14.** I / We further confirm that the information/ documents submitted by me /us are true and correct to best of my/our knowledge and belief and that in the event it is revealed subsequently after opening of the tender or after the allotment of work / contract to me / us that any information given by me / us or any document uploaded/ submitted by me/us in this e-tender is false or incorrect, I / We shall compensate the Municipal Corporation of Greater Mumbai for any such losses or inconvenience caused to the Corporation in any manner and will not resist any claim for such compensation on any ground whatsoever. I / We agree to undertake that I / We shall not claim in such case any amount by way of damages or compensation for cancellation of the contract given to me / us or any work assigned to me / us or is withdrawn by the Corporation.
- 15.** I/we solemnly confirm the compliance of all the requirements/ Conditions of the tender documents.

Full name and complete address with
Tel. Nos. & E-mail address of all partners

Yours faithfully,

Signature of Tenderer
Trading under the name and style
of.....
Office Stamp

WITNESS:

(1) Full Name
And Address
.....

Signature

(2) Full Name
And Address
.....

Signature

Annexure:-3
Environmental Standards

1. Ambient Air Quality Monitoring

As per Solid Waste Management Rules 2016 (SWM Rules 2016) or amendments thereafter with respect to baseline site parameters.

2. Noise Pollution

The measurement of ambient noise would be done at the interface of the facility with the surrounding area, i.e., at plant boundary. According to The Noise Pollution (Regulation & control) Rules, 2000, the standards for noise for areas/zones are presented in Table below.

Table : Standards for noise in different areas/zones

Area Code	Category of Areas/Zones	Limits in dB	
		Day Time 6AM to 10PM	Night Time 10PM to 6AM
A.	Industrial area	75	70
B.	Commercial area	65	55
C.	Residential area	55	45
D.	Silence zone	50	40

Depending upon the site specific location, the appropriate norms should be followed.

3. Standards for treated leachate from landfill site

As per Solid Waste Management Rules 2016 (SWM Rules 2016) or amendments thereafter with respect to baseline site parameters.

4. Water Quality Monitoring

As per Solid Waste Management Rules 2016 (SWM Rules 2016) or amendments thereafter with respect to baseline site parameters.

5. Odour Monitoring (with respect to baseline site parameters)

Table

Odour detection threshold

As per CPCB Guidelines on 'Odour Pollution & Its Control (May 2008)'

Parameter	Odour detection threshold (ug/m ³)
SO ₂	2616
NH ₃	695
H ₂ S	1390
Aldehyde	1226
Methyl Mercaptan	1962

- 6.** For parameters which are not covered as above, Solid Waste Management Rules 2016 (SWM Rules 2016) and other applicable rules/norms or standard rules by any appropriate authority shall apply as amended from time to time.

(On the letter head of Tenderer)

Annexure:-4

Information of Tenderer as well as that of Manufacturer indicating Status.

e-Tender No.....

Date.....

Due date:-.....

Tenderer's Name	
Status (√ Tick)	<input type="checkbox"/> Individual <input type="checkbox"/> H.U.F. <input type="checkbox"/> Proprietary <input type="checkbox"/> Partnership <input type="checkbox"/> Pvt. Ltd. Co. <input type="checkbox"/> Jt. Venture. <input type="checkbox"/> Public Ltd. Co. <input type="checkbox"/> Co-op Society <input type="checkbox"/> Trust /Sanstha <input type="checkbox"/> Manufacturer <input type="checkbox"/> 100% Subsidiary of Manufacturer <input type="checkbox"/> Govt. unit <input type="checkbox"/> Semi Govt. unit <input type="checkbox"/> Authorized Distributor. <input type="checkbox"/> SSI <input type="checkbox"/> Other units
Addresses:- Tel. No:- Mob. No.:- Email- ID:- Fax No.:-	Residence Office / Factory Reg. Office (Use separate sheet if required)
Name/s of Individual/ Proprietor / All Partners /Authorized Person	 (Use separate sheet if required)
Addr. of All Partners/ Authorized Person Tel. No:- Mob. No.:- Email- ID:- Fax No.:-	 (Use separate sheet if required)
Name & Addr. of POA holder Tel. No:- Mob. No.:- Email- ID:- Fax No.:-	 (Use separate sheet if required)
Name & Addr. of Contact Person in case of urgency Tel. No:- Mob. No.:- Email- ID:- Fax No.:-	 (Use separate sheet if required)

Authorized Signatory of Company Rubber stamp

Annexure: -5

Authorization Letter for Attending Pre-bid Meeting / Tender Opening
(On the letter head)

No.....

Date.....

To The.....
Municipal Corporation of Greater Mumbai,
Mumbai.

Sub: Tender No.....due date.....

Sir,

We here by authorize Mr.as our authorized representative, to represent us on the following occasion:-

- i. Pre-bid Meeting to be held on.....at.....a.m./p.m.
- ii. Tender Opening on..... at..... a.m. /p.m.

Kindly permit him to attend the same.

Yours faithfully, Signature:

Name of signatory:

Designation:

Rubber Stamp:

Annexure:-6

Draft articles of agreement for Execution of Works

Tender No..... Due on .../.../.....

**Standing Committee Resolution No..... of..... / Mayor's/
Municipal Commissioner's Sanction No. Dated.....**

Contract for Carrying out work of
.....

During the period from..... to

THIS AGREEMENT MADE ON THIS.....Day of

Two Thousand Between.....

(Partner /Proprietor's Full Name) in habitant/s of Mumbai, carrying on business at
.....

in Mumbai under the style and name of Messers for and on behalf of
himself / themselves, his / their heirs, executors, administrators and assigns (
Hereinafter called = the Contractor/s') of the FIRST PART
and.....Shri/ Smt.

..... the Dy. Municipal Commissioner in which expressions are
included unless such inclusion is inconsistent with the context or meaning therefore include Dy.
Municipal Commissioner and any officers of Municipal Corporation of Greater Mumbai
authorized by the Dy. Municipal Commissioner and shall also
include their successors & assign / assignee for the time being holding office, of the SECOND
PART and the Municipal Corporation of Greater Mumbai (Hereinafter called _ the Corporation')
of the THIRD PART.

WHEREAS the Municipal Commissioner for Greater Mumbai has interallia deputed
under Section 56 and 56 (b) of the Mumbai Municipal Corporation Act 1888 his powers, functions
and duties under the provisions contained in Chapter III of the Mumbai Municipal Corporation Act
1888 to the Dy. Municipal Commissioner

AND WHEREAS the Dy. Municipal Commissioner in pursuance of the power vested in
him / her under the provision of the Mumbai Municipal Corporation Act 1888
and in accordance with the provision of the said Act, invited Tender for the work

of..... and / or certain work mentioned in the schedule / specification here to annexed.

AND WHEREAS the contractor/s has/have submitted Tender for the said work and his / their said Tender was accepted by the Municipal Commissioner with the approval of the Mayor/ Standing Committee/ Education Committee of the Corporation on the Terms and Conditions hereinafter specified.

AND WHEREAS the said Contractor/s has / have paid deposit of Rs...../- (Rupees.....) in the office of as Performance Security for the due and faithful performance of this contract OR has / have furnished the General Undertaking and Guarantee for Rs...../- (Rupees.....) of Bank, for the payment interalia of the said amount of the Performance Security Deposit in the office of for the due and faithful performance of this contract.

NOW THESE PRESENTS WITNESS and it is hereby agreed and declared between and by the parties hereto as follows:-

In this agreement words and expressions shall have the same meanings as are respectively assigned to them in the General Conditions of Contract for works hereinafter referred to.

The following documents shall be deemed to form and be read and construed, as part of this agreement viz.

- a) The said E- Tender and Letter of Acceptance
- b) The drawings
- c) The Technical Specification & Scope of Work
- d) General Conditions of Contract for Civil Works of the Municipal Corporation of Mumbai as amended up to date.
- e) Performance Security Deposit
- f) Appendices
- g) Any other document listed in the contract data as forming part of the contract.

In consideration of the payments to be made by the Commissioner to the contractor as hereinafter-mentioned the contractor hereby covenants with the Commissioner to complete the Works / Supply in all respects with the provision of the contract.

The Commissioner hereby covenants to pay to the Contractor in consideration of the completion of the works/ supply the contract sum, at times and in the manner prescribed by the contract.

IN WITNESS WHERE of the parties hereto have caused their respective common seals to be hereto affixed (or hereunto set their respective hands and seals) the day and year above written.

Signed and delivered by the contractors

.....
.....

In the presence of

Trading under the name & style of

..... Full

Name

Address

Contractors

.....
.....

Signed by the Director / Dy. MC

in the presence of

Director/ Dy. MC

.....

The Common seal of the Municipal Corporation of Brihan Mumbai was hereunto affixed on the 20..... in the presence of two Members of the Standing Committee / Education Committee of the Municipal Corporation.

(1)

(1)

.....

.....

(2)

(2)

.....

.....

and in the presence of the Municipal Secretary.

.....

Municipal Secretary

Annexure-7

(Blank draft form is available on the counter of Chief Accountant –Treasury, MCGM)

BANKERS' GUARANTEE IN LIEU OF PERFORMANCE SECURITY DEPOSIT FOR WORK

THIS INDENTURE made thisday of20....

BETWEEN

THE.....BANK incorporated under the English/Indian Companies Act and carrying on business in Mumbai (hereinafter referred to as 'the bank' which expression shall be deemed to include its successors and assigns) of the first part

..... inhabitants carrying on business at.....

.....in

Mumbai under the style and name of Messers

.....(hereinafter referred to as 'the contractors') of the second part Shri.....

THE MUNICIPAL COMMISSIONER FOR GREATER MUMBAI

(hereinafter referred to as 'the Commissioner' which expression shall be deemed, also to include his successor or successors for the time being in the said office of Municipal Commissioner) of the third part and THE MUNICIPAL CORPORATION OF GREATER MUMBAI (hereinafter referred to as 'the Corporation') of the forth part WHEREAS the contractors have submitted to the Commissioner tender for the execution of the work of

.....and the terms of such tender/contract require that the contractors shall deposit with the Commissioner as Performance Security Deposit a sum of Rs..... (Rupees.....)

AND WHEREAS if and when any such tender is accepted by the Commissioner, the contract to be entered into in furtherance thereof by the contractors will provide that

such deposit shall remain with and be appropriated by the Commissioner towards the Performance Security Deposit to be taken under the contract and be redeemable by the contractors, if they shall duly and faithfully carry out the terms and provisions of such contract and shall duly satisfy all claims properly chargeable against them thereunder AND WHEREAS the Contractors are constituents of the Bank and in order to facilitate the keeping of the accounts of the contractors, the Bank with the consent and concurrence of the Contractors has requested the Commissioner to accept the undertaking of the Bank hereinafter contained in place of the contractors depositing with the Commissioner the said sum as Performance Security Deposit as aforesaid AND WHEREAS accordingly the Commissioner has agreed to accept such undertaking. NOW THIS AGREEMENT WITNESSES that in consideration of the premises, the Bank at the request of the Contractors (hereby testified) UNDERTAKES WITH the Commissioner to pay to the Commissioner upon demand in writing, whenever required by him, from time to time, so to do, a sum not exceeding in the whole Rs.....(Rupees.....) under the terms of the said tender and/or the contract. The B.G. is valid upto "Notwithstanding anything what has been stated above, our liability under the above guarantee is restricted to Rs..... only and guarantee shall remain in force upto unless the demand or claim under this guarantee is made on us in writing on or before all your right under the above guarantee shall be forfeited and we shall be released from all liabilities under the guarantee thereafter."

IN WITNESS
WHEREOF
WITNESS (1)

Name and
.....
Address
.....

..... WITNESS (2)
Name and the duly constituted Attorney
Manager
Address
.....

The Bank and the said Messers
.....(Name of the Bank)

WITNESS (1) Name
and
Address
.....

WITNESS (2) for Messers

Name and (Name of the Contractor)

Address
.....

Annexure-7 (A)
LIST OF APPROVED BANKS

1. The following Banks with their branches in Greater Mumbai and upto Virar and Kalyan have been approved only for the purpose of accepting Banker's Guarantee from 1997-98 onwards until further instructions.
2. The Bankers Guarantee issued by branches of approved Banks beyond Kalyan and Virar can be accepted only if the said Banker's Guarantee is countersigned by the Manager of a Branch of the same Bank, within the Mumbai City Limit categorically endorsing thereon that said bankers Guarantee is binding on the endorsing Branch of the Bank with Mumbai limits and is liable to be on forced against the said branch of the Bank in case of default by the contractor / supplier furnishing the Bankers Guarantee.

List of the Approved Banks

(A) S.B.I. and its subsidiary Banks:	(C) Scheduled Commercial Banks:
(1) State Bank of India	27) Corporation Bank
(2) Deleted.	(28) Bank of Madura Ltd.
(3) State Bank of Hyderabad	(29) Bank of Rajasthan Ltd.
(4) State Bank of Mysore	(30) Banaras State Bank Ltd.
(5) State Bank of Patiala	(31) Bharat Overseas Bank Ltd.
(6) State Bank of Saurashtra	(32) Catholic Syrian Bank Ltd.
(7) State Bank of Travankore	(33) City Union Bank Ltd.
(8) State Bank of Indore	(34) Development Credit Bank
(B) Nationalised Banks:	(35) Dhanalakshmi Bank Ltd.
(9) Canara Bank	(36) Federal Bank Ltd.
(10) Andhra Bank	(37) Indus Ind. Bank Ltd.
(11) Bank of Baroda	(38) I.C.I.C.I. Banking Corporation Ltd.
(12) Bank of India	(39) Global Trust Bank Ltd.
(13) Bank of Maharashtra	(40) Jammu and Kashmir Bank Ltd.
(14) Central Bank of India	(41) Karnataka Bank Ltd.

(15) Dena Bank	(42) Karur Vysya Bank Ltd.
(16) Indian Bank	(43) Lakshmi Vilas Bank Ltd.
(17) Indian Overseas Bank	(44) Nadungadi Bank Ltd.
(18) Oriental Bank of Commerce	(45) Ratnakar Bank Ltd.
(19) Punjab National Bank	(46) Sangli Bank Ltd.
(20) Punjab & Sind Bank	(47) South Indian Bank Ltd.
(21) Syndicate Bank	(48) S.B.I. Commercial & Int. Bank Ltd.
(22) Union Bank of India	(49) Tamilnadu Mercantile Bank Ltd.
(23) Vijaya Bank	(50) United Western Bank Ltd.
(24) UCO Bank	(51) Vysya Bank Ltd.
(25) United Bank of India	
(26) Corporation Bank	
(D) Scheduled Urban Co-op. Banks:	(E) Foreign Banks:
(52) Abhyudaya Co.op.Bank Ltd.	(69) A.B.M. Aviro Bank (N.Y.)
(53) Bassein Catholic Co.op. Bank Ltd.	(70) American Express Bank Ltd.
(54) Bharat Co.op. Bank Ltd.	(71) ANZ Grindlays Bank
(55) Bombay Mercantile Co.op. Bank Ltd.	(72) Bank of America N.T. & SA.
(56) Cosmos Co.op. Bank Ltd.	(73) Bank of Tokyo Ltd.
(57) Greater Mumbai Co.op. Bank Ltd.	(74) Bankindosuez
(58) Maharashtra State Co.op. Bank Ltd.	(75) Banque Nationale de Paris
(59) Mumbai Dist.Central Co.op. Bank Ltd.	(76) Barclays Bank
(60) Janata Sahakari Bank Ltd.	(77) City Bank N.A.
(61) New India Co.op. Bank Ltd.	(78) Hongkong & Shanghai Banking Corpn.
(62) North Canara G.S.B.Co.op. Bank Ltd.	(79) Mitsui Taiyokbe Bank Ltd.
(63) Rupee Co.op. Bank Ltd.	(80) Standard Chartered Bank Ltd.
(64) Sangli Urban Co.op. Bank Ltd.	(81) Cho Hung Bank
(65) Saraswati Co.op. Bank Ltd.	(82) State Bank of Bikaner & Jaipur

(66) Shamrao Vithal Co.op. Bank Ltd.

(67) Citizen Bank Ltd.

(68) Mahanagar Co-op. Bank Ltd.

In addition to the list of banks above , following banks in the list of RBI (Reserve Bank of India) will also be allowed for bank guarantee.

RBI's list of banks can be downloaded from

<https://rbidocs.rbi.org.in/rdocs/publications/pdfs/84656.pdf>.

From this list of RBI, banks under following heads with their branches in Greater Mumbai and in suburbs & extended suburbs up to Virar and Kalyan have been approved for accepting bank guarantee :-

SBI And Associates, Nationalized Banks, Other Public Sector Banks, Private Sector Banks, Foreign Banks, and Urban Co-operative Banks.

(Format)

Annexure:- 8

Municipal Corporation of Greater Mumbai

No.....

dt...../...../.....

Office Address:

Letter of Acceptance

To M/s

Address/:-

Sub:- (Name of Work / Supply of.....)

Ref :- Your offer to our Tender No..... dt.....

due on

dt..... for the above work/ Supply.

Dear Sir,

Your tender offer for the above Work / Supply has been accepted by the Municipal Commissioner/ Mayor by sanction No.....dated..... /Standing Committee / Education Committee of this Corporation in their meeting held on/..../....., being the lowest responsive tender, at the total contract cost of Rs/- . The regular work order will be issued shortly / Regular / Periodical indents will be placed on you by the authorized person of user department accordingly.

You are, therefore, directed to make necessary preliminary arrangements for execution of Work / Supply.

You are also directed to furnish Performance Security Deposit amounting to Rs...../- as per tender condition, within thirty days from receipt of this letter of acceptance.

If you fail to furnish Performance Security Deposit within stipulated time the earnest money deposit paid by you shall be forfeited and further action of black listing of your firm shall be initiated which please note.

It will also be necessary to execute a written contract. You are, therefore requested to collect necessary set of contract documents from the office of.....on payment of legal charges and stationary charges as applicable.

Thanking you

Yours faithfully,

ANNEXURE -9

MUNICIPAL CORPORATION OF GREATER MUMBAI

FORM OF INTEGRITY PACT

This Agreement (hereinafter called the Integrity Pact) is entered into on ----day of the -----
-----month of 20---- between Municipal Corporation of Greater Mumbai acting
through Shri -----(Name and
Designation of the officer) (hereinafter referred to as the "M.C.G.M." which expression
shall mean and include, unless the context otherwise requires, his successors in office and
assigns) of the First Part and M/s. -----
------(Name of the company) represented by Shri -----

-----, Chief Executive Officer / Authorised signatory (Name and Designation of the officer) (hereinafter called as the "Bidder / Seller" which expression shall mean and include, unless the context otherwise requires, his successors and permitted assigns) of the Second Part.

WHEREAS THE MCGM invites bid for the -----

------(Name of the Stores / Equipment / Service, Tender No. & Date) and the

Bidder / Seller is willing to submit bid for the same and

WHEREAS the BIDDER is a private Company / Public Company /
Government Undertaking / Partnership Firm / Ownership Firm / Registered Export Agency,
constituted in accordance with the relevant law in the matter and the MCGM is Urban Local Body.

NOW, THEREFORE

To avoid all forms of corruption by following a system that is fair, transparent and free from any influence / prejudiced dealings prior to, during and subsequent to the currency of the contract to be entered into with a view to:-

Enabling the MCGM to obtain the desired said stores / equipment/ services/ works at a

competitive price in conformity with the defined specifications by avoiding the high cost and the distortionary impact of corruption on public procurement, and

Enabling BIDDERS to abstain from bribing or indulging in any corrupt practice in order to secure the contract by providing assurance to them that their competitors will also abstain from bribing and other corrupt practices and the MCGM will commit to prevent corruption, in any form, by its officials by following transparent procedures. In order to achieve these goals, the MCGM will appoint an external independent monitor who will monitor the tender process and execution of the contract for compliance with the principles mentioned above.

The parties hereto hereby agree to enter into this Integrity Pact and agree as follows:-

1. COMMITMENTS OF THE M.C.G.M.

- 1.1 M.C.G.M. commits itself to take all measures necessary to prevent corruption and follow the system, that is fair, transparent and free from any influence / prejudice prior to , during and subsequent to the currency of the contract to be entered into to obtain stores / equipments / services at a competitive prices in conformity with the defined specifications by avoiding the high cost and the distortionary impact of corruption on public procurement.
- 1.2 The MCGM undertakes that no employee of the MCGM, connected directly or indirectly with the contract, will demand, take a promise for or accept, directly or through intermediaries, any bribe, consideration, gift, reward, favour or any material or immaterial benefit or any other advantage from the BIDDER, either for themselves or for any person, organization or third party related to the contract in exchange for an advantage in the bidding process, bid evaluation, contracting or implementation process related to the contract.
- 1.3 M.C.G.M. will during tender process treat all bidders with equity and reason.
The M.C.G.M. before and during tender process provide to all bidders the same information and will not provide to any bidder any confidential / additional information through which the bidder could obtain an advantage in relation to the tender process or execution of contract.
- 1.4 In case any such preceding misconduct on the part of such official(s) is reported by the Bidder to the MCGM with full and verifiable facts and the same is prima facie found to be correct by the Municipal Corporation of Greater Mumbai, necessary disciplinary proceedings, or any other action as deemed fit, including criminal proceedings may be initiated by the MCGM and such a person shall be debarred from further dealings related to the contract process. In such a case while an enquiry is being conducted by the MCGM the proceedings under the contract would not be stalled.

2. COMMITMENTS OF THE BIDDERS / CONTRACTORS

- 2.1 The Bidder commits itself to take all measures necessary to prevent corrupt practices, unfair means and illegal activities during any stage of its bid or during any pre-contract or post-contract stage in order to secure the contract or in furtherance to secure it.
- 2.2 The Bidders will not offer, directly or through intermediaries, any bribe, gift, consideration, reward, favour, any material or immaterial benefit or other advantage, commission, fees, brokerage or inducement to any official of the MCGM, connected directly or indirectly with the bidding process or to any MCGM person, organization or third party related to the contract in exchange for any advantage in the bidding, evaluation, contracting and implementation of the contract.
- 2.3 The BIDDER further undertakes that it has not given, offered or promised to give, directly or indirectly any bribe, gift, consideration, reward, favour, any material or immaterial benefit or other advantage, commission, fees, brokerage or inducement to any official of the MCGM or otherwise in procuring the contract or forbearing to do or having done any act in relation to the obtaining or execution of the contract or any other contract with MCGM for showing or forbearing to show favour or disfavour to any person in relation to the contract or any other contract with MCGM.
- 2.4 The Bidders / Contractors will not enter with other Bidders into any undisclosed agreement or understanding, whether formal or informal, in particular regarding prices, specifications, certifications, subsidiary contracts, submission or non submission of bids or any other actions to restrict competitiveness or to introduce cartelization in the bidding process.
- 2.5 The Bidders/ Contractors will not commit any offence under relevant Anti- corruption Laws of India. Further, the Bidders will not use improperly, for purposes of competition or personal gain or pass on to others, any information or document provided by M.C.G.M. as part of the business relationship regarding plans, technical proposals and business details including information obtained or transmitted electronically.
- 2.6 The Bidders / Contractors of foreign origin shall disclose the names and addresses of agents / representatives in India, if any, and Indian Bidders shall disclose their foreign principals or associates.
- 2.7 The Bidder shall not lend to or borrow any money from or enter into any monetary dealings or transactions, directly or indirectly, with any employee of the M.C.G.M.
- 2.8 The Bidder will not bring any Political, Governmental or Diplomatic influence to gain undue advantage in its dealing with M.C.G.M.

- 2.9 The Bidder will promptly inform the Independent External Monitor (of M.C.G.M.) if he receives demand for a bribe or illegal payment / benefit and If the comes to know of any unethical or illegal practice in M.C.G.M.
- 2.10 The Bidders / Contractors will disclose any and all payments he has made, is committed to or intends to make to agents, brokers or any other intermediaries in connection with the award of the contract while presenting his bid.
- 2.11 The Bidders / Contractors shall not lend to or borrow any money from enter into any monetary dealings directly or indirectly, with any employee of the M.C.G.M. or his relatives.
- 2.12 The BIDDER will not collude with other parties interested in the contract to impair the transparency, fairness and progress of the bidding process, bid evaluation, contracting and implementation of the contract.
- 2.13 The Bidders / Contractors will undertake to demand from all sub contractors a commitment in conformity with this Integrity Pact.
- 2.14 The bidders / Contractors will not instigate third persons to commit offences outlined above or be an accessory to such offences.

3. PREVIOUS TRANSGRESSION

- 3.1 The Bidder declares that no previous transgressions occurred in the last 3 years immediately before signing of this Integrity Pact, with any other company in any country or with Public Sector Enterprises in India in respect of any corrupt practices envisaged hereunder that could justify BIDDER's exclusion from the tender process.
- 3.2 If the Bidder makes incorrect statement on this subject, he can be disqualified from the tender process or the contract if already awarded, can be terminated for such reasons.

4. DISQUALIFICATION FROM TENDER PROCESS AND EXCLUSION FROM FUTURE CONTRACTS

If the Bidders/ Contractors or anyone employee acting on his behalf whether or without the knowledge of the Bidder before award of the contract has committed a transgression through a violation of aforesaid provision or in any other form such as put his reliability or credibility into question, the M.C.G.M. is entitled to exclude the bidder from the tender process or to terminate the contract if already signed and take all or any one of the following actions, wherever required.

- 4.1 To immediately call off the pre-contract negotiations without assigning any reason or giving any compensation to the Bidder. Further, the proceedings with the other Bidders would continue.
- 4.2 The Earnest Money Deposit (in pre-contract stage) and/or Security Deposit / Performance Bond (after the contract is signed) shall stand forfeited either fully or partially, as decided by the M.C.G.M. and M.C.G.M. shall not be required to assign any reasons therefor.
- 4.3 To immediately cancel the contract, if already signed, without giving any compensation to the Bidder.
- 4.4 To recover all sums already paid with interest thereon at 5% higher than the prevailing Base rate of State Bank of India.
- 4.5 If any outstanding payment is due to the Bidder from M.C.G.M. in connection with any other contract, such outstanding payment could also be utilized to recover the aforesaid sum and interest.
- 4.6 To encash any advance Bank Guarantee and performance bond/warranty, if furnished by the Bidder, in order to recover the payment already made by M.C.G.M. along with interest.
- 4.7 To cancel all other contracts with the Bidder. The Bidder shall be liable to pay compensation for any loss or damages to the M.C.G.M. resulting from such cancellation / rescission and the M.C.G.M. shall be entitled to deduct the amount so payable from the money due to the Bidder.
- 4.8 Forfeiture of Performance Bond in case of a decision by the M.C.G.M. to forfeit the same without assigning any reason for imposing sanction for violation of the Pact.
- 4.9 The decision of M.C.G.M. to the effect that the breach of the provisions of this Pact has been committed by the Bidder shall be final and conclusive on the Bidder.
- 4.10 The Bidder accepts and undertakes to respect and uphold the absolute right of M.C.G.M. to resort to and impose such exclusion and further accepts and undertakes not to challenge or question such exclusion on any ground including the lack of any hearing before the decision to resort to such exclusion is taken.
- 4.11 To debar the Bidders/ Contractors from participating in future bidding process of M.C.G.M. for a minimum period of three years.

4.12 Any other action as decided by Municipal Commissioner based on the recommendation by Independent External Monitors (IEMs).

5. FALL CLAUSE

5.1 The Bidder undertakes that it has not supplied similar products / systems or subsystems in the past six months in the Maharashtra State for quantity variation upto -50% or +10%, at a price lower than that offered in the present bid in respect of any other Ministry / Department of the government of India or PSU or MCGM and if it is found at any stage that similar products / systems or sub systems was supplied by the BIDDER to any other Ministry / Department of the Government of India or a PSU or MCGM at a lower price, then that very price will be applicable to the present case and the difference in the cost would be refunded by the BIDDER to the MCGM, if the contract has already been concluded, else it will be recovered from any outstanding payment due to the bidder from MCGM.

6. EXTERNAL INDEPENDENT MONITOR / MONITORS

- 6.1 The M.C.G.M. appoints competent and credible external independent Monitor for this Pact. The task of the Monitor is to review independently and objectively, whether and to what extent the Parties comply with the obligations under this Agreement.
- 6.2 The Monitor is not subject to instructions by the representatives of parties and perform his functions neutrally and independently and report to the Municipal Commissioner / concerned Additional Municipal Commissioner.
- 6.3 Both the parties accept that the IEM has the right to access without restriction, to all documentation relating to the project / procurement, including minutes of meetings.
- 6.4 The Bidder shall grant the IEM upon his request and demonstration of a valid interest, unrestricted and unconditional access to his project documentation. The same is applicable to sub contractors.

- 6.5 The IEM is under contractual obligation to treat, the information and documents of the Bidder / Contractor/ sub-contractor, with confidentiality.
- 6.6 The MCGM will provide to the IEM sufficient information about all meetings among the parties related to the Project provided such meetings could have an impact on the contractual relations between the parties. The parties will offer to the IEM the option to participate in such meetings.
- 6.7 As soon as the IEM notices, or believes to notice, a violation of this Agreement, he will so inform the Additional Municipal Commissioner. The IEM can in this regard submit non-binding recommendations. If Additional Municipal Commissioner has not, within a reasonable time, taken visible action to proceed against such offence, the IEM may inform directly to the Municipal Commissioner.
- 6.8 The IEM will submit a written report to the Municipal Commissioner / Additional Municipal Commissioner within 8 to 10 weeks from the date of service of intimation to him by M.C.G.M./ Bidder and should the occasion arise, submit proposals for correcting problematic situations.
- 6.9 The word "IEM" would include both singular and plural.
- 6.10 Both the parties accept, that the recommendation of IEM would be in the nature of advice and would not be legally binding. The decision of Municipal Commissioner in any matter / complain will be the final decision.

7. VALIDITY OF THE PACT

- 7.1 The validity of this Integrity Pact shall be from the date of its signing and extend upto two years or the complete execution of the contract to the satisfaction of both the M.C.G.M. and BIDDER / Seller, including warranty period, whichever is later. In case BIDDER is unsuccessful, this Integrity Pact shall expire after six months from the date of the signing of the contract.
- 7.2 If any claim is made/ lodged during the validity of this contract, such claim shall be binding and continue to be valid despite the lapse of this pact

unless it is discharged / determined by the Municipal Commissioner / Additional Municipal Commissioner of the M.C.G.M.

8. FACILITATION OF INVESTIGATION

In case of any allegation of violation of any provisions of this Pact or payment of commission, the MCGM or its agencies OR Independent External Monitor shall be entitled to examine all the documents including the Books of Accounts of the BIDDER and the BIDDER shall provide necessary information and documents in English and shall extend all possible help for the purpose of such examination

9. MISCELLANEOUS

9.1 This Agreement / Pact is subject to the Indian Laws, place of performance and jurisdiction is the registered office of the M.C.G.M. i.e. Mumbai and the actions stipulated in this Integrity Pact are without prejudice to any other legal action that may follow in accordance with the provisions of the extant law in force relating to any civil or criminal proceedings.

9.2 If the Contractor is a partnership or a consortium, this Agreement

9.3 Should one or several provisions of this Agreement turn out to be invalid, the remainder of this Pact remains valid. In this case, the Parties will strive to come to an Agreement to their original intentions.

10. The Parties hereby sign this Integrity Pact at -----on-----

MCGM

BIDDER/SELLER

Signature

Name of officer	-----	-----
Designation	-----	-----
Name of Company	-----	-----
Address	-----	-----
	-----	-----
Dated	-----	-----

WITNESS-1(MCGM)

Witness-1(BIDDER/SELLER)

Signature	-----	-----
Name of officer	-----	-----
Designation	-----	-----
Name of Company	-----	-----
Address	-----	-----
	-----	-----
Dated	-----	-----

ANNEXURE -10

MUNICIPAL CORPORATION OF GREATER MUMBAI

GRIEVANCE REDRESSAL MECHANISM

Procuring Entity, M.C.G.M. has formed a Grievance Redressal Mechanism for redressal of grievances. Any Bidder or prospective Bidder aggrieved that any decision, action or omission of the procuring entity being contrary to the provisions of the tender or any rules or guidelines issued therein, may within a period of 10 days or any such other period, as may be specified in the pre-qualification document, bidder registration document or bidding documents make an application for review of such decision or action to procuring entity [Director (M.E.&M.H.) for medical tenders, Director (E.S.&P.) and/or concerned D.M.C. for Engineering Department, concerned D.M.C. for the other tenders]. While making such an application for review, aggrieved bidders or prospective bidders shall clearly specify the ground or grounds in respect of which he feels aggrieved. Provided that after declaration of a bidder as a successful in Packet 'A' (General Requirements), an application for review may be filed only by a bidder who has participated in procurement proceedings and after declaration of successful bidder in Packet 'B' (Technical Bid), an application for review may be filed only by successful bidders of Packet 'A'. Provided further that, an application for review of the financial bid can be submitted, by the bidder whose technical bid is found to be acceptable / responsive.

Upon receipt of such application for review, M.C.G.M. may decide whether the bid process is required to be suspended pending disposal of such review.

The M.C.G.M. after examining the application and the documents available to him, give such reliefs, as may be considered appropriate and communicate its decision to the Applicant and if required to other bidders or prospective bidders, as the case may be.

M.C.G.M. shall deal and dispose off such application as expeditiously as

possible and in any case within 30 days from the date of receipt of such application or such other period as may be specified in pre-qualification document, bidder registration document or bid documents, as the case may be.

Where M.C.G.M. fails to dispose off the application within the specified period or if the bidder or prospective bidder feels aggrieved by the decision of the procuring entity, such bidder or prospective bidder may file an application for redressal before the 'Procurement Redressal Committee' within 15 days of the expiry of the allowed time or of the date of receipt of the decision, as the case may be. Every such application for redressal before Redressal Committee shall be accompanied by fee of Rs.25,000/- fee shall be paid in the form of D.D. in favour of M.C.G.M.

Procurement Redressal Committee will consists of not less than three members including its Chairman who shall be the retired Judge of High Court and two members of the Committee will be from the field of Public Procurement and experience at senior level in Public Administration or Public Finance or Management or Engineering or Specific Project or Management of Public Sector Enterprises.

On receipt of the application, the Committee shall after giving opportunity of hearing to the procuring entity, M.C.G.M. as well as the Applicant, determine the issue taking into consideration the rules and guidelines as well as tender conditions, terms of the pre-qualification, bidder registration or bidding document, as the case may be and communicate its

Recommendations including corrective measures to be taken to M.C.G.M. and to the Applicant, if necessary, the Committee may held more sittings to dispose the application.

No application shall be maintainable before the Procuring Committee in regard of any decision of the M.C.G.M. relating to following issues:

- a) Determination of need of procurement
- b) The decision of whether or not to enter into negotiations.
- c) Cancellation of a procurement process for certain reasons.

The Procurement Redressal Committee may recommend to the procuring entity the suspension of the procurement process pending disposal of the application, if in its opinion, failure to do so, is likely to lead miscarriage of justice.

On receipt of recommendation of the Committee, Municipal Commissioner will communicate his decision thereon to the Applicant and to the Committee within 15 days or such further time not exceeding 30 days, as may be considered necessary from the date of receipt of the recommendation and in case of non-acceptance of any recommendation, the reason of such non-acceptance shall also be mentioned in such communication.

Municipal Commissioner and/or Procurement Redressal Committee, if found, come to the conclusion that any such complaint or review is of vexatious, frivolous or malicious nature and submitted with the intention of delaying or defeating any procurement or causing loss to the procuring entity or any other bidder, then such complainant shall be punished with fine, which may extend to Five Lac rupees or two percent of the value of the procurement, whichever is higher.

Annexure-11
Mandatory fulfillment and Technical Evaluation of Technical Bid

(I) Mandatory fulfillment

1 - Plant layout/ Area utilization plan covering:

- (a) Covered shed
- (b) Plant and Machineries
- (c) Working space
- (d) Storage/Temporary storage
- (e) Office, canteen
- (f) Laboratory
- (g) Vehicle washing arrangement/wheel washing system
- (h) Parking arrangement
- (i) Storage facility for processed waste, fuel etc.
- (j) Internal /Access road.

Apart from above, it is expected that the bidder will also include facilities such as fencing arrangement for working and excavation area, rest room, drainage arrangement/Temporary surface drainage, street lighting, overall site security etc.

2 – Weight / Volume measurement.

- Weighment System with CCTV

3 - Final offsite disposal from Mulund Dumping Ground :

Disposal manifest system plan with details indicating site wise information. This will be judged on the basis of letter of authorization/permission/undertaking from the owner of the site/agencies meeting the norms of state/central relevant rules.

- (i) No. of site
- (ii) Site location
- (iii) Distance in km
- (iv) Quantity disposed off.
- (v) Transport arrangement
- (vi) Permission/authorization for disposal site.

Mandatory fulfillment is the part of technical evaluation .The information provided therein will be evaluated for its adequacy.

(II) Technical Evaluation

The technical proposal as submitted shall be presented before the committee. This committee will carry out evaluation of the bids received. The bidder has to score minimum 60% marks to qualify in the technical evaluation.

Technical Evaluation			
<p>Only those plans can be submitted in technical proposal which have been followed or implemented necessarily in any of the projects submitted by the bidders to prove his past experience. Any improvements in the existing plans is allowed to be submitted provided they can be scientifically substantiated. It is expected that the bidder will do the due diligence while submitting the following data. If any or more parameters are not required, marks will be proportionately adjusted.</p> <p>Maximum marks would be given to the bidder whose submission is comparatively best and other bidders would be given marks proportionately</p>			
Section	Description of Parameter	Sub-Section	Maximum marks 100
1	(A) Capabilities and Experience		Max 35
	Bidder's work experience as per Category-I of Technical Criteria	Max 30	
	(a) From 1,20,000 tons to less than 1,80,000 tons	18	
	(b) From 1,80,000 tons to less than 2,40,000 tons	21	
	(c) From 2,40,000 tons to less than 3,00,000 tons	24	
	(d) From 3,00,000 tons to less than 3,60,000 tons	27	
	(e) 3,60,000 tons & above	30	
	OR		
	Bidder's work experience as per Category-II of Technical Criteria	Max 30	
	(a) From 1,20,000 tons to less than 1,80,000 tons	18	
	(b) From 1,80,000 tons to less than 2,40,000 tons	21	
	(c) From 2,40,000 tons to less than 3,00,000 tons	24	
	(d) From 3,00,000 tons to less than 3,60,000 tons	27	
	(e) 3,60,000 tons & above	30	
	(B) Team Leader:	5	
	Team leader will be evaluated based on his educational qualification and experience in SWM sector.		

2	Process Design		Max 15
	2A Preliminary studies & reports :	5	
	Pre-assessment of waste characteristics (Physico-chemical characteristics and geological investigation) Submission of detailed report of waste sampling & characteristics with number of samples taken, GPS location with date. Reports should be certified by NABL (National Accreditation Board for Testing and Calibration Laboratories)/recognised by MoEF. The parameters should include - Percentage of recyclables (such as metals, plastics etc.), percentage of inert, calorific value, C/N ratio and any additional critical parameter.		
	2B Landfill gas management , Odour management and Leachate treatment plan	6	
	2C Overall process design and implementation plan		
	(a) Adequacy of Input mass balance with process flow chart (volume, weight & energy basis): This may include Biodegradable material, Soil, Non-Biodegradable material (recyclable material), Inert, Hazardous waste etc.	2	
	(b) Adequacy of Process output with mass balance (weight, volume & energy basis) and quality standard to be disposed off (Copy of output quality standards with respect to applicable Rules/regulations/Standards to be attached) This may include LFG, RDF, Compost, Soil, Recyclables, Inert, Hazardous waste etc.	2	
3	Overall Plant Design and Requirement (All the plant design, equipments submitted in technical proposal should be reflected in the financial proposal. If any discrepancy is observed in financial proposal with rate analysis and is not justified satisfactorily by the bidder, the bid shall be rejected)		Max 25
	3A Plant Design and Requirement:		
	Adequacy of Pretreatment based on the processing method adopted (such as quantity of Chemical/Culture or any other material/process required, quantity of Water required, Number of days required for preprocessing etc.)	1	
	Adequacy of Excavation (Tonnes/day) based on number and capacity of excavator/front end loader, total capacity of excavation/day etc.	1	

	Adequacy of Dumpers based on number and type of vehicle or other transport means with capacity, total capacity etc.	1	
	Adequacy of Conveyor /Trommel/Screen Capacity (Tons per hour) based on the number and capacity, total capacity etc.	1	
	Adequacy of waste sorting scheme (based on trommels no. and capacity (Tons/Hour),magnetic separator, stone removal ,manual separation, flying object arresting system etc.	1	
	Adequacy of Overall operation and maintenance plan based on Breakdown maintenance plan, Preventive maintenance plan etc	1	
	Adequacy of Standby arrangement	1	
	3B Modular process design and implementation plan (Please submit calculation capacity wise for Line Balancing)		
	If the proposed plant design modular progressively and the total capacity of the modules sufficient to clear the required waste from the site within prescribed time period per year. The proposed plant should include all the relevant information to assess the modularity of the plant. (Provide evidence of similar modules working elsewhere)	5	
	OR If the proposed plant design is not modular but total capacity of the plant is sufficient to clear the required waste from the site within prescribed time period per year.	3	
	3C Final offsite disposal from Mulund Dumping Ground with a detailed transport arrangement:		
	Disposal manifest system plan with details indicating site wise information. This will be judged on the basis of letter of authorization/ permission/ undertaking from the owner of the site. detailed transport arrangement shall include no. of trucks, capacity and other details.	5	
	If MoU is submitted along with Final offsite disposal plan	4	
	OR If MCGM's Land at village Karvale is to be used	2	
	3D Implementation plan (Detailed work plan/ Bar chart(Timeline weekly/ monthly/ yearly to achieve target)	4	
4	Environmental Mitigation and Monitoring Plan with respect to prescribed standards/manuals/rules		Max 5
	Online environment monitoring and mitigation system plan which includes,		

	(i) Air monitoring and mitigation plan (ii) Noise monitoring and mitigation plan	1 1	
	Fire control system	1	
	Health and Safety Management	1	
	Surface and Ground water monitoring	1	
5	Power Point Presentation of all the above parameters of the Technical Evaluation Sheet before technical committee		Max. 20

Annexure -12

**Work Experience Certificate from the Statutory Auditor/Client regarding work
experience criteria/technical capacity**

Based on its books of accounts and other published information authenticated by it, this is to certify that ----- (name of the Applicant/Member) is sole contractor/Lead partner/JV partner for (title of the project).

The project is commissioned on (date of commissioning of the project).

We further certify that MSW scientifically processed/reclaimed during the period from _____ to _____ is _____ tonnes or cubic meter and the technology adopted is _____ for the _____ (title of the project).

Name of the audit firm/Client: (Signature, name and designation of the Authorised Signatory) Seal of the audit firm/ Client:

Date:

Attach Explanatory Notes to the Certificate, if necessary, statutory auditor means the entity that audits and certifies the annual accounts of the company.

In case the project is owned by the Applicant company or in case of client certificate, this language may be suitably modified.

Annexure -13

PARENT COMPANY GUARANTEE

Name of Contract/Contract No.:

Name and address of Employer: _____ (together with successors and assigns).

We have been informed that _____ (*name of Contractor*) (hereinafter called the "Contractor") is submitting an offer for such Contract in response to your invitation, and that the conditions of your invitation require his offer to be supported by a parent company guarantee.

In consideration of you, the Employer, awarding the Contract to the Contractor, we (*name of parent company*) irrevocably and unconditionally guarantee to you, as a primary obligation, the due performance of all the Contractor's obligations and liabilities under the Contract, including the Contractor's compliance with all its terms and conditions according to their true intent and meaning.

If the Contractor fails to so perform his obligations and liabilities and comply with the Contract, we will indemnify the Employer against and from all damages, losses and expenses (including legal fees and expenses) which arise from any such failure for which the Contractor is liable to the Employer under the Contract.

This guarantee shall come into full force and effect when the Contract comes into full force and effect. If the Contract does not come into full force and effect within a year of the date of this guarantee, or if you demonstrate that you do not intend to enter into the Contract with the Contractor, this guarantee shall be void and ineffective. This guarantee shall continue in full force and effect until all the Contractor's obligations and liabilities under the Contract have been discharged, when this guarantee shall expire and shall be returned to us, and our liability hereunder shall be discharged absolutely.

This guarantee shall apply and be supplemental to the Contract as amended or varied by the Employer and the Contractor from time to time. We hereby authorise them to agree any such amendment or variation, the due performance of which and compliance with which by the Contractor are likewise guaranteed hereunder. Our obligations and liabilities under this guarantee shall not be discharged by any allowance of time or other indulgence whatsoever by the Employer to the Contractor, or by any variation or suspension of the works to be executed under the Contract, or by any amendments to the Contract or to the constitution of the Contractor or the Employer, or by any other matters, whether with or without our knowledge or consent.

This guarantee shall be governed by the law of the same country (or other jurisdiction) as that which governs the Contract and any dispute under this guarantee shall be finally settled as per the Arbitration clause under the Contract in accordance with Indian Arbitration and Conciliation

Act, 1996. We confirm that the benefit of this guarantee may be assigned subject only to the provisions for assignment of the Contract.

Signed by: _____ (signature)
(signature)

_____ (name)

(position in parent company)

Signed by: _____

_____ (name)

(position in parent company)

Annexure-14

Self-Certification by the Tenderer stating that the technology proposed to be used for the subject project has been operational for a period of three years anywhere in the world

(Bidders have to provide documentary evidence for the same)

Annexure-15

Taxes and Duties

With reference to the rate quoted in BOQ for the tender, applicable taxes/duties are as mentioned below:-

Sr.No.	Taxes/Duties	Percentage
1		
2		
3		
.		
.		

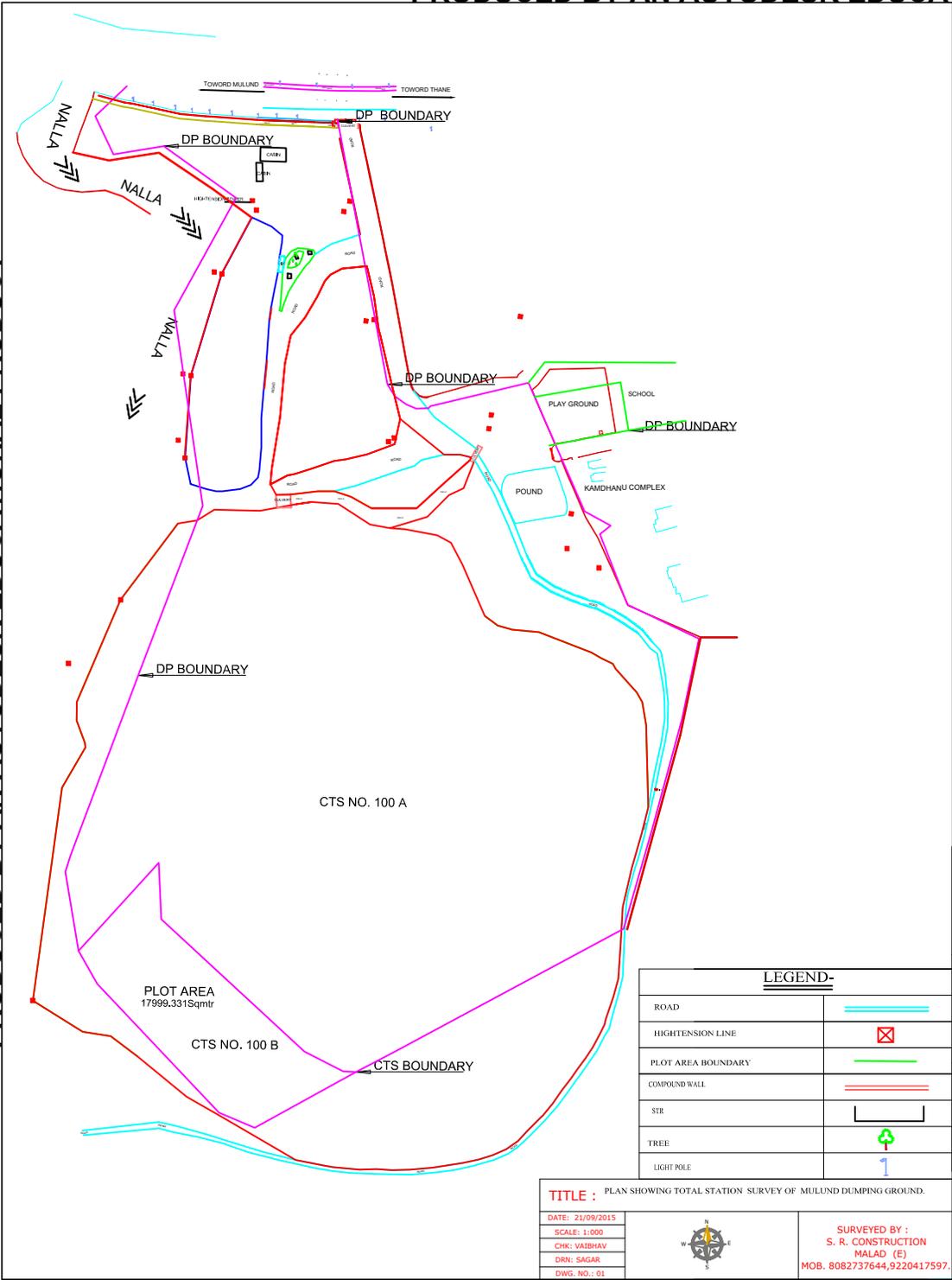
Name & Signature of the Authorized signatory of the tenderer with company seal.

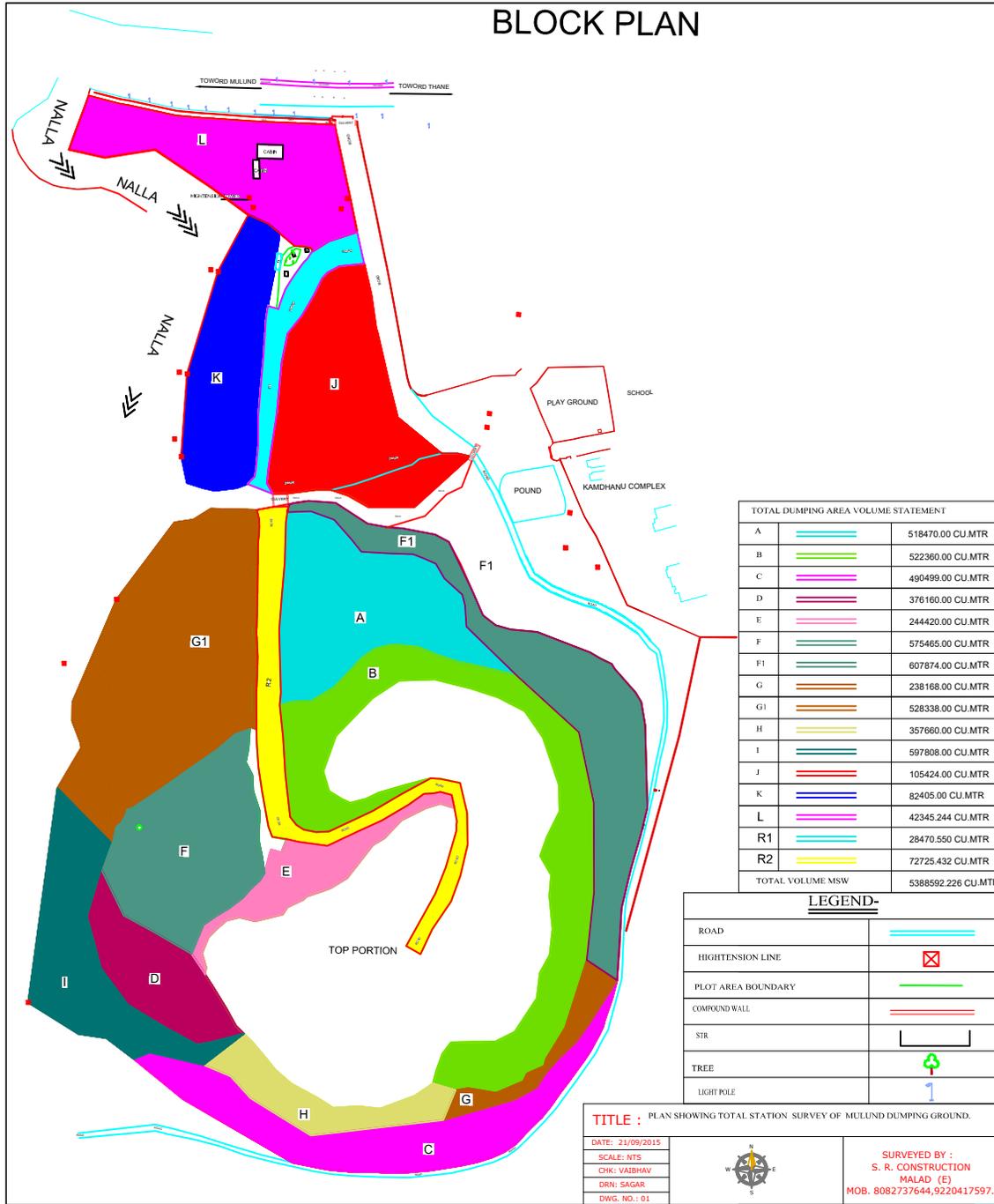
Annexure-16

DELETED

Annexure-A

DELETED





Annexure-19
Price Adjustment

Adjustment for Fuel and Lubricants

Price adjustment for increase or decrease in the cost POL (fuel and lubricants) shall be paid in accordance with the following formula.

$$V_1 = 0.85 \times P_1 / 100 \times R (F_1 - F_0) / F_0$$

V_1 = increase or decrease in the cost of work during the month under consideration due to changes in the rates for fuel and lubricants.

F_0 = the official retail price of non-branded Diesel at the existing consumer pumps **of IOC at Mumbai**, on the due date of submission of Bids.

F_1 = the official retail price of non-branded Diesel at the existing consumer pumps of **IOC at Mumbai**, on the last date of the quarter previous to the one under consideration to which a particular interim payment certificate is related.

P_1 = Percentage of fuel and lubricants component of the work shall be 10%.

R = Total value of work done during the month.

Adjustment for Fuel (CNG)

Price adjustment for increase or decrease in the cost CNG shall be paid in accordance with the following formula.

$$V_1 = 0.85 \times P_0 / 100 \times R \times (C_1 - C_0) / C_0$$

V_1 = increase or decrease in the cost of work during the month under consideration due to changes in the rates for CNG.

C_0 = the official retail price of CNG at the existing consumer pumps of **MGL at Mumbai**, on the due date of submission of Bids.

C_1 = the official retail price of CNG at the existing consumer pumps of **MGL at Mumbai**, on the last date of the quarter previous to the one under consideration to which a particular interim payment certificate is related.

P_0 = Percentage of CNG component of the work shall be 5%.

R = Total value of work done during the month.

Adjustment for Labor Component

Price adjustment for increase or decrease in the cost due to labour shall be paid in accordance with the following formula.

$$V_1 = 0.85 \times P_L / 100 \times R \times (L_1 - L_0) / L_0$$

V_1 = increase or decrease in the cost of work during the month under Consideration.

L_0 = the labour wages for unskilled workers notified by Govt. of Maharashtra for Mumbai on the due date of submission of bids.

L_1 = the labour wages for unskilled workers notified by Govt. of Maharashtra for Mumbai under consideration on the 1st day of the month.

PL = Percentage of Labour component of the work shall be 35%.

R = Total value of work done during the month.

Adjustment for Machinery & Machine Tools Component

Price adjustment for increase or decrease in the cost of machinery and machine tools procured by the Contractor shall be paid in accordance with the following formula.

$$V_p = 0.85 \times P_p / 100 \times R \times (P_i - P_o) / P_o$$

V_p = increase or decrease in the cost of work during the month under consideration due to changes in the rates of machinery and machine tools.

P_o = the all India average wholesale price index for machinery and machine tools on the due date of submission of bids as published by Economic Adviser, Govt. of India, Ministry of Commerce and Industry, New Delhi.

P_i = the all India average wholesale price index for machinery and machine tools on the last date of the quarter previous to the one under consideration to which a particular interim payment certificate is related, as published by Economic Adviser, Govt. of India, Ministry of Commerce and Industry, New Delhi.

P_p = Percentage of plants and machinery spares component of the work shall be 25%

R = Total value of work done during the month.

Adjustment for Other local materials

Price adjustment for increase or decrease in the cost of local materials other than machinery and machine tools, POL and CNG procured by the Contractor shall be paid in accordance with the following formula

$$V_m = 0.85 \times P_m / 100 \times R \times (M_i - M_o) / M_o$$

V_m = increase or decrease in the cost of work during the month under consideration due to changes in the rates for local material other than machinery and machine tools, POL and CNG.

M_o = the all India average wholesale price index (all commodities) on the due date of submission of Bids, as published by Economic Adviser, Govt. of India, Ministry of Commerce and Industry, New Delhi.

M_i = the all India average wholesale price index (all commodities) on the the last date of the quarter previous to the one under consideration to which a particular interim payment certificate is related, as published by Economic Adviser, Govt. of India, Ministry of Commerce and Industry, New Delhi.

P_m = Percentage of local material component (other than machinery and machine tools, POL and CNG) of the work shall be 25%

R = Total value of work done during the month.

NOTE :

- (i) Price adjustment shall be applicable on all the monthly bills passed by the Engineer-in-Charge for payment from the second year of COD of the project.
- ii) The base price shall be considered as on the due date of submission of bids.
- (iii) Various cost components mentioned above are pre decided and shall not be amended during entire contract period and no claim shall be entertained from the concessionaire in this regard.
- (iv) The adjustment may be positive or negative depending upon the rise or fall of index / prices / wages.

Annexure-20
Irrevocable Undertaking

(On Rs.500/- Stamp Paper)

I Shri/Smt. aged, years Indian Inhabitant. Proprietor/Partner/Director of M/s. resident at do hereby give Irrevocable undertaking as under;

- 1) I say & undertake that as specified in section 171 of CGST Act, 2017, any reduction in rate of tax on supply of goods or services or the benefit of input tax credit shall be mandatorily passed on to MCGM by way of commensurate reduction in prices.
- 2) I further say and undertake that I understand that in case the same is not passed on and is discovered at any later stage, MCGM shall be at liberty to initiate legal action against me for its recovery including, but not limited to, an appeal to the Screening Committee of the GST Counsel.
- 3) I say that above said irrevocable undertaking is binding upon me/my partners/company/other Directors of the company and also upon my/our legal heirs, assignee, Executor, administrator etc.
- 4) If I fail to compliance with the provisions of the GST Act, I shall be liable for penalty/punishment or both as per the provision of GST Act.

Whatever has been stated here in above is true & correct to my/our own knowledge & belief.

Solemnly affirmed at

DEPONANT

This day of

BEFORE ME

Interpreted Explained and Identified by me.

PART- V

CONTENTS

SR.NO.		DESCRIPTION
1.	Pro-forma 'A'	Information regarding status of Bidders
2.	Pro-forma 'B'	List of similar works
3.	Pro-forma 'C'	Details of the proposed equipments, plant and machinery
4.	Pro-forma 'D'	Details of proposed employees
5	Pro-forma 'E'	Undertaking
6.	Pro-forma 'F'	Deviations
7.	Pro-forma 'G'	Power of Attorney for signing of Application
8	Pro-forma 'H'	Power of Attorney for Lead Member of Joint Venture
9	Pro-forma 'I'	Joint Bidding Agreement
10	Pro-forma 'J'	Format of Comfort Letter to Lenders/Bankers/Financial Institutions
11	Pro-forma 'K'	Declaration cum Indemnity Bond
12	Pro-forma 'L'	Form of undertaking to provide collateral warranties

PRESCRIBED PROFORMA

PRO-FORMA 'A'

Information regarding status of Bidders

1	Bidder's Name	
2	Bidder's Address and contact nos.	
3	Status of Bidder (Proprietor concern/ Partnership concern / Pvt. Ltd. Co./ Public Ltd. Co etc..)	
4	Year of Incorporation	
5	Number of similar works carried out	
6	Has the bidder or his partner or shareholder been blacklisted in the past by MCGM	
7	Vendor No.	
8	Details of Equipments / staff	
9	Bankers of the bidder, Branch & A/c. No.	
10	Present business	
11	List of current jobs of comparable nature in hand	
12	List of works executed during last 7 Year	Year Cost (Rs.)
13	Evidence of financial capacity to execute a contract of this magnitude	
14	E-mail ID of the bidder	

Trading under the name & style of

(Signature & Stamp)

PRO-FORMA 'B'

LIST OF THE SIMILIER WORKS IN THE PAST 3 YEARS

Sr. No.	Work	Capacity in MT	AMOUNT (IN RS)	Organisation for which work is carried out with work Experiene certificate
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Signature of the bidder

PRO-FORMA 'C'

DETAILS OF THE PROPOSED EQUIPMENTS, PLANTS AND MACHINERY

Sr. No.	Name of the Equipments	Nos.
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Signature of the bidder

PRO-FORMA 'D'

DETAILS OF THE PROPOSED EMPLOYEES

Sr. No.	Name of the EMPLOYEE	Qualification	Designation	Length of service
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Signature of the bidder

PRO-FORMA 'E'

Undertaking

To,
The Municipal Commissioner,
Brihanmumbai Mahanagar Palika,
Mahapalika Marg,
Mumbai – 400 001.

Ref : Tender due on

Sir,

I / W e have read all the terms & c onditions, Specifications a s stipulated in the under reference Tender / Tender Notice and accept the same.

Yours faithfully,

Bidder's Signature

Address :- _____

Office Stamp :- _____

Tel. No. _____

PRO-FORMA 'F'

**DEVIATIONS OBSERVED IN THE SPECIFICATIONS, MUNICIPAL TERMS
AND CONDITIONS AND REQUIREMENTS**

Bidder shall state briefly the deviations if any.

Item / Clause	Deviation	Remarks

Signature of the Authorised
Signatory and Stamp

PRO-FORMA 'G'

Power of Attorney for signing of Application

(on Rs. 500 Stamp paper)

Know all men by these presents, We..... (name of the firm and address of the registered office) do hereby irrevocably constitute, nominate, appoint and authorise Mr/ Ms (name), son/daughter/wife of and presently residing at, who is presently employed with us / the Lead Member of our Joint Venture and holding the position of, as our true and lawful attorney (hereinafter referred to as the "Attorney") to do in our name and on our behalf, all such acts, deeds and things as are necessary or required in connection with or incidental to submission of our application for pre-qualification and submission of our bid for the work proposed by the Municipal Corporation of Greater Mumbai (the "MCGM") including but not limited to signing and submission of all applications, bids and other documents and writings, participate in Pre-bid meeting and other meetings and providing information/ responses to the MCGM, representing us in all matters before the MCGM, signing and execution of all contracts and undertakings consequent to acceptance of our bid, and generally dealing with the MCGM in all matters in connection with or relating to or arising out of our bid for the said project and/ or upon award thereof to us and/or till the entering into of the contract with the MCGM.

AND we hereby agree to ratify and confirm and do hereby ratify and confirm all acts, deeds and things lawfully done or caused to be done by our said Attorney pursuant to and in exercise of the powers conferred by this Power of Attorney and that all acts, deeds and things done by our said Attorney in exercise of the powers hereby conferred shall and shall always be deemed to have been done by us.

IN WITNESS WHEREOF WE,, THE ABOVE NAMED PRINCIPAL HAVE EXECUTED THIS POWER OF ATTORNEY ON THIS DAY OF, 20... For

(Signature)
(Name, Title and
Address)
Witnesses:

1

2

(Notarised) Accepted

.....

(Signature) (Name, Title and
Address of the Attorney)

Notes:

- The mode of execution of the Power of Attorney should be in accordance with the procedure, if any, laid down by the applicable law and the charter documents of the executant(s) and when it is so required, the same should be under common seal affixed in accordance with the required procedure.
- Wherever required, the Applicant should submit for verification the extract of the charter documents and documents such as a resolution/ power of attorney in favour of the person executing this Power of Attorney for the delegation of power hereunder on behalf of the Applicant.

For a Power of Attorney executed and issued overseas, the document will also have to be legalised by the Indian Embassy and notarised in the jurisdiction where the Power of Attorney is being issued. However, the Power of Attorney provided by Applicants from countries that have signed the Hague Legislation Convention 1961 are not required to be legalised by the Indian Embassy if it carries a conforming Apostille certificate.

PRO-FORMA 'H'
Power of Attorney for Lead Member of Joint Venture

Whereas Municipal Corporation of Greater Mumbai ("MCGM") has invited applications from interested parties for 'Dumpsite Reclamation at Mulund Dumping Ground (MDG) in Mumbai by adopting suitable technology for existing garbage dump' (the "Project").

Whereas,, a and
(collectively the "Joint Venture") being Members of the Joint Venture are interested in bidding for the Project in accordance with the terms and conditions of the tender and other connected documents in respect of the Project,

and

Whereas, as per tender conditions it is necessary for the Members of the Joint Venture to designate one of the members as the Lead Member with all necessary power and the MCGM to do for and on behalf of the Joint Venture, all acts, deeds and things as may be necessary in connection with the Joint Venture's bid for the Project and its execution.

NOW THEREFORE KNOW ALL MEN BY THESE PRESENTS

We, having our registered office at,
M/s.

..... having our registered office at, and
.....

having our registered office at, (hereinafter collectively referred to as the "Principals") do hereby irrevocably designate, nominate, constitute, appoint and authorise M/s

..... having its registered office at, being one of the Members of the Joint Venture, as the Lead Member and true and lawful attorney of the Joint Venture (hereinafter referred to as the "Attorney"). We hereby irrevocably authorise the Attorney to conduct all business for and on behalf of the Joint Venture and any one of us during the bidding process and, in the event the Joint Venture is awarded the concession/contract, during the execution of the Project and in this regard, to do on our behalf and on behalf of the Joint Venture, all or any of such acts, deeds or things as are necessary or required or incidental to the submission of its bid for the Project, including but not limited to signing and submission of all applications, bids and other documents and writings, participate in bidders and other conferences, respond to queries, submit information/ documents, sign and execute contracts and undertakings consequent to acceptance of bid of the Joint Venture and generally to represent the Joint Venture in all its dealings with the MCGM, and/ or any other Government Agency or any person, in all matters in connection with or relating to or arising out of the Joint Venture's bid for the Project and/ or upon award thereof till the contract is signed with the MCGM.

AND hereby agree to ratify and confirm and do hereby ratify and confirm all acts, deeds and things lawfully done or caused to be done by our said Attorney pursuant to and in exercise of the powers conferred by this Power of Attorney and that all acts, deeds and things done by our said Attorney in exercise of the powers hereby conferred shall and

shall always be deemed to have been done by us/ Joint Venture.

IN W ITNESS W HEREOF W E T HE P RINCIPALS A BOVE N AMED HAVE EXECUTED THIS POWER OF AT TORNEY ON THIS DAY OF20...

For (Signature) (Name & Title)

For (Signature)
..... (Name & Title)

For (Signature)
..... (Name & Title)

Witnesses:

.....
(Executants)

(To be executed by all the Members of the Joint Venture)

Notes:

- The mode of execution of the Power of Attorney should be in accordance with the procedure, if any, laid down by the applicable law and the charter documents of the executant(s) and when it is so required, the same should be under common seal affixed in accordance with the required procedure.
- Wherever required, the Applicant should submit for verification the extract of the charter documents and documents such as a resolution/ power of attorney in favour of the person executing this Power of Attorney for the delegation of power hereunder on behalf of the Applicant.
- For a Power of Attorney executed and issued overseas, the document will also have to be legalised by the Indian Embassy and not arise in the jurisdiction where the Power of Attorney is being issued. However, the Power of Attorney provided by Applicants from countries that have signed the Hague Legislation Convention 1961 are not required to be legalised by the Indian Embassy if it carries a conforming Apostille certificate.

PRO-FORMA 'I'
Joint Bidding Agreement

(To be executed on Stamp paper of appropriate value)

THIS JOINT BIDDING AGREEMENT is entered into on this the day of
..... 20...

AMONGST

1. {..... Limited, a company incorporated under the Companies Act, 2013} and having its registered office at (hereinafter referred to as the “First Part” which expression shall, unless repugnant to the context include its successors and permitted assigns)
2. {..... Limited, a company incorporated under the Companies Act, 2013} and having its registered office at (hereinafter referred to as the “Second Part” which expression shall, unless repugnant to the context include its successors and permitted assigns)
3. {..... Limited, a company incorporated under the Companies Act, 2013 and having its registered office at (hereinafter referred to as the “Third Part” which expression shall, unless repugnant to the context include its successors and permitted assigns)}

The above mentioned parties of the FIRST, SECOND and, THIRD PART are collectively referred to as the “Parties” and each is individually referred to as a “Party”

WHEREAS,

- A. _____, established under the _____, represented by its _____ and having its principal offices at _____] (hereinafter referred to as “the MCGM” which expression shall, unless repugnant to the context or meaning thereof, include its administrators, successors and assigns) has invited tender by its e-Tender No.
dated for the project.
- B. The Parties are interested in jointly bidding for the project as members of a Joint Venture and in accordance with the terms and conditions of the tender and other bid documents in respect of the project, and

- C. It is a necessary condition under the tender that the members of the Joint Venture shall enter into a Joint Bidding Agreement and furnish a copy thereof with the Application.

NOW IT IS HEREBY AGREED as follows:

1. Definitions and Interpretations

In this Agreement, the capitalized terms shall, unless the context otherwise requires, have the meaning ascribed thereto under the tender.

2. Joint Venture

The Parties do hereby irrevocably constitute a Joint Venture (the “Joint Venture”) for the purposes of jointly participating in the bidding process for the project.

The Parties hereby undertake to participate in the bidding process only through this Joint Venture and not individually and/or through any other Joint Venture constituted for this project, either directly or indirectly or through any of their Associates.

3. Covenants

The Parties hereby undertake that in the event the Joint Venture is declared the selected Bidder and awarded the Project, it shall incorporate a special purpose vehicle (the “SPV”) under the Indian Companies Act 2013 for entering into contract with the MCGM and for performing all its obligations as the Contractor in terms of the contract for the project.

4. Role of the Parties

The Parties hereby undertake to perform the roles and responsibilities as described below:

- a) Party of the First Part shall be the Lead member of the Joint Venture and shall have the power of attorney from all Parties for conducting all business for and on behalf of the Joint Venture during the Bidding Process and until the Work Order under the Contract when all the obligations of the SPV shall become effective;
- b) {Party of the Second Part shall be the second Member of the Joint Venture; and}
- c) {Party of the Third Part shall be the third Member of the Joint Venture; and}

5. Joint and Several Liability

The Parties do hereby undertake to be jointly and severally responsible for all obligations and liabilities relating to the Project and in accordance with the terms of the tender and the Contract, till such time as the project completion is achieved under and in accordance with the Contract.

6. Shareholding in the SPV

- 6.1 The Parties agree that the proportion of shareholding among the Parties in the SPV shall be as follows:

First Party:

Second Party:

{Third Party:}

- 6.2 The Parties undertake that they shall comply with all equity lock-in requirements set forth in the tender & contract.
- 6.3 The Parties undertake that the Lead Member will hold highest equity in the SPV at all time during the term of the Concession Agreement.

7. Representation of the Parties

Each Party represents to the other Parties as of the date of this Agreement that:

- a. Such Party is duly organised, validly existing and in good standing under the laws of its incorporation and has all requisite power and authority to enter into this Agreement;
- b. The execution, delivery and performance by such Party of this Agreement has been authorised by all necessary and appropriate corporate or governmental action and a copy of the extract of the charter documents and board resolution/ power of attorney in favour of the person executing this Agreement for the delegation of power and authority to execute this Agreement on behalf of the Joint Venture Member is annexed to this Agreement, and will not, to the best of its knowledge:
 - i. require any consent or approval not already obtained;
 - ii. violate any Applicable Law presently in effect and having applicability to it;
 - iii. violate the memorandum and articles of association, by-laws or other applicable organisational documents thereof;
 - iv. violate any clearance, permit, concession, grant, license or other governmental authorisation, approval, judgment, order or decree or any mortgage agreement, indenture or any other instrument to which such Party is a party or by which such Party or any of its properties or assets are bound or that is otherwise applicable to such Party; or

create or impose any liens, mortgages, pledges, claims, security interests, charges or Encumbrances or obligations to create a lien, charge, pledge, security interest, encumbrances or mortgage in or on the property of such Party, except for encumbrances that would not, individually or in the aggregate, have a material adverse effect on the

financial condition or prospects or business of such Party so as to prevent such Party from fulfilling its obligations under this Agreement;

- c. this Agreement is the legal and binding obligation of such Party, enforceable in accordance with its terms against it; and
- d. there is no litigation pending or, to the best of such Party's knowledge, threatened to which it or any of its Affiliates is a party that presently affects or which would have a material adverse effect on the financial condition or prospects or business of such Party in the fulfillment of its obligations under this Agreement.

8. Termination

This Agreement shall be effective from the date hereof and shall continue in full force and effect until the completion of the Project is achieved under and in accordance with the contract, in case the Project is awarded to the Joint Venture. However, in case the Joint Venture is not selected for award of the Project, the Agreement will stand terminated upon return of the E.M.D. by the MCGM to the Bidder.

9. Miscellaneous

This Joint Bidding Agreement shall be governed by laws of India.

The Parties acknowledge and accept that this Agreement shall not be amended by the Parties without the prior written consent of the MCGM.

IN WITNESS WHEREOF THE PARTIES ABOVE NAMED HAVE EXECUTED AND DELIVERED THIS AGREEMENT AS OF THE DATE FIRST ABOVE WRITTEN.

SIGNED, SEALED AND DELIVERED
For and on behalf of

LEAD MEMBER by:

(Signature)
(Name)
(Designation)
(Address)

SIGNED, SEALED AND DELIVERED
For and on behalf of

SECOND PART

(Signature)
(Name)
(Designation)
(Address)

SIGNED, SEALED AND DELIVERED

For and on behalf of

THIRD PART

(Signature)
(Name)
(Designation)
(Address)

In the presence of:

- 1.
- 2.

1. The mode of the execution of the Joint Bidding Agreement should be in accordance with the procedure, if any, laid down by the Applicable Law and the charter documents of the executant(s) and when it is so required, the same should be under common seal affixed in accordance with the required procedure.
2. Each Joint Bidding Agreement should attach a copy of the extract of the charter documents and documents such as resolution / power of attorney in favour of the person executing this Agreement for the delegation of power and authority to execute this Agreement on behalf of the Joint Venture Member.

For a Joint Bidding Agreement executed and issued overseas, the document shall be legalized by the Indian Embassy and notarized in the jurisdiction where the Power of Attorney has been executed.

PRO-FORMA 'J'

Format of Comfort Letter to Lenders/Bankers/Financial Institutions

To,

.....

Sub: Dumpsite Reclamation at Mulund Dumping Ground (MDG) in Mumbai by adopting suitable technology for existing garbage dump –
No objection to raise fund from bank/s, financial institution/s by mortgaging the plant and machinery, movable assets to be erected at Mulund Dumping Ground (MDG) of MCGM.

Dear Sir,

MCGM has granted permission to your company (existing contractor company) for executing the above mentioned work. The permission is limited only for the aforesaid purpose and it neither means nor has to be constructed that the land/site is transferred or leased or licensed.

We have no objection to raise funds from any Bank/s, financial institution/s in order to complete the aforesaid work by mortgaging the plant and machinery and / or movable assets as a second charge. First charge will be of MCGM to the extent of penalties leviable under the contract entered for the aforesaid work.

It is further informed that in case of any default of repayment with respect to these funds, bank/s or financial institution/s may be allowed to initiate recovery proceedings against the existing contractor company to the extent of mortgaged plant and machinery and / or the moveable assets only and MCGM has no objection to allow the authorized personnel of bank/s, financial institution/s to enter the project site in connection with recovery proceedings, subject to realisation of any amounts/ penalty payable to MCGM, which are leviable under the contract by the MCGM.

In case of default by the contractor company, MCGM may allow the bank/s or financial Institution/s to substitute the existing contractor company by another competent contractor with sanction of MCGM by executing a tripartite agreement between the said new contractor, the existing bank/s or financial Institution and MCGM for execution of the project works as per the terms and conditions of the tripartite agreement and by operating through an Escrow account.

PRO FORMA 'K'

DECLARATION CUM-INDEMNITY BOND

(On Rs. 500/- notarized Stamp Paper)

I, _____ of _____
do hereby declared and undertake as under.

1. I declared that I have submitted certificates as required to Executive Engineer (Monitoring) at the time of registration of my firm / company _____ and there is no change in the contents of the certificates that are submitted at the time of registration.
2. I declared that I _____ in capacity as Manager / Director / _____ Partners/ P _____ roprietors of _____ has not been charged with any prohibitory and / or penal action such as demotion, suspension, black listing / de-registration or any other action under the law by any Government and / or Semi Government and / or Government Undertaking.
3. I declared that, all the details given regarding machinery are true and correct.
4. I declared that, I have perused and examined the tender document including addendum, condition of contract, specification, drawings, bill of quantity etc. Forming part of tender and accordingly, I submit my offer to execute the work as per tender documents at the rates quoted by me in capacity as _____ of _____.
5. I further declared that if, I am allotted the work and I failed to carry out the allotted work in accordance with the terms and conditions and within the time prescribed and specified, MCGM is entitled to carry out the work allotted to me by any other means at my risk and cost, at any stage of the contract.
6. I also declared that I will not claim any charge / damages / compensation for non availability of site for the contract work at any time.
7. I also declared that MCGM staff will not be held responsible for any accident / untoward even at site.
8. I also declared that the information submitted in e- Packet A and B is true and correct.
9. I also declared that the decision regarding any financial implication levied by central / State Govt. will be borne by the contractor.

10. I Indemnify Municipal Commissioner and the other officers of MCGM or their agents for any Damages, Loss, or Injury, any legal suit, proceeding or legal action whatsoever that may be caused at any time by me or any of her staff of _____ company, for the work undertaken and all such damage, damages, injury or loss, legal suit, legal action, I shall be solely responsible in individual as well as official capacity and such loss, damages, injury shall be made good and / or as the case may be shall be paid immediately by me / company to the satisfaction of the MCGM.

Dated _____ day of _____, 20

Identified by me

Before me

Advocate

PRO FORMA 'L'

FORM OF UNDERTAKING TO PROVIDE COLLATERAL WARRANTIES

(To be enclosed)

Contract Name:-

In the event that the Tender Submission submitted by us is accepted by MCGM (the Employer) we, the Bidder, hereby undertake that our Technology Provider and each of our Principal Subcontractors (those engaged by the Contractor to provide specialist design or supply services for the Works including technology provider) will provide a Collateral Warranty , as required by the Contract.

The Bidder shall sign the undertaking below on behalf of the Bidder's Subcontractors and where the Technology Provider and/or Subcontractors are known at the time of the Submission Deadline then they shall also each sign the undertaking below.

Contractor:-

Name:		Date:
Signature:		
Company Name:		

Technology Provider:-

Name:		Date:
Signature:		
Company Name:		

[Subcontractors]:-

Name:		Date:
Signature:		
Company Name:		

Name:		Date:
Signature:		
Company Name:		

MUNICIPAL CORPORATION OF GREATER MUMBAI

Solid Waste Management Project Department

Ch.E./566/SWM/Project/dt.03.01.2018

Corrigendum-I

(Bid No. 7100109494)

Sub:- e- tender for “ Dumpsite Reclamation at Mulund Dumping Ground (MDG) in Mumbai by adopting suitable technology for existing garbage dump.”

With reference to e-Tender published on 23.12.2017 for the subject work, it is hereby informed that pre-bid meeting of the same is re-scheduled on 06.01.2018, 3.00 PM at Municipal Head Office, 2nd Floor, Annexe Building, Mahapalika Marg, Fort, Mumbai-400001. All future Addenda/Corrigenda (if any) will be published on MCGM’s website www.mcgm.gov.in under “Tenders ->Tenders & Quotations -> Tenders & Quotations ->Department->Solid Waste Management" and “Tenders ->Tenders & Quotations -> Major Projects ->Department->Solid Waste Management” tab.

Sd/-

E.E.(SWM)- New Project

MUNICIPAL CORPORATION OF GREATER MUMBAI

Solid Waste Management Project Department

Ch.E./607/SWM/Project/dt.17.01.2018

Corrigendum-II

(Bid No. 7100109494)

Sub:- e- tender for “ Dumpsite Reclamation at Mulund Dumping Ground (MDG) in Mumbai by adopting suitable technology for existing garbage dump.”

Ref:- Bid No. 7100109494.

With reference to e-Tender published on 23.12.2017 for the subject work, it is hereby informed that the due date for submission of e-tender is extended from 18.01.2018, 4.00 pm up to 01.02 .2018, 4.00 pm. Packets A & B will be opened on 03.02 .2018, after 4.00 pm. All future Addenda/Corrigenda will be published on MCGM’s website www.mcgm.gov.in under “Business ->Tenders & Quotations -> Tenders & Quotations ->Department->Solid Waste Management” and “Business ->Tenders & Quotations -> Major Projects ->Department->Solid Waste Management” tab.

Sd/-

E. E. (SWM –New Project)

MUNICIPAL CORPORATION OF GREATER MUMBAI

Solid Waste Management Project Department

Ch.E./ 618 /SWM/Project/dt. 24.01.2018

Corrigendum-III

(Bid No. 7100109494)

Sub:- e- tender for “ Dumpsite Reclamation at Mulund Dumping Ground (MDG) in Mumbai by adopting suitable technology for existing garbage dump.”

Ref:- Bid No. 7100109494.

With reference to e-Tender published on 23.12.2017 for the subject work and in accordance with queries received in response to the pre-bid meeting held on 06.01.2018 , this Corrigendum – III is being issued herewith. Remaining terms & conditions of the tender will remain same. Modified clauses shall be applicable to the repeated clauses or clauses of the same meaning wherever applicable in the entire tender document including technical evaluation. Due date for submission of e-tender is same i.e. 01.02 .2018, 4.00 pm. All future Addenda/Corrigenda (if any) will be published on MCGM’s website www.mcgm.gov.in under “Business ->Tenders & Quotations -> Tenders & Quotations ->Department->Solid Waste Management" and “Business ->Tenders & Quotations -> Major Projects ->Department->Solid Waste Management” tab.

Sr. No.	Existing Clause	Modified Clause
1	<p align="center">(Part-I, Chapter-4, Page No. 23)</p> <p align="center">SPECIAL INSTRUCTIONS TO TENDERERS</p> <p align="center">(Addition of Clause-11)</p>	<p align="center">SPECIAL INSTRUCTIONS TO TENDERERS</p> <p>11. a. The Bidder shall be responsible to get statutory and security clearances for their employees, nationals and company, if required as per rules, regulations, acts and their amendments from time to time as prescribed by Government of India and its statutory administrative offices.</p> <p>b. The Bidder shall be responsible for fulfillment of statutory requirements of Government of India for Foreign Direct Investments and any other business requirements.</p> <p>c. Employer at the request of the Tenderer, will provide all possible assistance in the form of supporting documents (as required under the Law), to get the above permissions without any obligation to Employer. All necessary fees and incidental expenses required to be paid for obtaining such permits shall be borne by and be the liability of the Tenderer.</p> <p>Note :- Bidder has to comply for the clauses a,b & c above before opening of Packet –C. Failure to which will be treated as non curable defect and 10 % of EMD will be forfeited.</p>

Sr. No.	Existing Clause	Modified Clause
2	<p>(Part-I, Chapter-5, Page No. 25)</p> <p>Clause 3-</p> <p>Note - ii) Non-curable Defect shall mean shortfalls in submission such as:-</p>	<p>Clause 3-</p> <p>Note - ii) Non-curable Defect shall mean:-</p>
3	<p>(Part-I, Chapter-7-C, Page No. 30)</p> <p>Clause (B-5)</p> <p>The rates quoted should be firm for the entire contract period and no change on any account shall be allowed.</p>	<p>Clause (B -5)</p> <p>The rates quoted should be firm for the entire contract period except price adjustment as per Annexure - 19.</p>
4	<p>(Part-III, Chapter-1, Page No. 64)</p> <p>Clause -2.1 (9)</p> <p>The inert waste disposal plan shall also be proposed by the bidder which will include identification of an inert waste disposal area / site to be approved by relevant competent authorities. The said land shall be in lawful possession of the bidder and agreement between contractor & the land owner shall clearly mention that land shall be used for the purpose of disposal of inerts/rejects of this project. Alternatively if bidder requires, MCGM's land maximum up to 20 Ha (200,000 Square Meter) at village Karvale near Taloja (Survey No. 26A, 26B, 29/1, 29/2, 29/3, 29/4, 29/5, 29/6, 29/7, 31, 40) will be allotted for the disposal of</p>	<p>Clause -2.1 (9)</p> <p>The inert waste disposal plan shall also be proposed by the bidder which will include identification of an inert waste disposal area / site to be approved by relevant competent authorities. The said land shall be in lawful possession of the bidder and agreement between contractor & the land owner shall clearly mention that land shall be used for the purpose of disposal of inerts/rejects of this project. Alternatively if bidder requires, MCGM's land maximum up to 20 Ha (200,000 Square Meter) or as per the availability of land at village Karvale near Taloja (Survey No. 26A, 26B, 29/1, 29/2, 29/3, 29/4, 29/5, 29/6, 29/7, 31, 40) will be allotted for the disposal of inerts/rejects of this project. The land may not be contiguous and contractor has to fill and level the land using inerts/rejects at Taloja as directed by MCGM</p>

Sr. No.	Existing Clause	Modified Clause
	<p>inerts/rejects of this project. The land may not be contiguous and contractor has to fill and level the land using inerts/rejects at Talaja as directed by MCGM.</p>	
5	<p>(Part-III, Chapter-1, Page No. 72-73)</p> <p>Clause -4 (v)</p> <p>Advance Mobilization loan of 10% of contract cost but not exceeding 25% of plant & machinery cost will be given as per usual terms & conditions of GCC of MCGM against the Bank Guarantee by modifying the clause. Portion of modified clause as follows:-</p> <p>The Corporation will make advance to the contractor for the works in two installments. The first installment shall be equal to 5% of contract cost or 12.5% of plant & machinery cost as the case may be and will be paid after submission of plant and machinery invoices copies. The payment of the first installment of advance shall be due after (i) execution of the form of agreement by the parties thereto. (ii) payment of Security Deposit by the Contractor and (iii) Submitting the Bank Guarantee by the Contractor in the form of a Bank specified in the tender for an amount equal to 7% of the contract cost or 17.5% of plant & machinery cost as the case may be (with includes 2% extra for the interest charges). The first installment of advance shall be paid to the Contractor within 28 days after fulfilling all the above requirements under sub items (i) to (iii) Payment of second instalment of the mobilization advance up to 5%</p>	<p>Clause -4 (v)</p> <p>Advance Mobilization loan up to 10% of contract cost will be given to the contractor as per usual terms & conditions of GCC of MCGM against the Bank Guarantee.</p> <p>The Corporation will make advance to the contractor for the works in two installments. The first installment shall be equal to 5% of contract cost and will be paid after submission of plant and machinery invoices copies. The payment of the first installment of advance shall be due after (i) execution of the form of agreement by the parties thereto. (ii) payment of Security Deposit by the Contractor and (iii) Submitting the Bank Guarantee by the Contractor in the form of a Bank specified in the tender for an amount equal to 7% of the contract cost (which includes 2% extra for the interest charges). The first installment of advance shall be paid to the Contractor within 28 days after fulfilling all the above requirements under sub items (i) to (iii)</p> <p>After certification by the Engineer that the preliminary works are completed satisfactorily, payment of second instalment of the mobilization advance up to 5% of contract cost will be due within a period of 28 days from erection of plant and machinery, preliminary site establishment works such as construction of access roads to site, Engineer's office, Contractor's site office, Stores, Workshop sheds, etc. to the satisfaction of the Engineer.</p> <p>After certification by the Engineer that the preliminary works are completed satisfactorily, the second installment will be released after</p>

Sr. No.	Existing Clause	Modified Clause
	<p>of contract cost or 12.5% of of plant & machinery cost as the case may be will be due within a period of 28 days from erection of plant and machinery, preliminary site establishment works such as construction of access roads to site, Engineer's office, Contractor's site office, Stores, Workshop sheds, etc. to the satisfaction of the Engineer. After certification by the Engineer that the preliminary works are completed satisfactorily, the second installment will be released after the Contractor submits the Bank Guarantee from a Bank acceptable to the Corporation for an amount equal to 7% of the contract cost or 17.5% of of plant & machinery cost as the case may be (with includes 2% extra for the interest charges). Bank Guarantee shall be submitted in the approved prescribed form. The Bank Guarantee/s for the Mobilization Advance should be valid till the full recovery advance is made. The Contractor shall use the advance payment only towards expenses for plant and machinery, preliminary site establishments works, and to meet expenses required specifically to carry out the works.</p> <p>The above advance shall bear simple interest at 12% per annum. The interest on the amounts paid as advance is chargeable from the date the amount is paid. The contractor shall produce all quotations, invoices, vouchers and accounts or receipts in connection with expenditure in respect of plant and machinery cost.</p>	<p>the Contractor submits the Bank Guarantee from a Bank acceptable to the Corporation for an amount equal to 7% of the contract cost (which includes 2% extra for the interest charges). Bank Guarantee shall be submitted in the approved prescribed form. The Bank Guarantee/s for the Mobilization Advance should be valid till the full recovery advance is made. The Contractor shall use the advance payment only towards expenses for plant and machinery, preliminary site establishments works, and to meet expenses required specifically to carry out the works.</p> <p>The above advance shall bear simple interest at 12% per annum. The interest on the amounts paid as advance is chargeable from the date the amount is paid. The contractor shall produce all quotations, invoices, vouchers and accounts or receipts in connection with expenditure in respect of plant and machinery cost.</p>

Sr. No.	Existing Clause	Modified Clause
6	<p align="center">(Part-IV, Annexure-2, Page No. 81)</p> <p align="center"><u>Declaration by the Tenderer</u></p> <p>10 I/We hereby agree to execute the additional work/ supply to the extent of 50% over and above the office estimates at the quoted rate and terms and conditions of contract, but within the contract period as and when called upon by the Municipal Commissioner, Additional Municipal Commissioner, Director or Dy. Municipal Commissioner to do so.</p>	<p align="center"><u>Declaration by the Tenderer</u></p> <p>10 I/We hereby agree to execute the additional work/ supply as per Standard General Conditions of Contract for Construction Works , SECTION-A, Chapter -10, Variations</p>
7	<p>(Part-V, PRO FORMA 'L', Page No. 148)</p> <p align="center">FORM OF UNDERTAKING TO PROVIDE COLLATERAL WARRANTIES</p> <p align="center">(To be enclosed)</p>	<p align="center">FORM OF UNDERTAKING TO PROVIDE COLLATERAL WARRANTIES</p> <p align="center">(To be enclosed on Rs. 500/- notarized stamp paper)</p>

Sd/-

Dy.Chief Engineer (SWM – New Projects)

Background Data, Reports and Information

(Note:- The data, Reports and Information provided herewith of MSW composition, Waste characterization by IIT at Mulund Dumpsite, Press Note, CSIR-CENTRAL ROAD RESEARCH INSTITUTE Report, NEERI Report etc are not part of tender document and provided only for the information of bidders for the project of dumpsite reclamation at Mulund Dumping Ground)

(Note:- The data, Reports and Information provided herewith of MSW composition, Waste characterization by IIT at Mulund Dumpsite, Press Note, CSIR-CENTRAL ROAD RESEARCH INSTITUTE Report, NEERI Report etc are not part of tender document and provided only for the information of bidders.)

Municipal Solid Waste Composition

(Average Characteristics of MSW Reaching the Three Dumping Grounds of Mumbai May 2005)

(Extract from DPR for JnNURM, Nov.2007)

		Deonar	Gorai	Mulund
Sr. No.	Particular	Avg. 7 Days (3 Shifts)	Avg. 7 Days (3 Shifts)	Avg. 7 Days (3 Shifts)
A	Weight of Sample collection for Physical Analysis (Kg.)	100	100	100
A.	<u>Physical Characteristics (% of total weight)</u>			
i.	Wet organic Material (above 1sq. inch mesh)			
	a. Kitchen waste	39.24	39.95	41.48
	b. Fruit waste	8.33	10.76	12.05
	c. Flower waste	0.14	0.00	0.00
	d. Green grass	0.62	0.00	0.00
	e. Animal Excreta	0.00	0.00	0.00
ii.	Wet organic Material (below 1 sq. inch mesh)	3.79	3.31	3.26
	Total Wet Organic Material	52.12	54.03	56.79
iii.	Dry organic material			
	a. Dry grass	9.60	9.14	3.05
	b. Dry tree remaining	0.48	2.9	4.57
	c. Cotton waste	2.57	2.33	6.81
	d. Wood Chips	0.33	0.1	0.95
	e. Wooden furniture waste	0.62	1.52	0.19
	Total Dry Organic Material	13.60	15.99	15.57
iv.	Recyclable Materials			
	a. Plastic	10.14	8.62	9.00
	b. Paper	7.52	6.09	7.38
	c. Cardboard	0.00	0.28	0.24
	d. Thermocol	0.19	0.05	0.24
	e. Glass	0.71	0.76	0.52
	f. Rubber	0.52	0.9	0.19
	g. Leather	0.67	0.71	0.81
	h. Metals	0.19	0.14	0.00
	Total Recyclable Material	19.94	17.55	18.38

		Deonar	Gorai	Mulund
Sr. No.	Particular	Avg. 7 Days (3 Shifts)	Avg. 7 Days (3 Shifts)	Avg. 7 Days (3 Shifts)
v.	Inert			
	a. Sand and Silt	12.03	9.4	7.74
	b. Stone	0.86	0.86	0.57
	c. Bricks	2.48	2.14	1.52
	Total Inert Material	15.37	12.40	9.83
	B. <u>Chemical Characteristics</u>			
	Weight of Sample collected for Chemical Analysis (Kg.)	5	5	5
	1. C/N Ratio	29.98	25.13	22.71
	2. Lower Calorific Value (K Cal/Kg.)	905.19	940.05	948.38
	3. Moisture (%)	66.66	68.44	69.45
	4. Iron (ppm)	1.60	0.34	1.10
	5. Cd (ppm)	0.18	0.18	0.19
	6. Cr (ppm)	0.07	0.07	0.08
	7. Cu (ppm)	0.39	0.33	0.44
	8. Mn (ppm)	0.35	0.38	0.32
	9. Pb (ppm)	0.46	0.39	0.48
	10. Ni (ppm)	0.07	0.06	0.06
	11. Zn (ppm)	0.09	0.06	0.06

The following observation can be made from the tabulated summary resented below :

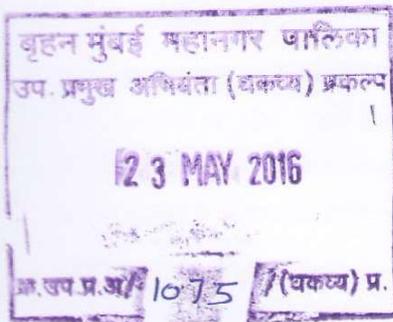
- The contents of biodegradable wastes are high (54%) followed by recyclable fractions (18.6%) mainly consisting of rubber and leather, plastics, metals, cardboard, grass etc. The recyclable content are high because the sample was collected either directly from the vehicle or as soon as the vehicle unloaded the waste at the dumping ground, i.e. prior to rag pickers had an opportunity to pick the recyclable component from the waste stream;
- The inert waste (12.5%) mainly consist of street sweeping consisting of sand, soil, earth and stone;
- The moisture content of the waste is high (68%) and is likely to be higher during the monsoon period;
- Calorific value of waste is low, around 931 kcal/kg;
Although construction and demolition waste analysis was not included in the sampling exercise conducted by IL&FS, it is essential to note that there is an increase of these components in the waste stream due to increase in the construction activities in Mumbai.

Report
on

Waste Sampling, its Characterization & Analysis at Mulund Dumpsite

Submitted to
Municipal Corporation of Greater Mumbai (MCGM)

by
Dr. Anurag Garg
Centre for Environmental Science and Engineering,
Indian Institute of Technology Bombay, Powai, Mumbai



MAY, 2016

Waste Sampling, its Characterization & Analysis at Mulund Dumpsite

1. Background and Objectives of the Study

The Mulund dumping ground has been operational since 1968 and has a total area of 24 hectares (~60 acres). It is situated in the eastern Suburbs of the City along Thane creek. The Mulund dumping ground has a daily intake of over 4000 metric tonne (MT) of municipal solid waste (MSW) from Mumbai city. As per Municipal Corporation of Greater Mumbai (MCGM) records, over 5.4 million m³ of MSW has been dumped at this site during last 48 years (Personal communication). At the landfill site, the waste is dumped upto around 10 m to 30 m depth at different locations from the main road level (Eastern Expressway). In the view of lack of suitable land and concerns for environmental pollution, the reclamation of Mulund dumpsite is being suggested. Landfill mining is considered as one of the potential options for recovery of useful waste materials and redevelopment of the land. Landfill mining is defined by Krook et al. (2012) as “a process for extracting materials or other solid natural resources from waste materials that previously have been disposed of by burying them in the ground”.

The primary purpose of this study was to get a notion about the characteristics of waste buried in Mulund dumping ground to assist in future reclamation endeavors.

2. Waste Sampling Methodology

Identification of sampling locations

To achieve the above objective, appropriate number of sampling locations was identified and the mixed waste samples were subjected to characterization. As per the guidelines issued by New Jersey Department of Environmental Protection for a landfill restoration, for a landfill of size 50 - 100 acreage, a minimum of 17 sampling points need to be identified at a frequency of 1 sampling bore hole for every 3 acres (URL 1). Since the net area of the Mulund dumping ground was approximately 62 acres, a total 24 locations were identified for characterizing the buried waste.

The locations were identified after conducting a reconnaissance survey of the dumping ground (Figure 1) and consultation with MCGM officials at the dumpsite. The purpose of this survey was to get an insight into topography of the site and demarcate the areas which are difficult to access or prone to fire. The information on approximate volume of waste dumped



in different sections of the site was obtained from the map provided by Municipal Corporation of Greater Mumbai (MCGM). The section-wise MSW volume is presented in Figure 2 and Table 1. Figure 2 was created by digitizing the original map obtained from MCGM (attached as Appendix A). However, the information about the age of waste dumped at majority of locations was unavailable. The sampling points (total no. = 24) are marked as 'x' on Figure 2.

It was informed by MCGM official at the dumpsite that MSW at the sections J and K (which are also close to the site office) was dumped in year 2014 within a span of 3 months. The depth of waste at these locations was approximately 6-7 m above the existing road within the dumpsite (R1). These two sections currently occupy approximately 4 ha land area which can be used as potential site for waste processing after clean up in near future. Hence, a total 6 sampling locations (4 vertical trenches and 2 horizontal trenches) were marked in this area to obtain as much as information on waste characterization.

From the active dumping location (shown in blue colour in Figure 2), no trenches were dug since this area mostly consists of fresh waste the characterization of which was not within the scope of current study. The waste segregation activities were also being performed in this area. Apart from this, the appropriate boreholes locations could not be identified in sections C and I. It was found during reconnaissance survey that these areas were prone to fires and not safe for sampling. Besides, waste samples buried below existing roads (R1 and R2) and those buried beneath the office building (L1) were also not collected.



Figure 1. Images of Mulund dumping ground

Anurag Garg

ANURAG GARG
Associate Professor
Centre for Environmental Science and Engineering
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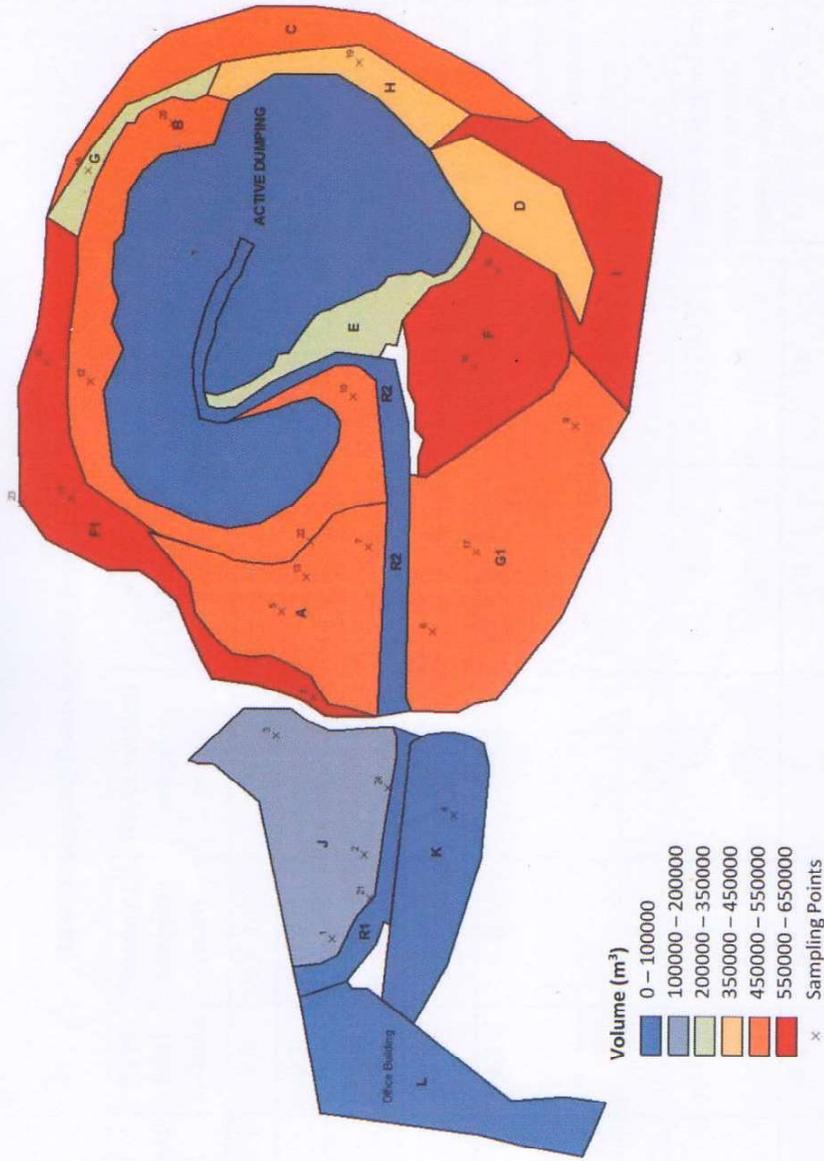


Figure 2. Net volume of waste dumped and sampling locations selected at various sections of the Mulund dumping ground (Source: original map provided by MCGM)

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Table 1. Sampling Points Selected for the Collecting Waste Samples

Region	Volume of Waste dumped (m ³)*	% of total volume	Number of sampling points	No. of vertical sampling points	No. of horizontal sampling points	Sample ID	Remarks
A	518470	9.6	3	3	0	5,7,13	-
B	522360	9.7	4	3	1	10,14,20,22**	-
C	490499	9.1	0	0	0	-	Fire prone area, hence sampling was not done due to safety issues
D	376160	7.0	0	0	0	-	Fire prone area, hence sampling was not done due to safety issues
E	244420	4.5	0	0	0	-	Active dumping site, and the majority of waste up to 4 m depth is expected to be fresh, hence samples were not collected from this location
F	575465	10.7	2	2	0	15,16	-
F1	607874	11.3	4	3	1	8,11,12,23**	Largest volume of waste stored in this region, so vertical as well as horizontal trenches were dug.
G	238168	4.4	1	1	0	18	-
G1	528338	9.8	3	3	0	6,7,9	-
H	357660	6.6	1	1	0	19	-

AS

Table 1 contd.....

I	597808	11.1	0	0	0	0	-	Fire prone area, hence sampling was not done due to safety issues
J	105424	2.0	5	3	2	1,2,3,21**, 24**	Entire waste was dumped within a span of 3 month, hence entire waste may be expected to have similar composition	
K	82405	1.5	1	1	0	4	Entire waste was dumped within a span of 3 month, hence entire waste may be expected to have similar composition	
L	42345	0.8	0	0	0	-	Sampling not done as the waste was buried below the administrative office building	
R1	28470	0.5	0	0	0	-	Sampling not done as the waste was buried below the existing roads	
R2	72725	1.3	0	0	0	-	Sampling not done as the waste was buried below the existing roads	
Total	5388591	100	24	20	4	-	Approximately 5.4 million tons of MSW is dumped at the entire site	

*From map provided by MCGM; ** Horizontal trenches

Ans

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Excavation and sampling Procedures

The waste sampling was completed during April 2016 with the assistance of MCGM. For collecting samples, an excavator was used for digging vertical and horizontal trenches at pre-decided sampling points.

It should be noted that the vertical trenches were dug to a depth of 4 m from the top after removing inert material whereas the horizontal trenches were dug from the periphery to a depth of 1 m inwards. These were the maximum penetration depths which could be reached with available excavator without disturbing the slope stability (Figure 3). The protocol used in this study was similar to that recommended by Florida Department of Environmental Protection (URL 2).

The waste quantity collected from various locations was ranged from 63 – 155 kg. Only from one location less waste quantity (i.e., 36 kg) could be withdrawn. A total of 2300 kg of mixed MSW was collected from the entire dumping ground which was further used for characterization. The collected samples were thoroughly mixed by the excavator to obtain a well mixed representative sample (Figure 3b).

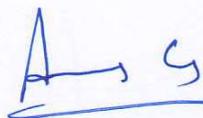
3. Analysis of Waste Samples

The well mixed waste samples were then analyzed both onsite and offsite. For offsite analysis, 5 – 6 kg of the well mixed samples were taken to Indian Institute of Technology (IIT) Bombay and analyzed for moisture content, total organic matter (TOM), high calorific value (HCV) and ash content in the laboratory. The remaining mixed waste was used to determine physical composition and particle size distribution. The respective procedures adopted for various characteristics (determined during onsite as well as offsite) are given in subsequent sub-sections.

(a) Onsite analysis

Particle Size Distribution

The waste samples were segregated into different size range: greater than 50 mm (termed as 'coarse' fraction), 50 - 20 mm ('intermediate' fraction) and less than 20 mm size ('fine' fraction) using appropriate sieves. Below 50 mm mesh size sieve, a 20 mm mesh size screen was placed, as shown in Figure 4. The waste was placed over the 50 mm sieve and spread manually using wooden objects so that the smaller fraction falls through the pores onto the



sieve with 20 mm mesh opening. The waste retained on the lower size mesh was again spread manually and the fraction passed through the screen was collected as fine fraction (less than 20 mm size). The waste fractions obtained in three different size ranges were then weighed and subjected to physical characterization.



(a)



(b)



(c)



(d)



(e)



(f)

Figure 3. Images of sampling and mixing of waste: (a) Digging of vertical trenches (b) Mixing of collected sample (c) Digging horizontal trenches (d) Image of horizontal trench #21 (e) Top view of vertical trench #8 (f) Top view of vertical trench #5



Physical composition

The screened waste fractions (coarse, intermediate and fine) were manually segregated into various components such as plastic, paper, textile, rubber, leather, glass, metals, garden waste and inerts to determine the physical composition at various locations. The weight of each component in the three fractions is reported in each size category as well as overall MSW composition at a particular sampling location.



Figure 4. Sieving of the waste materials into different fraction using 50 mm and 20 mm screens place one over the other

(b) Offsite Analysis

Moisture content

Approximately 1 - 1.5 kg of the well mixed sample was oven dried at a temperature of 105°C for 24 h duration. The difference between the initial weight (as received) and the final weight (dry sample) was taken as the loss in moisture content. The moisture was expressed as percent loss in moisture of the wet MSW (Lin et al., 2015).

Total organic matter (TOM)

TOM is a measure of carbonaceous volatile organics in tested oven-dried sample. Approximately 1 g oven-dried individual component was taken and placed in a crucible with lid in the muffle furnace (GMP GC-16, Global Corporation, Mumbai) for 550°C for 4 h (URL 3). After removing the sample from furnace, it was cooled to room temperature before recording weight. TOM was expressed as percentage loss in dry sample weight. TOM was

determined for individual waste components (such as plastic, leather, textile, garden waste and inerts) to reduce the error in measurement due to heterogeneous nature of waste. Apart from this, the organic content of a specific component is important to understand its nature. The analysis was repeated four times to determine the variation in TOM even for a specific component.

Ash content

The ash content in each of the MSW components was determined in a tubular furnace (Abhishek Scientific, Mumbai). The oven dried individual MSW constituents were placed inside the furnace at a temperature of 900°C for 1 h (ASTM D586 (2002)). The ash content was expressed as the percent weight of residue remaining after 1 h of the initial dry mass. Four replicates were used to determine ash content in waste samples.

High calorific value (HCV)

The experiment was performed in bomb calorimeter by burning the individual constituent of MSW in a high pressure oxygen atmosphere. The high pressure vessel was placed in a bucket filled with 2 L of water (Shi et al., 2016). A sample size of 1.0 g was used for each measurement. After firing, the sample was completely consumed which led to a temperature rise of water in the bucket. The heat of combustion was then calculated by multiplying the temperature rise of the water by a previously determined energy equivalent with a standard material (benzoic acid). Experiments were performed in four replicates for each component of the MSW sample collected.

Lower calorific value (LCV) of individual components was calculated by subtracting the latent heat of vaporization from HCV obtained from the bomb calorimeter experiment (Shi et al., 2016). The following formula was used to calculate LCV of a sample (URL 4):

$$LCV = HCV - M_w * L$$

where M_w is weight of water in kg per 1 kg of wet sample; L is the latent heat of vaporization of water (540 kcal/kg). Both LCV and HCV are expressed in kcal/kg. Using LCV and HCV for individual components, the overall calorific values (both LCV as well as HCV) for mixed waste were also estimated.

The entire methodology adopted to characterize MSW samples from various locations at MSW landfill site is summarized in Figure 5.



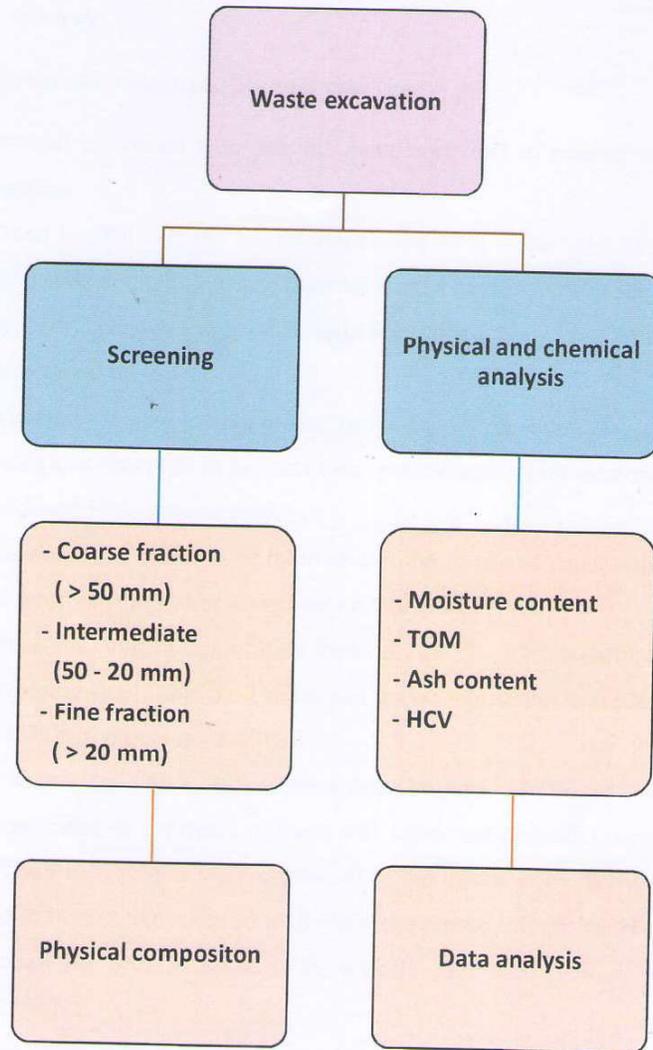


Figure 5. Methodology adopted for waste characterization

4. Major Results from Waste Analysis

Tables 2 – 7 and Figures 6 - 10 provide information on the physical and chemical compositions of MSW excavated from 24 sampling points. Moreover, section-wise waste composition is presented in Table 3 for the mixed waste irrespective of its size. The waste composition of the fraction greater than 50 mm is provided in Table 5 while Table 6 shows the section-wise distribution of the coarse fraction. The properties of individual components are presented in Table 7.

(a) *Onsite analysis*

Following observations were made from the analysis:

- i. The material excavated from the dumpsite consisted of plastic, textile, garden and inert fraction.
- ii. At Mulund landfill site, the inert material was 62% of the total MSW buried. On an average, plastic and textile waste together contributed to 29% of the net weight (Table 2 & Figure 6). Though the plastic waste was varied from 12 – 34% while the textile waste was found up to 10%.
- iii. Approximately 7% of garden waste (mixture of tree branches, coconut fiber and shells) was also observed in the excavated buried waste with minimum and maximum limits of 2 and 15%, respectively.
- iv. From the results, it can also be inferred that the food and paper waste dumped at the selected sampling sites were completely decomposed.
- v. As a whole, the contribution of inert fraction was 57 – 69% in different sections of the waste dumping site (Table 3). The second major contributor was plastic which ranged to 12 – 32% of the total mixed MSW.
- vi. Table 4 shows that ~40 – 70% of the waste (average = 52%) was below 20 mm size which comprised of a mixture of inert, soil, stone and degraded organic waste. It was very difficult to segregate the components in the fine fraction. By visual inspection, it appeared to be soil like material with glass and plastic impurities. Hence in this study, fine fraction has been assumed to be entirely composed of inert material and was noncombustible.
- vii. The waste material having particle size between 20 and 50 mm had the least mass and constituted less than 10% of the net waste. Hence no further characterization of this fraction was carried out.
- viii. The waste samples of size greater than 50 mm (coarse fraction) mainly consisted of plastic, garden and textile waste and constituted on an average 42% of the total waste (ranged from 25 - 52% at various locations). Figure 7 and Table 5 shows the composition of waste in this size range. On an average plastic waste was 46% while textile and garden wastes were 14 and 13%, respectively. Inert material was ~ 20% of the total fraction.



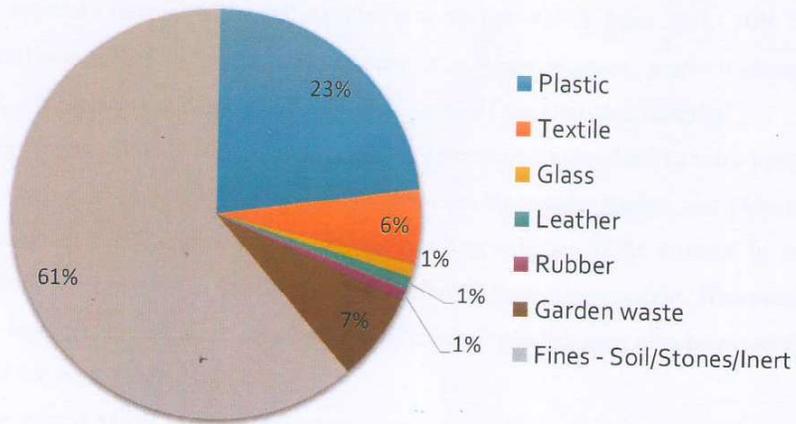


Figure 6. Average composition of the total buried MSW in Mulund Dumping Ground (up to a depth of 4 - 6m)

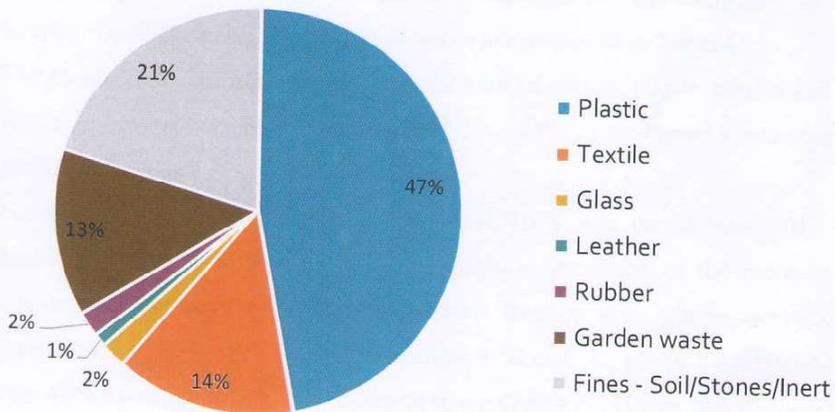


Figure 7. Average composition of the coarse fraction (> 50 mm) of the buried MSW in Mulund Dumping Ground (up to a depth of 4 - 6m)

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(b) Off-site analysis

- i. The moisture content in tested samples was varied widely from 20 to 70% with an overall average of 38% (Table 4). Except for a single location, where it exceeded to 70%, the moisture content was below 40% in 16 of the analyzed samples.
- ii. The average TOM of the mixed waste was determined to be 40% (on dry basis). The organic matter in MSW was mainly contributed by textile, garden and plastic waste fraction (Table 7). Furthermore, it can be observed that TOM content in the fine fraction was only 18%, which is an indication of high inert content. However, some fine degraded organics and small pieces of crushed plastics may also be present which could not be separated out.
- iii. In the mixed MSW samples collected from various locations, HCV varied from 3300 – 1992 kcal/kg (average HCV = 2562 kcal/kg). The maximum HCV was observed in the sample obtained from sampling point 12. The highest plastic and least inert fraction was found at this sampling point. As shown in Table 7, the plastic has the highest HCV. Therefore, its higher share will lead to increase in CV of the material. The average LCV of MSW at Mulund dumping side was calculated as ~ 2345 kcal/kg. The HCV and LCV for mixed waste are presented in Table 4.
- iv. The combustible fraction was taken as the sum of plastic, textile, garden and leather waste. In few sections K, F1, A, G1 and F, 35 – 45% of the buried waste seems to be combustible nature.
- v. For the coarser fraction (i.e., > 50 mm size), HCV was varied from 3018 – 5889 kcal/kg with an average of 4383 kcal/kg. It is attributed to the increase in the components contributing to the combustible fraction (i.e., plastic, textile, garden waste, leather waste etc.). Except in sections A, G and G1, plastic contributed to more than 40% by weight of the total coarse fraction (Table 6). Hence, this fraction showed potential for energy recovery.
- vi. From Table 7, it can be seen that the fine fraction had a substantially high ash content (~75 %) which indicated a high percentage of inorganic material in this fraction. This high ash content value makes fine fraction unsuitable for use in energy recovery options.
- vii. Plastic has the least ash residue after complete combustion, which explains its high HCV. However, it was still at higher side compared to the uncontaminated plastic. This is possibly due to the dirt or soil attached to the plastic.



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Table 2. Average composition (%) of the collected waste samples (on as received basis)

Sampling locations → Component ↓	Sample Composition																								Standard error				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		Average	Standard deviation	Max	Min
Plastic	14.6	14.7	25.4	32.2	23.0	25.8	14.7	20.7	14.1	22.0	28.4	34.4	24.5	27.0	18.2	27.9	31.9	12.4	17.3	18.9	18.0	16.0	30.2	33.4	22.8	6.9	34.4	12.4	1.4
Textile	7.0	6.2	10.0	6.2	8.4	5.3	6.6	1.5	4.4	2.3	7.0	8.9	7.3	5.0	10.4	8.1	6.5	7.2	7.3	5.2	9.4	0.2	6.8	3.6	6.3	2.5	10.4	0.2	0.5
Glass	0.7	0.6	1.2	0.0	2.5	0.5	1.4	0.4	1.0	1.2	0.5	2.8	0.4	3.1	0.5	1.3	0.7	0.2	0.7	0.4	0.2	1.1	2.0	1.2	1.0	0.8	3.1	0.0	0.2
Leather	1.4	0.0	0.2	0.0	0.5	1.9	0.0	0.9	0.8	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.1	0.7	2.1	1.5	0.6	0.0	0.6	0.7	2.1	0.0	0.1
Rubber	0.0	0.6	0.2	0.0	0.2	0.0	1.5	0.4	0.0	0.0	0.0	0.6	2.9	0.0	3.6	0.0	1.3	0.9	0.0	0.0	2.5	1.2	1.3	0.7	0.7	1.0	3.6	0.0	0.2
Metals	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.3	1.0	0.0	0.1
Garden Waste	4.4	6.0	5.5	4.2	9.0	3.9	4.2	3.0	13.1	4.3	6.0	7.6	6.6	11.2	2.4	7.1	4.3	9.0	7.0	14.8	6.2	6.4	5.3	4.8	6.5	3.1	14.8	2.4	0.6
Fines - Soil/Stones/Inert	71.9	71.8	57.5	57.3	56.4	62.6	71.5	73.0	66.6	69.1	55.9	45.8	57.5	53.7	64.9	55.6	55.2	69.8	66.6	60.0	61.6	73.6	53.7	56.3	62.0	7.7	73.6	45.8	1.6

Table 3. Section wise waste composition (as received basis)

Component	Net Sample Composition (%)																		
	A	B	F	F1	G	G1	H	J	K										
Plastic	21	21	23	28	12	24	17	21	32										
Textile	7	3	9	6	7	5	7	7	6										
Glass	1	1	1	1	0	1	1	1	0										
Leather	0	1	0	1	1	1	1	1	0										
Rubber	2	0	2	1	1	0	0	1	0										
Metals	0	0	0	0	0	0	0	0	0										
Food/garden waste/wood	7	9	5	5	9	7	7	5	4										
Soil/Stones/Inert	62	64	60	57	69	61	67	64	57										
Total	100	100	100	100	100	100	100	100	100										

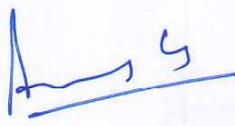

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Table 4. Physical and chemical characteristics of the collected waste samples

Sample locations Characteristics ↓	Sample Characteristics																								Standard error				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		Avg.	Standard deviation	Max	Min
% of fraction < 20 mm	-	-	71.6	53.9	54.6	49.3	49.6	62.5	55.0	54.0	44.6	41.3	47.0	43.2	51.1	49.8	42.9	60.0	54.8	50.8	50.1	67.3	41.8	40.7	51.6	8	72	41	1.76
% of fraction between 50-20 mm	-	-	3.5	11.6	3.6	5.0	8.0	3.9	3.6	4.9	3.2	10.6	8.5	15.4	10.8	4.9	5.7	5.6	3.5	6.6	3.3	3.5	9.7	13.6	6.8	4	15	3	0.79
% of fraction > 50 mm	-	-	24.9	34.4	41.8	45.7	42.4	33.5	41.4	41.1	52.3	48.2	44.5	41.4	38.1	45.3	51.4	34.5	41.8	42.6	46.5	29.2	48.5	45.7	41.6	7	52	25	1.47
Total weighed sample (kg)	75	89	129	142	90	136	98	119	136	155	94	69	102	63	69	36	88	73	65	93	94	85	66	85	95	30	155	36	6.46
Moisture Content (%)	47	24	21	32	41	45	34	42	45	35	36	34	23	21	31	36	47	30	43	56	37	71	37	37	38	11	71	21	2
TOM (%)	34.6	34.2	43.4	45.5	42.7	41.3	33.3	34.8	37.2	36.8	44.5	49.6	41.3	44.5	36.4	44.9	45.1	35.1	37.9	41.9	39.1	32.7	44.6	44.9	40.3	4.8	49.6	32.7	1.0
Ash Content (%)	56.3	55.9	46.1	45.7	45.4	49.8	55.5	56.5	52.7	53.9	45.0	37.8	45.8	43.3	51.0	44.7	44.2	54.8	52.6	48.2	49.4	57.1	43.3	44.7	49.2	5.4	57.1	37.8	1.1
HCV (kcal/kg)	2087	2050	2807	3085	2681	2714	2015	2244	2131	2372	2932	3332	2662	2847	2294	2927	3055	2018	2303	2479	2399	1992	2987	3069	2562	412	3332	1992	84
LCV (kcal/kg)	1947	1931	2619	2848	2416	2517	1770	1984	1928	2163	2731	3197	2540	2669	2082	2655	2883	1769	1978	2264	1987	1776	2773	2850	2345	427	3197	1769	87

*The physical composition was determined as received basis while the TOM and ash content were determined on dry waste basis.

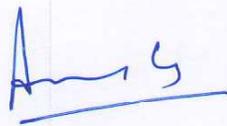

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Table 5. Waste Samples of size greater than 50 mm (i.e., coarse fraction)

Sample locations → Characteristics ↓	Sample Composition > 50 mm																								Average	Standard deviation	Max	Min
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
Plastic (%)	40.5	72.3	48.1	51.7	23.8	59.2	32.1	48.4	49.5	57.7	43.9	58.8	33.1	54.3	55.6	33.3	41.6	41.1	36.9	48.8	47.5	54.9	47.0	11.2	72.3	23.8		
Textile (%)	20.2	15.8	18.6	8.2	15.5	4.6	10.6	5.6	13.5	18.5	16.5	12.2	27.4	17.8	11.9	20.8	17.6	11.2	19.9	0.8	14.0	7.9	14.0	6.2	27.4	0.8		
Glass (%)	1.9	0.0	6.1	1.1	1.1	0.7	2.1	1.3	0.6	3.9	0.8	3.3	0.9	2.8	1.4	0.7	1.6	0.9	0.4	3.2	3.8	1.9	1.8	1.5	6.1	0.0		
Leather (%)	0.0	0.0	1.1	4.1	0.0	2.7	1.9	2.7	2.1	0.0	0.0	0.0	0.0	0.0	0.0	1.6	2.6	1.4	4.1	5.1	1.2	0.0	1.4	1.6	5.1	0.0		
Rubber (%)	0.7	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	1.1	6.4	0.0	7.9	0.0	2.4	2.5	0.0	0.0	5.3	4.2	2.5	1.6	1.7	2.3	7.9	0.0		
Metals (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.2	0.6	2.0	0.0		
Garden Waste (%)	8.8	9.3	17.9	6.9	9.1	7.9	29.0	8.8	11.3	12.2	11.8	16.0	4.0	15.7	7.3	22.0	16.2	29.8	12.3	20.0	10.8	9.0	13.5	6.8	29.8	4.0		
Soil/Stones/Inert	27.9	2.6	8.1	28.1	48.1	24.9	24.3	33.2	21.1	6.4	18.7	9.8	26.7	9.3	21.4	19.2	20.3	15.6	21.1	17.9	19.9	24.7	20.4	9.9	48.1	2.6		
TOM (%)	61.0	80.6	69.9	63.8	48.3	66.7	62.0	60.2	67.5	73.5	67.2	72.5	60.9	57.8	62.1	65.6	56.7	68.8	65.6	67.4	61.0	58.1	64.42	7.0	40.6	8.2		
Ash Content (%)	26.2	8.2	12.4	25.4	40.6	23.0	24.0	28.9	21.1	11.3	21.2	13.2	27.5	12.4	21.3	21.4	20.5	18.0	22.9	19.5	20.5	22.6	21.01	2.5	23.9	11.8		
HCV (kcal/kg)	4105	5889	4714	4602	3018	4890	3813	4283	4724	5156	4553	5075	4003	3809	4393	4114	3652	4369	4346	4641	4173	4101	4383	596	5889	3018		

*The physical composition was determined as received basis while the TOM and ash content were determined on dry waste basis.



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Table 6. Section wise waste composition of coarse fraction (as received basis)

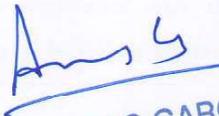
Component	Net Sample Composition								
	A	B	F	F1	G	G1	H	J	K
Plastic	39	49	44	53	33	36	42	46	72
Textile	17	7	23	13	21	11	18	14	16
Glass	3	2	2	2	1	1	2	1	0
Leather	0	2	0	2	2	2	3	2	0
Rubber	3	1	4	1	2	1	0	3	0
Metals	1	0	0	1	0	0	0	0	0
Garden Waste	13	19	10	11	22	15	16	11	9
Soil/Stones/Inert	25	19	18	18	19	33	20	23	3
Total	100	100	100	100	100	100	100	100	100

Table 7. Chemical properties of individual waste components (on dry basis)

Material	TOM (%)	Standard Error (%)	Ash Content (%)	Standard Error (%)	HCV (kcal/kg)	Standard Error (kcal/kg)
Plastic	86	± 6	5	± 1	6883	± 765
Textile	71	± 5	11	± 1	3920	± 239
Garden Waste	72	± 3	10	± 3	2916	± 143
Fines/Inert/Soil	18	± 2	75	± 3	868	± 96
Leather	67	± 5	30	± 3	3848	± 813

5. Limitations of this Study

- In this study waste could be extracted only up to a depth of 4 to 6 meters due to machinery constraints, though for a more accurate estimate boreholes should be dug up to the depth intended for clean-up. Only a few samples could be collected by horizontal excavation.
- As the information pertaining to the exact age of buried waste was not available, no correlation could be made between the waste characteristics and age of waste.
- Samples from few sections could not be taken due to fire risks and slope instability.


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6. Major Conclusions and Suggestions

- The majority of waste can be characterized as inert waste. However, a substantial waste mass can be utilized for energy recovery.
- Plastic was the second most predominant material accounting for nearly 23% of the total mass and it was much higher in the fraction greater than 50 mm size.
- The average HCV of the entire waste 2562 kcal/kg whereas the coarse fraction had an average HCV of 4383 kcal/kg.
- Generally, ash content in the coarse fraction (i.e., > 50 mm size) was quite low compared to the fine fraction.
- Based on TOM, ash content and low HCV, the fine fraction seems unsuitable for further processing. However, this material can be used as a cover material at landfill site.
- According to Solid Waste Management Rules, 2016, any material having calorific value greater than 1500 kcal/kg should be utilised for generating energy (Ministry of Environment, Forest and Climate Change (MoEFCC), 2016). The presence of high inerts (~60%) in mixed MSW may be a major constraint to use this material for energy recovery. However, the coarser fraction (> 50 mm) has great potential to be utilized in energy recovery processes after proper segregation (possibly by trommel screens).

References

1. ASTM D586 (2002) Standard Test Method for Ash in Pulp, Paper, and Paper Products, USA.
2. Lin, X., Wang, F., Chi, Y., Huang, Q., & Yan, J. (2015). A simple method for predicting the lower heating value of municipal solid waste in China based on wet physical composition. *Waste Management*, 36, 24–32.
3. Shi, H., Mahinpey, N., Aqsha, A., & Silbermann, R. (2016). Characterization, thermochemical conversion studies, and heating value modeling of municipal solid waste. *Waste Management*, 48, 34–47.
4. Krook, J., Svensson, N., Eklund, M., Johansson, N., & Frändegård, P. (2010). Landfill mining: a review of three decades of research. In Knowledge Collaboration & Learning for Sustainable Innovation: 14th European Roundtable on Sustainable Consumption and Production (ERSCP) conference and the 6th Environmental Management for Sustainable Universities (EMSU) conference organized by Delft

University of Technology and The Hague University of Applied Sciences; TNO, The Netherlands, October 25-29, 2010.

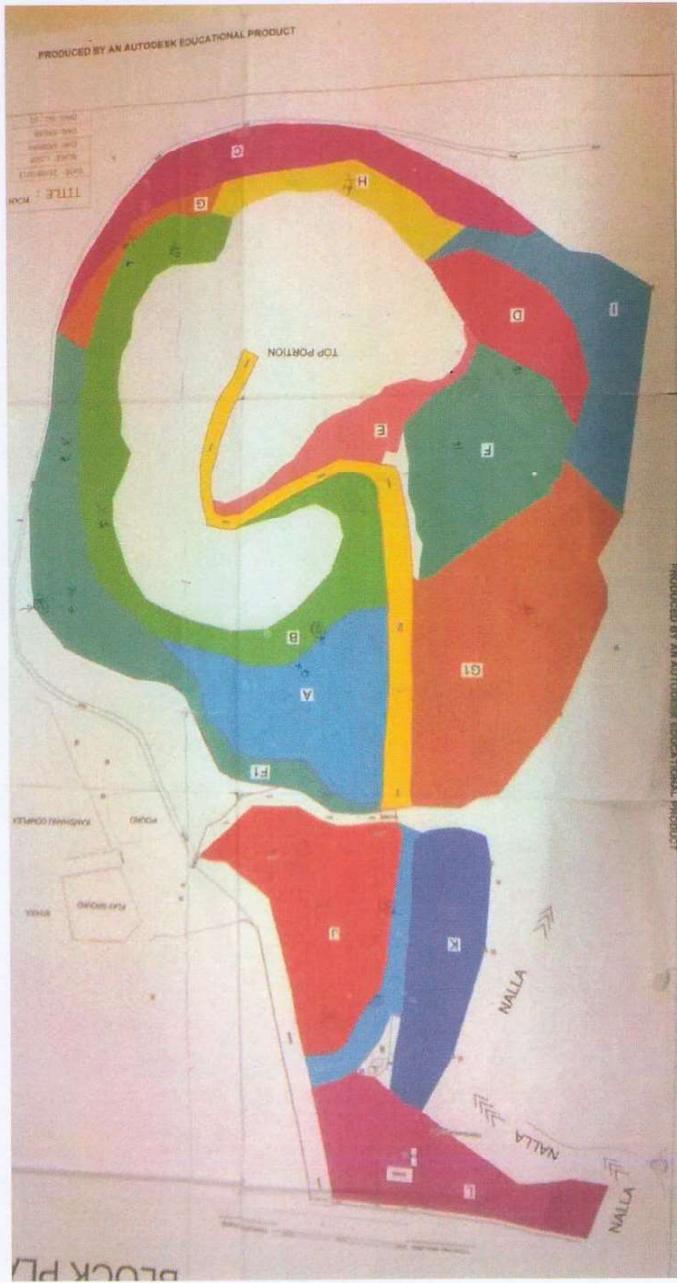
5. Ministry of Environment, Forest and Climate Change (MoEFCC), 2016. Solid Waste Management Handling Rules, 2016. The Gazette of India, Notification: REGD. NO. D. L.-33004/99.
6. URL 1: http://www.nj.gov/dep/srp/guidance/srra/landfill_guidance.pdf (accessed on 14/5/2016)
7. URL 2: https://www.dep.state.fl.us/waste/quick_topics/publications/shw/recycling/InnovativeGrants/IGYear9/finalreport/PerdidoLandfill_MiningReportfinal.pdf (accessed on 14/5/2016)
8. URL 3: <http://www.bis.org.in/sf/fad/FAD72189C.pdf> (accessed on 14/5/2016)
9. URL 4: http://www.worldbank.org/urban/solid_wm/erm/CWG%20folder/Waste%20Incineration.pdf (accessed on 14/5/2016)



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Appendix A
Dumping Ground Map Provided by MCGM



Ans 5

Press Information Bureau
Government of India
Ministry of Road Transport & Highways

27-June-2016 16:22 IST

CSIR's CRRI validates usage of Ghazipur Municipal Waste to NHAI for earth-filling in construction of highways

NHAI had entrusted the assignment of technically verifying whether Solid Waste Material generated from Municipal/City waste can be utilized for highway construction to CSIR-Central Road Research Institute (CRRI). The CSIR-CRRI conducted a study by collecting 70 tonnes of Municipal Solid Waste from different locations of 5/10/15 years old from Ghazipur land fill site of Municipal Corporation of Delhi and have recommended the following :

The municipal solid waste contains about 65 to 70 % of Soil components which can be used in embankment construction after segregation from the municipal solid waste. The methodology suggested for use is by drying the collected municipal solid waste and passing through different sieves. The percentage passing from the 16 mm sieve contains 44 to 48 % of municipal solid waste which can be directly used in embankment construction. For utilizing the municipal solid waste passing through 32 mm sieve, the segregation of plastic material and PVC etc., will have to be blown by using high capacity blowers at the segregation plant.

Director CRRI presented the report and findings to Chairman NHAI in presence of senior NHAI officers and various stake holders.

The Municipal Corporation of Delhi (East) had earlier approached NHAI to make use of waste at Ghazipur Landfill site, whereupon Chairman NHAI had commissioned analytical study through CRRI. NHAI plans utilization of this Solid Waste Material for its highway construction program on NH-24, i.e. Meerut Expressway. To allay the doubts of Concessionaires and to encourage them to utilize this waste, NHAI has offered to indemnify the Concessionaires for the stretches where this waste material shall be tried. Also, NHAI will write to MoEF to allow usage of solid waste material in lieu of fly-ash wherever feasible. This initiative of NHAI shall promote the construction of Green Highways in the country as it amounts to substantial replacement of natural earth, mining of which causes environmental problems.

NHAI is already utilizing fly-ash upto 30% of earth filling in the Eastern Peripheral Expressway and using other slag materials elsewhere. This will be in keeping with Prime Minister's directions for use of waste in a productive way.

...

UM/AC

UTILIZATION OF MUNICIPAL SOLID WASTE IN ROAD EMBANKMENT CONSTRUCTION

A detailed study was carried out by CSIR- Central Road Research Institute to investigate the possibility of utilizing the Municipal Solid Waste (MSW) collected from Ghazipur, East Delhi as an embankment fill material. The MSW is proposed to be utilized in the widening of NH-24 (Delhi-Meerut Expressway) from the existing 4 lane to 14 lane. The construction would be carried out by National Highway Authority of India (NHAI) under the supervision of CSIR- Central Road Research Institute.

About 200 tons of Municipal Solid Waste was collected from three different locations on the landfill site, based on its age. These materials were dried and then segregated into different sizes in the existing compost plant. The different fractions were studied for their suitability for use in embankment construction. A segregation methodology was proposed in the study to arrive at a final material to be used in the embankment. This Municipal Solid Waste (MSW) was also studied for the presence of heavy metals by carrying out leachate studies. The segregated MSW is then characterised for its Geotechnical characteristics. Stability and Settlement analysis was also carried out to investigate its feasibility for embankment construction. It was concluded that ;

1. About 65-75% of segregated Municipal Solid wastes can be used for embankment construction.
2. Leachate studies indicate that MSW is a non hazardous material as concentration of heavy metals is within the permissible limit.
3. Typical design cross sections with MSW embankment have been arrived for experimental test track construction along the Delhi-Meerut expressway. The MSW embankment would be instrumented and monitored over a period of 2 years before recommending the material for large scale field applications.



View of Ghazipur MSW landfill, Delhi



Process of segregation

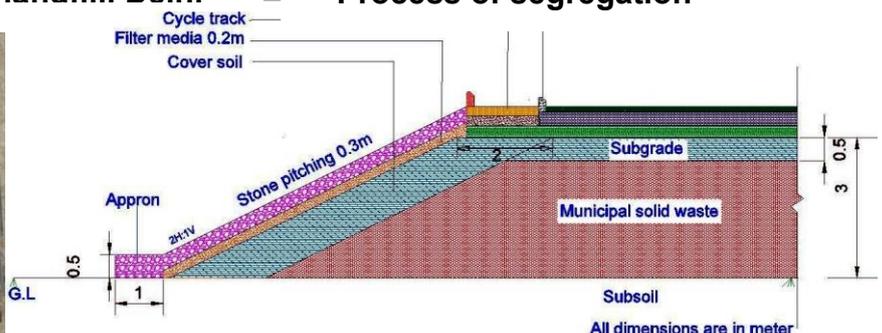


Fig 24:-vi Segregated MSW for construction structure Typical cross section of MSW embankment

FINAL REPORT

**UTILIZATION OF MUNICIPAL SOLID WASTE IN ROAD
EMBANKMENT**

SPONSORED BY

**NATIONAL HIGHWAY AUTHORITY OF INDIA
NEW DELHI**



SUBMITTED BY

**GEOTECHNICAL ENGINEERING DIVISION
CSIR-CENTRAL ROAD RESEARCH INSTITUTE**

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DISCLAIMER

All the data and technical information furnished in this report are based on the actual laboratory investigations. The responsibility of the CSIR - Central Road Research Institute (CRRI) is limited to the technical and scientific matters contained in this report.

Any use of the findings of the report without consulting CRRI by any other agency or person other than the client will be solely at their own risk and responsibility.

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UTILISATION OF MUNICIPAL SOLID WASTE IN ROAD EMBANKMENT

1.0 INTRODUCTION

Rapid growth of population, industrialization and urbanization during the last few decades has resulted in generation of huge quantity of Municipal Solid Wastes (MSW) in different cities. Delhi generates about 7000 tons/day of MSW and all the three existing dump sites (Ghazipur, Bhalswa and Okhla) have exhausted their capacity. The Ghazipur landfill was started in the year 1984 and is still in use. It spreads over an area of approximately 3×10^5 m² and is situated near National Highway-24. It is located at the close proximity of the Hindon canal. On an average 2200 tons/day of waste is dumped and the waste fill height varies from 30-35 m. Different constituents of this waste dump include: groceries, food scraps, vegetable remains, packing materials, paper, remains of used coal, ash, wood, metals, plastics, ceramics, cloth, glass, etc. Construction & demolition waste consisting of sand, bricks and concrete block are also part of the dump. Further, waste from the adjacent poultry market, fish market, slaughter house, dairy farm and non-infectious hospital waste are also part of the huge hillock of MSW dump. The MSW is dumped haphazardly without segregation and at present it is in irregular shape. A typical pictorial view of Gazipur land fill site is shown in Fig. 1.



Fig.1 Typical view of Ghazipur MSW dumping yard

The huge dump of Ghazipur landfill is affecting the health, hygiene, sanitation and aesthetics of surrounding area. The place has become a home for rats, flies, bacteria, mosquitoes, all having the potential of causing many human diseases. If these wastes are not properly disposed off, they can prove perilous and environmental hazard. It is very important for Engineers and Environmentalists to adopt sustainable waste management programs to minimise the release of these materials into the environment where they can affect public health and eco-system.

Large scale infrastructural development is being carried out in the country considering the huge surge in the industrial and consumer goods production. Several thousands of kilometre of roads are built in the form of National Highway Development (NHDP) program and Pradhan Mantri Gram Sadak Yojana (PMGSY) program. This requires huge quantities of road construction materials both for construction and maintenance of roads. Use of local soil and conventional aggregates for road construction needs to be reduced as it affects our environment and is disastrous for the future. Also, the conventional soil and good quality aggregates are also depleting very fast especially in an urban area, and have to be brought from large distances, increasing tremendously, the cost of the project. The accumulated Municipal Solid Waste (MSW) in the Ghazipur landfill is now seen as a potential source of material for bulk utilisation in embankment construction in the 14 lane widening of NH-24, the construction of which would start in next few months.

In this connection National Highway Authority of India (NHAI) approached CSIR-Central Road Research Institute, New Delhi to carry out a detailed study to investigate the possibility of use of this material as an embankment fill. It was emphasized that the study shall be carried out as a pilot project, the outcome of which could be utilised and applied in different cities at the National level. Accordingly, a proposal was prepared by CSIR-CRRI, to carry out this R&D study in three phases the scope and objectives of which include: development of methodology for segregation, laboratory characterisation, design, construction of experimental test tracks, instrumentation and monitoring. Results need to be analysed and specifications have to be developed for large scale field applications. This report discusses the results of Phase 1 of study; where in a methodology has

been proposed for segregation of MSW. The report also discusses the results of a) Geotechnical characterization of MSW b) Settlement analysis and c) Typical cross sections of MSW embankment of 3m and 5m height embankment for field construction.

2.0 SCOPE AND OBJECTIVES

The objective of this project is to develop the guidelines, technical specifications for the application of MSW in road embankment construction. The scope of work is limited to the following activities.

- Development of a methodology for segregation and identification of material for embankment construction.
- Geotechnical characteristics of identified material to investigate its feasibility for embankment applications.
- Investigation on heavy metal constituents, other harmful products by chemical analysis of identified material.
- Analysis of total settlement of municipal solid waste embankment fill.
- Slope stability analysis for embankment constructed with municipal solid wastes.
- Finalization of typical cross – sections of MSW embankment for field construction.

3.0 DEVELOPEMENT OF METHODOLOGY FOR SEGREGATION

The Municipal Solid Waste (MSW) is a heterogeneous material which cannot be used as such in embankment construction. It has large size plastics, clothes and even boulder size C&D waste. MSW needs to be segregated/separated by adopting a suitable methodology before using it for road embankment construction. The segregated material can then be easily compacted in the field with conventional methods and equipments. Details of R&D study adopted for segregation of MSW is discussed below. Based on the result of the study; a methodology has been proposed for segregation of MSW.

3.1 Collection of raw Garbage (MSW)

To develop the segregation methodology, about 200 tons of raw garbage (Municipal Solid Waste) was collected from Ghazipur landfill, East Delhi. This was collected from three pre-identified locations according to its age, based on the height of the dump and as per available data with EDMC. However as the samples were collected from the slope of the MSW, this cannot be authenticated about the exact age of the MSW collected.

The biodegradability of MSW depends on the time of dumping and it would affect its physical, chemical and geotechnical properties. Approximately 70 tons of garbage was collected from each of these three locations of different ages (1) 5 years old (2) 10 years old and (3) 15 years old. The approximate locations on a Google map is shown in Fig 2.



Fig 2. Collection of MSW of different age- Locations on a google image

3.2 Segregation and composition analysis

Segregation and composition analysis of MSW samples were carried out to know the proportion of different size of heterogeneous materials and its composition. The analysis would help to arrive at suitable material to be used for embankment construction. The R&D study was carried out at IL & FS Compost plant, Okhla, New Delhi.

3.2.1 Segregation

The study on the segregation of raw garbage was carried out at an already existing compost plant at Okhla, New Delhi. The trommel/sieve sizes used in the composting process were also adopted for segregation of raw garbage (MSW). The garbage collected from different locations was first dried in the compost plant (Fig.3) before the process of segregation. The compost plant has different trommels/sieves which has the option to segregate the garbage in different sizes as, Retained on 80mm, Passing 80mm , Passing and Retained on 35mm, Passing and Retained on 16mm, Passing and Retained on 4mm. To develop the segregation methodology, raw garbage was segregated in different trommel/sieve sizes starting from 80 mm to passing 4mm. The samples segregated in different sieves would give an insight regarding the possible selection of material for embankment construction. The method of segregation adopted in the compost plant has been discussed below.

- a) The dried MSW is first fed into 80 mm trommel through a conveyor belt. The papers, plastics, cloths and other constituents remained on the 80mm sieve were removed by an air blower provided in the plant set-up. The high pressure blower removes all the large size papers, plastics, clothes as shown in (Fig.4). The heavier larger size C&D aggregates including large size brick bats are retained on 80mm sieve. However, these materials can also be removed manually as shown in Fig. 5.



Fig.3 Drying of garbage in compost plant



Fig.4 Loading and Separation of plastics from 80mm Trommel/Sieve



Fig.5:- Removal of Brick bats, C&D waste from the conveyor

- b) The material passing 80 mm sieve (Fig.6) was then fed into 35mm size trommel/seive, where the MSW will get further segregated into materials retained on 35 mm and material passing 35 mm (Fig.7). In this process, there would be more removal of plastics, paper, clothes, etc.
- c) The MSW passing 35 mm trommel/sieve size, further passes through a conveyor into a 16mm trommel/sieve, which further segregates the materials into two parts viz. Retained on 16 mm and Passing 16mm (Fig.8).
- d) The MSW passing 16 mm is then allowed to pass through a 4 mm trommel/sieve, which further segregates the MSW into retained on 4 mm and passing 4 mm (Fig.9).



Fig.6 Fraction passing 80 mm sieve.



Fig.7 Fraction passing 35 mm sieve.



Fig.8 Fraction passing 16 mm sieve.



Fig.9 Fraction passing 4 mm sieve.

During the segregation study, the percent weight retained and passing different trommel/sieve sizes was calculated separately. These values were estimated by collecting different fractions using mini trucks and weighing them appropriately in the plant. (Fig.10 and Fig. 11(a,b)).

The percentage of different fractions after segregation is summarized in Table1.



Fig. 10 Collection of MSW passing 80mm



(a)



(b)

Fig.11:- Collection of MSW passing 16mm

Table 1:- Percentage of different fractions after segregation of raw garbage

Age of MSW	% Passing 80mm sieve	% Retained on 35mm + % Retained 16mm sieve	% Passing 16mm sieve	% Retained on 4mm sieve	% Passing 4mm sieve
5 yrs	79	32	47	18	29
10 yrs	65	21	44	17	27
15 yrs	68	20	48	14	34

It is observed that, in all the three types of MSW of different ages, that

- (a) About 65-79% of the material passes through 80 mm sieve with substantial amount of plastics, paper & cloths and
- (b) About 44-48% of the MSW passes through 16mm sieve with minimum plastics.
- (c) Substantial amount of useful aggregates were observed to be retained on 35mm and 16mm Trommel/Sieves.

3.2.2 Composition analysis

Composition analysis of different fraction was carried out to know the amount of different constituents viz. soil, plastics, metals, textiles, papers etc in the heterogeneous mix. This would help to identify a particular fraction for use in the embankment construction.

About 30-40kg of MSW passing through 80mm, 35mm, 16mm, 4mm sieves were collected randomly during segregation process and were dried before composition analysis. Different constituents were separated manually and weighed (Fig 12).



Fig.12 Manual Separation of MSW passing 80mm

This process was repeated for MSW of different ages. The results of the composition analysis for different fractions are shown in Fig 13 – Fig 17. Some of the conclusions drawn from composition analysis are given below;

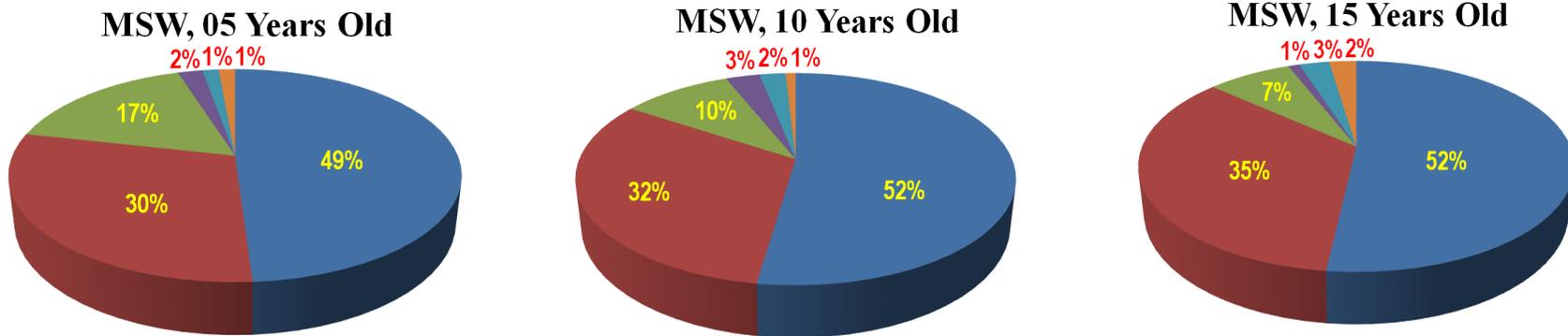


Fig 13:- Results of composition analysis of MSW retained on 80mm

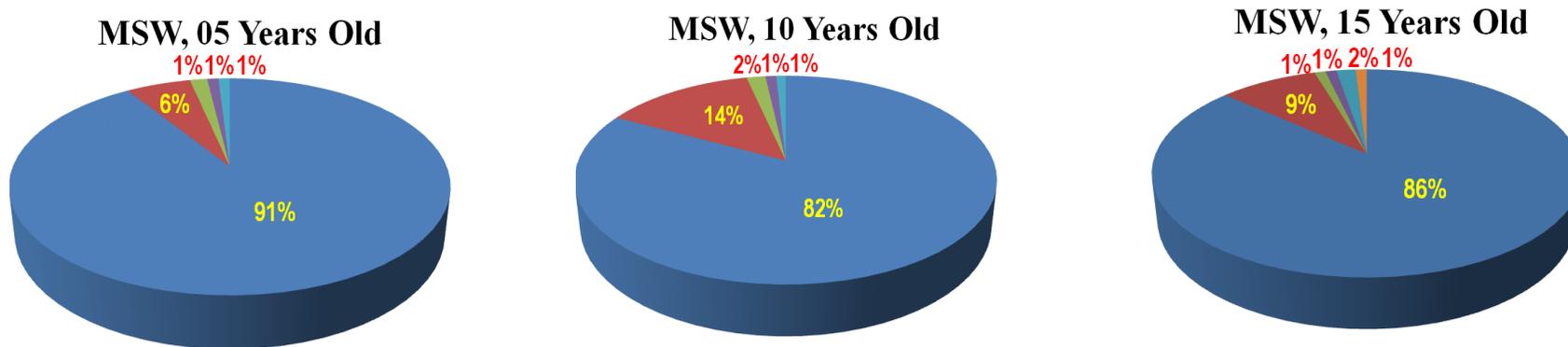


Fig 14:- Results of composition analysis of MSW passing 80mm

■ Soil
 ■ Plastic
 ■ Textiles
 ■ Metals
 ■ Wood
 ■ Paper
 ■ Rubber
 ■ Glass & Others

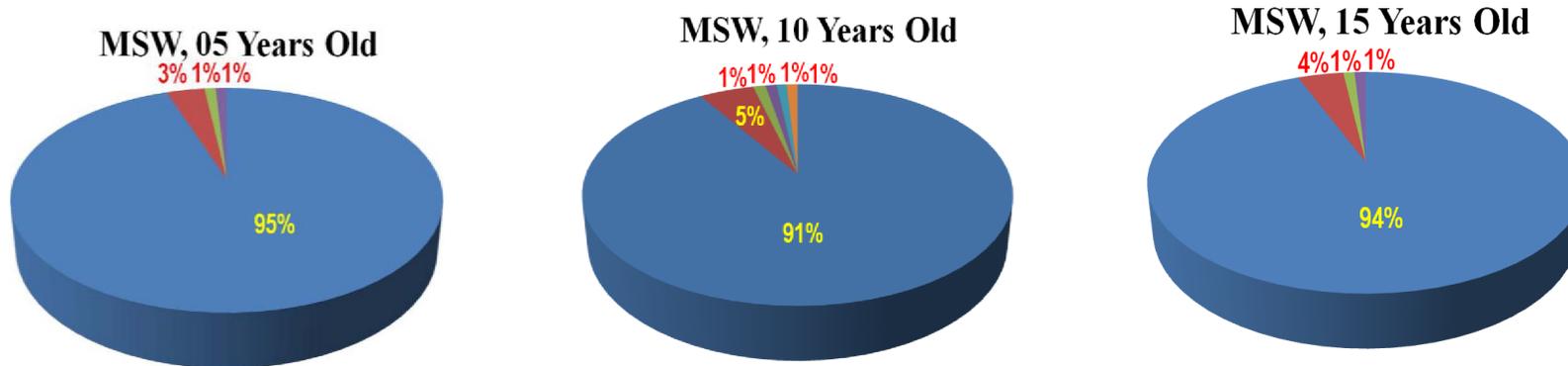


Fig.15 Results of composition analysis of MSW passing 35 mm sieve

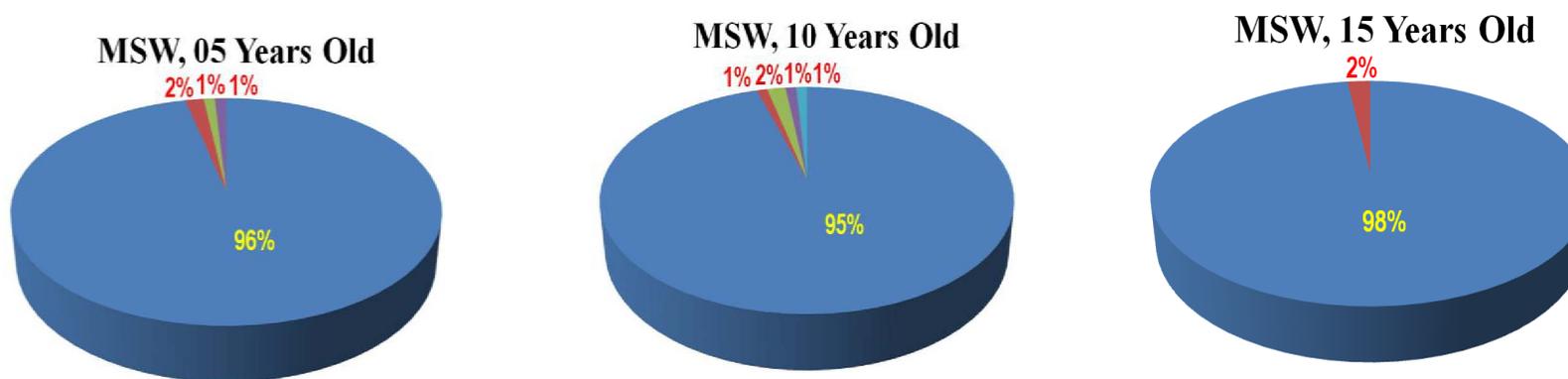


Fig.16 Results of composition analysis of MSW passing 16 mm sieve

■ Soil ■ Plastic ■ Textiles ■ Metals ■ Wood ■ Paper ■ Rubber ■ Glass & Others

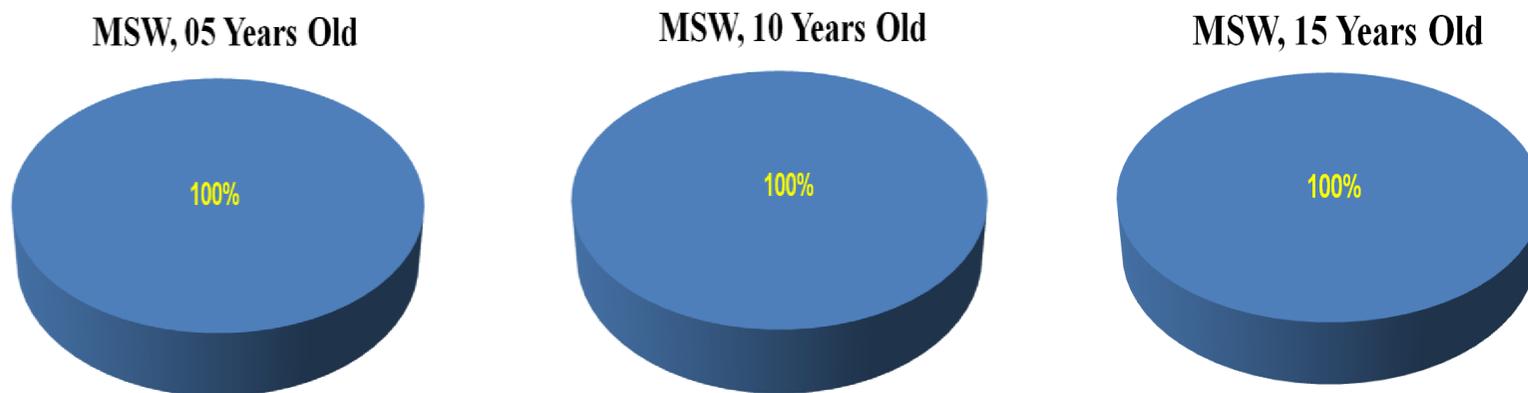


Fig 17:- Results of composition analysis of MSW passing 4mm

■ Soil ■ Plastic ■ Textiles ■ Metals ■ Wood ■ Paper ■ Rubber ■ Glass & Others

Some of the conclusions drawn from composition analysis are given below:

- a) The percentage of soil content increases as the raw MSW is successively segregated through 80 mm, 35mm, 16mm, and 4mm. The soil content which was about 50% retained on 80mm sieve increases to 100% when it was passed through 4mm sieve.
- b) Other than soil, plastics and textiles were observed to be major constituents in different segregated MSW
- c) The percentage content of metals, wood, paper, rubber, glass is observed to be less than 1% in different segregated MSW.
- d) It is concluded that there is no variation in soil content or other constituents with the age of the MSW.

The variation of plastics and other constituents in MSW of different ages with sieve size is shown in Fig-18. It is observed that the amount of plastics and other constituents sharply reduces when it is passed through 80mm sieve (50% to 15%). With the successive sieving, this amount reduces and becomes negligible when it is passed through 4mm sieve.

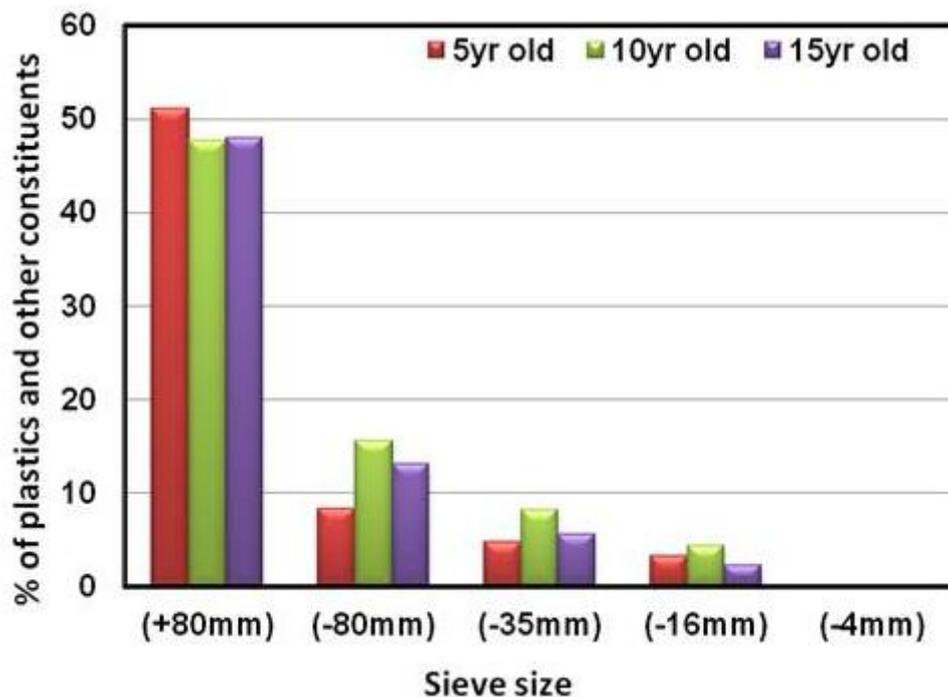


Fig 18:- Variation of plastics and other constituents with Trommel size

3.3 SUITABILITY OF SEGREGATED MSW FOR EMBANKMENT CONSTRUCTION

The fraction passing 80mm, 35mm, 16mm & 4mm sieve were visually observed for a typical MSW with 10 years age. These fractions were geotechnically characterized before arriving at conclusions regarding their feasibility for embankment construction. Fractions retained on 35mm,16mm were also studied. Details of the study is given in subsequent sections.

3.3.1 Fractions passing 80mm, 35mm, 16mm and 4mm

The fraction passing/retained on 80mm sieve are found to have different ingredient:-

- (a) C&D wastes which is considered to be a good material for embankment construction. However in these fractions, substantial amount of plastics, textiles, papers are also present, which may create compaction problems during construction in the field. Hence this fraction cannot be used directly without segregation in embankment construction.
- (b) To identify/select a particular fraction among the remaining fraction (passing 35mm, passing 16mm, passing 4mm sieve), their preliminary geotechnical characteristics were studied by carrying out specific gravity tests, plasticity and Modified Proctor compaction tests. The results are summarised in Table 2. The compaction characteristics of different fractions are shown in the Fig19.

Table 2 : Preliminary geotechnical characteristics of segregated MSW.

Property	Passing 35mm	Passing 16mm	Passing 4mm
Specific gravity	1.84	1.80	1.93
Plasticity characteristics	NP	NP	NP
Maximum Dry Density (MDD), KN/m ³	15.7	15.7	16.0

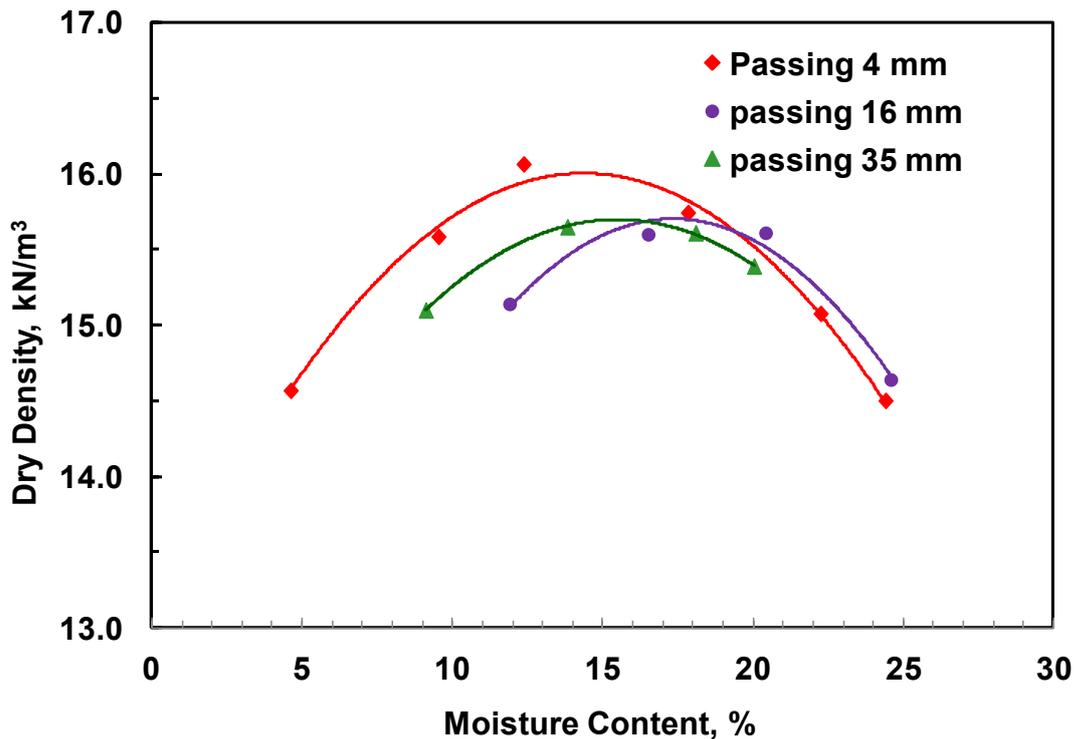


Fig 19:- Compaction curves for segregated MSW (5 Years)

Important conclusions drawn are given below:-

- a) There is no substantial difference in the Maximum Dry Density (MDD) of materials of different fractions (15.7 to 16 KN/m³). Also, as the sieve size reduces, there is a reduction in the amount of plastics and coarse aggregates as discussed earlier in Fig.18.. The balancing proportion between them may be the reason for insignificant change in the MDD. The optimum moisture content varied in the range 14 to 17%.
- b) In general, as the sieve size reduces, the specific gravity of the fraction increases.
- c) The fraction passing 35mm sieve also has substantial amount of plastics, textiles and papers and was considered unsuitable for embankment construction.
- d) The fraction passing 16mm sieve shows a minimal amount of plastics. Considering its higher quantity in MSW (44-48%) and its MDD satisfying the

MORTH specification, this fraction can be directly used for embankment construction.

3.3.2 Fractions retained on 35mm & 16mm

As per MORTH specifications, the soil less than 75mm can be used for embankment construction. It is observed from Table 1 that about 65-79% of MSW is passing through 80 mm sieve which needs to be effectively used for embankment construction. But the presence of considerable amount of plastics and textiles make it impractical for embankment construction. If these unsuitable materials are removed during segregation, the fraction passing 80 mm fraction can also be used directly in embankment. This would help in the bulk utilization of MSW in road construction.

In the segregation plant, the fraction passing 80mm passes through 35mm and 16mm sieves during the process of segregation. As discussed in Section 3, it has already been concluded that MSW passing 16mm sieve can be directly used for embankment construction. But It is observed that MSW retained on 35mm and 16mm sieve has good amount of C&D wastes/aggregates (20-32%) which needs to be effectively utilised for embankment construction. However, it has substantial amount of plastics, textiles and papers. If these unwanted removed by adopting some methodology in the plant, it can be effectively used in embankment construction.

To investigate the possibility of using MSW retained on 35mm and 16mm, a laboratory experiment was carried out. Two bags of MSW passing 80mm was dried in the open air (Fig.20). The dried material was then passed through 37.5mm sieve. The material retained on 37.5mm is collected in a tray. It was observed that this segregated material has aggregates with substantial amount of plastics. To remove the plastics, papers, textiles and other light material, an experimental setup simulating the fall of the material from the conveyor in the actual plant, was developed in the laboratory (Fig 21).

For simulating the high pressure blower, a table fan was placed. As the material is slowly allowed to fall, with the table fan in the running position, all the plastics, papers and other light weight material fell far away, while the heavier aggregates and other materials get collected right below .



Fig.20:- Fraction passing 80 mm



Fig.21:- Experimental setup for segregation of fractions retained on 37.5mm and 16mm

The material passing 37.5mm is then further passed through 16mm sieve. The MSW retained on 16mm is again separated from plastics, papers, textiles etc by air blowing as discussed above. Like earlier, The aggregates and other heavier material falls right below. The view of materials retained on 37.5mm and 16mm sieve before and after air blowing is shown in Fig. 22 (a,b) and Fig. 23 (a,b) respectively.

Material passing 16mm sieve is then mixed with material retained on 37.5mm and 16mm after airblowing which forms the final material for use in embankment construction (Fig 24).This is nothing but the material passing 80 mm sieve with removal of plastics, papers, textiles etc. The proposed methodology for segregation of the raw MSW before its use in embankment construction is shown in Fig.25.



Fig.22 (a) Fraction retained on 37.5mm sieve before air blowing



Fig.22 (b) Fraction retained on 37.5mm sieve after air blowing



Fig.23 (a) Fraction retained on 16mm sieve before air blowing



Fig.23 (b) Fraction retained on 16mm sieve after air blowing



Fig 24:-view of final material selected for embankment construction.

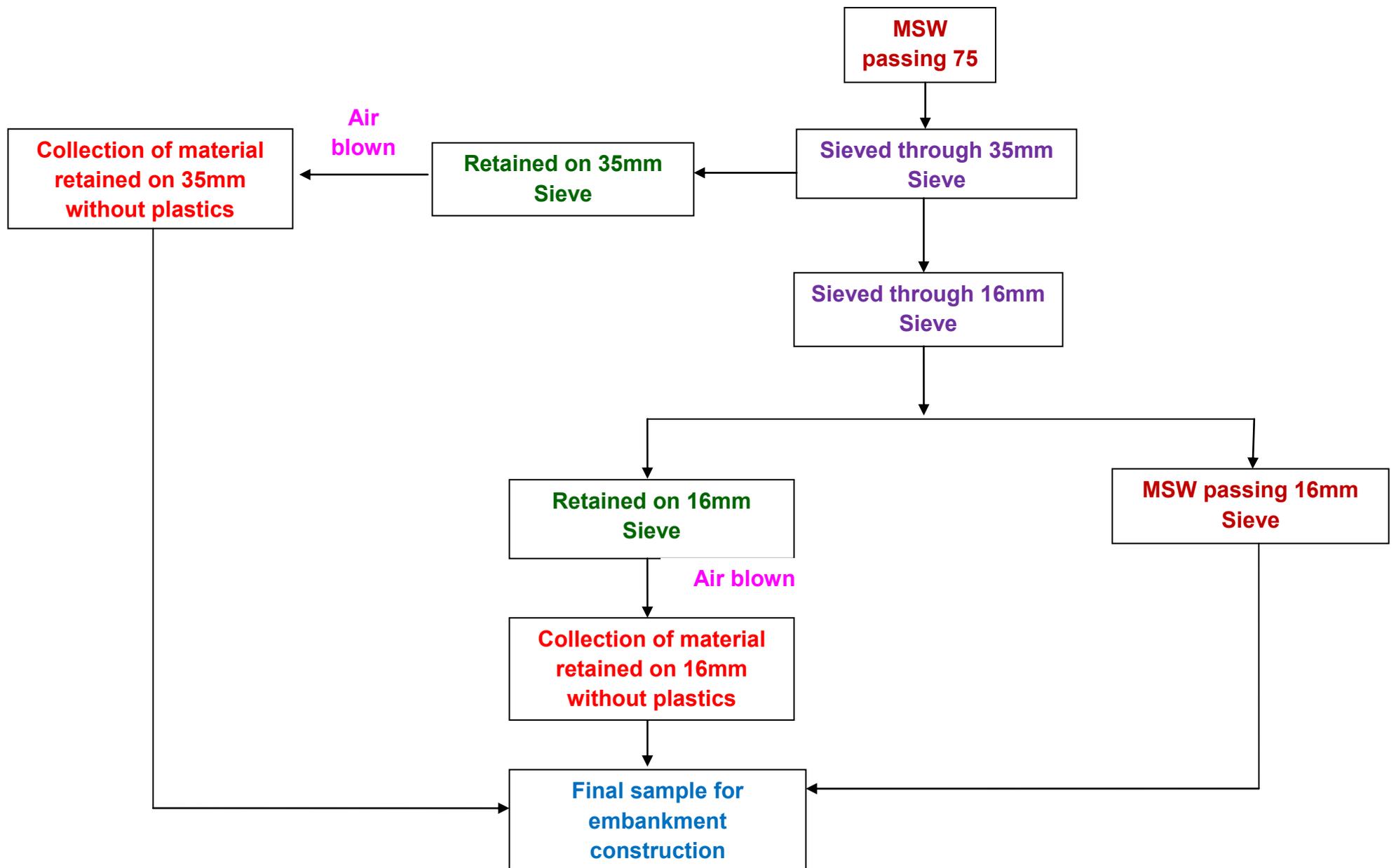


Fig .25:- Proposed methodology for segregation

4.0 PHYSICAL AND CHEMICAL CHARACTERISATION OF MSW

Physical and chemical characteristics of municipal solid waste are very important to know that the presence of different toxic metals and their possibility of polluting the underground water resources. About 500 gm of dry MSW passing 425 micron was dried and investigated for both physical and chemical characteristics by standard procedure in an NBA accredited laboratory. The results have been summarized in Tables 3, 4, 5.

Table 3. Physical and chemical characteristics of Municipal Solid Waste

Parameters	Units	A	B	C	Test Methods
pH	-	7.4	7.6	7.6	IS : 2720 (Part-26)
Moisture content	%	1.3	0.8	1.1	IS:2720(pt-2) 1973
Total nitrogen (N)	mg/kg	92.4	60.74	59.89	IS:14684 : 1999
Phosphorous (P)	mg/kg	36.96	28	20.7	IS: 10158- 1982
Nitrate (NO ₃)	mg/kg	10	<5.0	10.3	ICARDA
Nitrogen	mg/kg	92.4	60.74	59.89	IS : 14684 -1999
Electrical Conductivity	µs/cm	3017	1720	1935	APHA 22nd. Ed. 2012, 2510
Sulphur	mg/kg	5143	3001.2	3495.3	IARI manual for soil
Nitrite (NO ₂ -N)	mg/kg	<5.0	9	<5.0	APHA 4500 NO ₂ - B
C:N ratio	mg/kg	13.584	279:01:00	317:01:00	By conversion method
Total Inorganic Content	%	87	90.1	92.1	APHA 22nd EDN 2012.5910B
Chloride (Cl)	mg/kg	2563	1590	1843	Lab Sop No- 24(Section- 18)
Sulphate (SO ₄)	mg/kg	15430	9003.7	10485	IARI Manual for Soil
Calcium (Ca)	mg/kg	2718	1172.4	1225.5	APHA 22nd Edn.2012(3120. B)
Magnesium (Mg)	mg/kg	1020	890	868	USEPA 3050B/3051/3052
Organic Matter	%	5.17	2.93	3.3	IS : 2720 (Part - 22)
Cation Exchange Capacity	meq/100gm	40.41	31.5	44.59	IS:2720(pt-24) - 1976

Table 4: Heavy metals content in the leachate of MSW

Heavy Metals	A (mg/l)	B (mg/l)	C (mg/l)	Regulatory Limit (mg/l)	Test Methods
Antimony & antimony compounds	<0.03	<0.03	<0.03	15	USEPA:1311/30 50/3052
Arsenic & arsenic compounds	<0.03	<0.03	<0.03	5	USEPA:1311/30 50/3052
Cadmium & cadmium compounds	<0.1	<0.1	<0.1	1	USEPA:1311/30 50/3052
Mercury & mercury compounds	<0.1	<0.01	<0.01	0.2	USEPA:1311/30 50/3052
Selenium & selenium compounds	<0.03	<0.03	<0.03	1	USEPA:1311/30 50/3052
Total chromium compounds	<0.1	<0.014	0.032	5	USEPA:1311/30 50/3052
Cobalt compounds	<0.1	<0.1	<0.1	80	USEPA:1311/30 50/3052
Copper compounds	0.58	0.59	1.02	25	USEPA:1311/30 50/3052
Lead & lead compounds	<0.1	<<0.1	<0.1	5	USEPA:1311/30 50/3052
Molybdenum compounds	<0.1	<0.1	<<0.1	350	USEPA:1311/30 50/3052
Nickel compounds	0.13	0.23	0.33	20	USEPA:1311/30 50/3052

Regulatory limits as per HSW Rules 2016

Source: G.S.R 395 (E)[04-04-2016] : Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016

Table 5 Heavy metal content in the solid mass of MSW

Heavy Metals	A (mg/kg)	B (mg/kg)	C (mg/kg)	Regulatory Limit (mg/kg)	Test Methods
Antimony & antimony compounds	<1.0	<1.0	<1.0	50	USEPA:1311/3050/3052
Arsenic & arsenic compounds	<1.0	<1.0	<1.0	50	USEPA:1311/3050/3052
Cadmium & cadmium compounds	<2.0	<2.0	<2.0	50	USEPA:1311/3050/3052
Mercury & mercury compounds	<1.0	<1.0	<1.0	50	USEPA:1311/3050/3052
Selenium & selenium compounds	<1.0	<1.0	<1.0	50	USEPA:1311/3050/3052
Total chromium compounds	<2.0	<2.0	<2.0	5000	USEPA:1311/3050/3052
Cobalt compounds	<2.0	<2.0	<2.0	5000	USEPA:1311/3050/3052
Copper compounds	11.6	11.6	20	5000	USEPA:1311/3050/3052
Lead & lead compounds	<2.0	<2.0	<2.0	5000	USEPA:1311/3050/3052
Molybdenum compounds	<2.0	<2.0	<2.0	5000	USEPA:1311/3050/3052
Nickel compounds	2	4	6	5000	USEPA:1311/3050/3052

Regulatory limits as per HSW Rules 2016

Source: G.S.R 395 (E)[04-04-**2016**] : Hazardous and Other Wastes (Management and Transboundary Movement) **Rules, 2016**

It was observed that the value of pH is in the range of 7.4 to 7.6 for three different age samples. This indicates that MSW sample is slightly acidic in nature. Based on the leachate result, it can be concluded that MSW is non hazardous material as concentration of heavy metals is within the permissible limit.

5.0 GEOTECHNICAL CHARACTERISATION

Based on the segregation methodology proposed, three samples of MSW passing 80 mm of different ages are prepared in the laboratory. These materials were investigated for their geotechnical characteristics viz. grain size analysis, plasticity characteristics, compaction characteristics, shear strength, consolidation and permeability characteristics. The results of different geotechnical characteristics are discussed below;

5.1 Grain size analysis: Dry sieve analysis and hydrometer analysis were carried out as per IS: 2720 (Part 4) – 1985 to determine the variation in grain size characteristics. Different grain sizes present in MSW of different ages are given in Table 6.

Table 6. Results of grain size analysis

Grain Size	5 Years	10 Years	15 Years
Gravel (%)	39	38	31
Sand (%)	32.5	30	37
Silt (%)	24	27	27
Clay (%)	4.5	5	5

It is observed that the mix consists of about 70% of gravel and sand mix size with clay constituents of about 5%. The grain size distribution curves for MSW of different ages are shown in the Fig 26. The shape of different curves follows the same pattern as it is artificially prepared mix as per methodology shown in Fig.25. The MSW is concluded to be a coarse grained material with about 70% of its particles retained on 75 micron IS sieve. The MSW can be classified as GM, i.e. silty gravel which indicates its suitability for embankment construction.

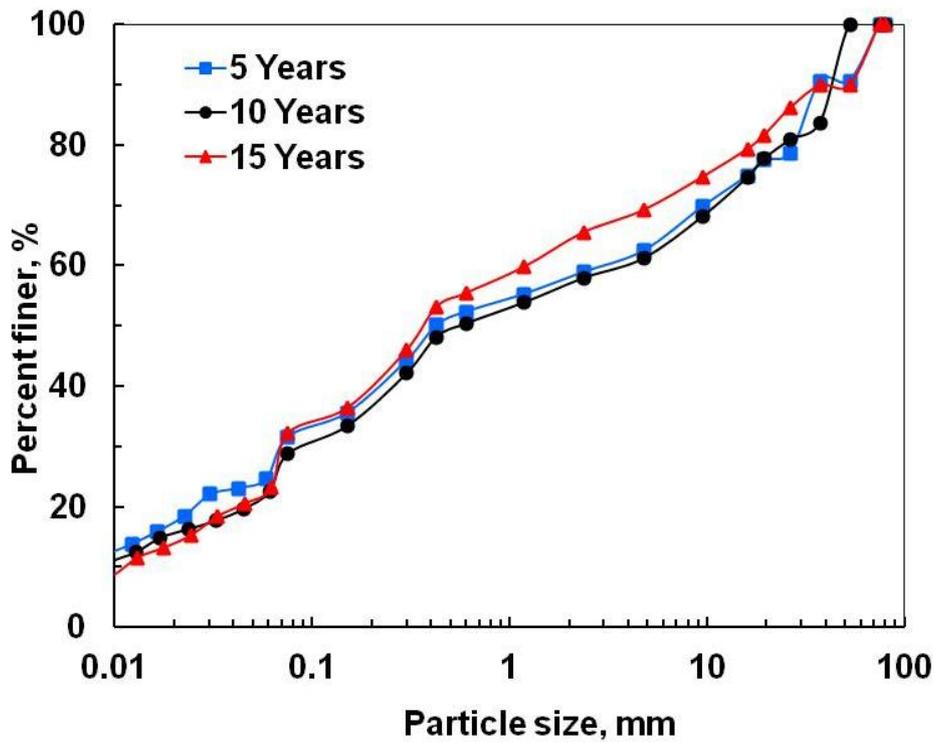


Fig. 26:- Grain size distribution curves of MSW samples

5.2 Atterberg limit test: The plasticity characteristics of different samples of MSW were determined as per IS: 2720 (Part 5) – 1985. The results indicated that it is non-plastic in nature. However, the liquid limit of different samples ranged between 32-34% indicating its medium plasticity characteristics, may be because of absorption of water by organic humus content present in the MSW.

5.3 Free Swell Index Test: Free swell index test was carried out as per IS:2720-Part 40. The swelling Index values ranged between 12-24% (Table 7). The values indicate that the MSW in general, is a low swelling material.

Table 7. Results of Free Swelling index test

Sl.No.	5 Years	10 Years	15 Years
1	24	14	12

5.4 Proctor Modified compaction test: Compaction characteristics of different samples were studied by carrying out Modified Proctor compaction tests as per IS: 2720 (Part 8) -1983. The variation of Maximum Dry Density (MDD) with Moisture content is shown in the Fig. 27.

The compaction curves are found to be flat indicating that dry density does not vary much with the variation in moisture content. The MDD varied in the range 16 – 16.7 kN/m³ and OMC in the range between 14 to 17%.The material could be used for more than 3m height embankment as per MORTH specifications, however stability analysis considering prevailing site conditions needs to be carried out before construction.

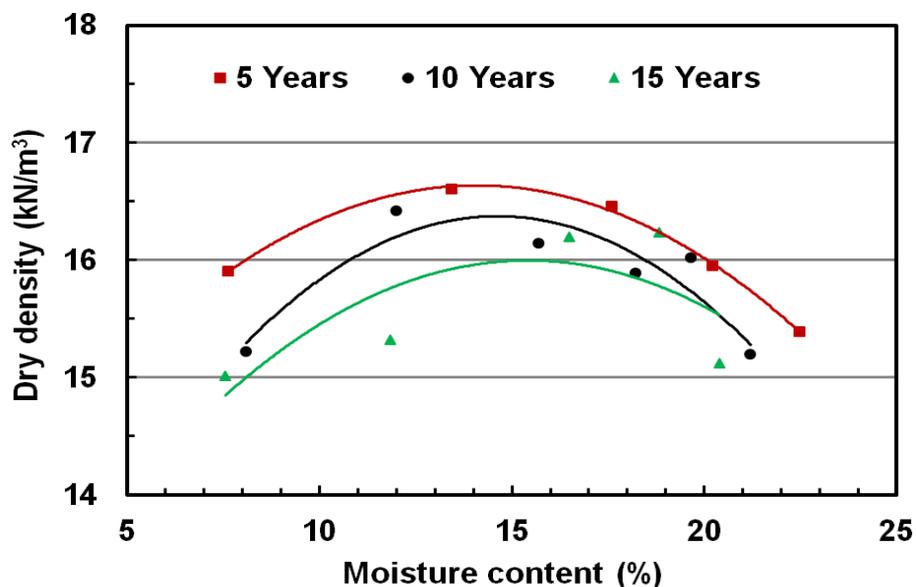


Fig. 27:-Compaction curves for different MSW samples

5.5 Direct shear test . Shear strength characteristics of different samples of MSW were studied as per as per IS: 2720 (Part 13)-1986. The test was carried out on compacted sample of size 6 cm x 6 cm x 2.5 cm at different normal stresses. The sample was compacted at its Optimum Moisture Content (OMC) to Maximum Dry Density (MDD). The sample was tested under the saturated condition. The normal stress varied in the range of 50 to 150 kN/m². The sample was then sheared at the rate of 0.625 mm/min. The variation of shear stress with shear displacement and

shear parameters evaluated for MSW sample (10 years old) is shown in Fig. 28 and 29 respectively. The volumetric behaviour as shown in Figure 30 which shows compression and dilation behaviour similar to conventional soil. The results of Direct Shear Test of MSW have been summarised in the Table 8.

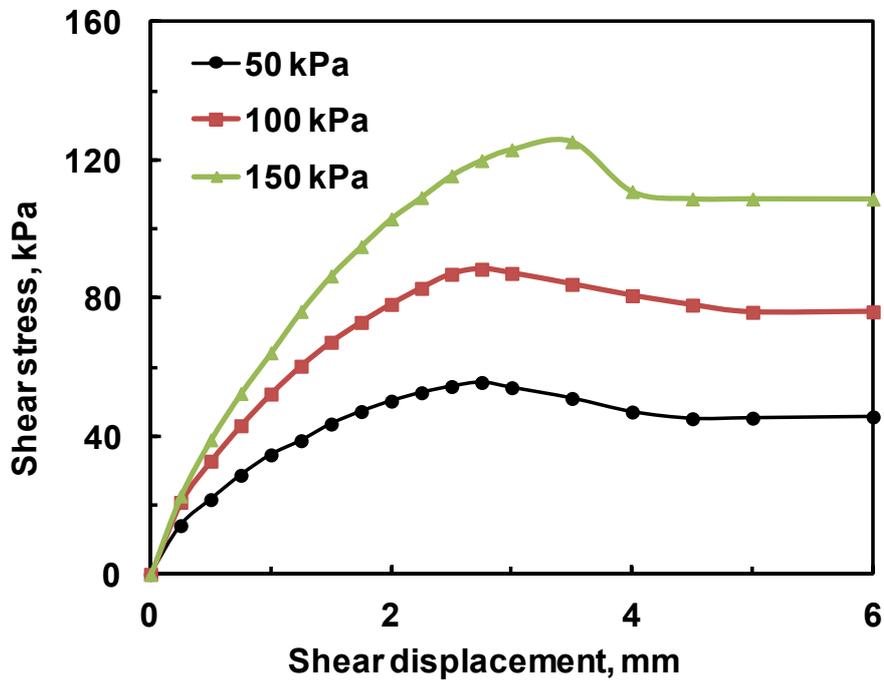


Fig. 28:- Shear stress-displacement curves for Municipal Solid Waste

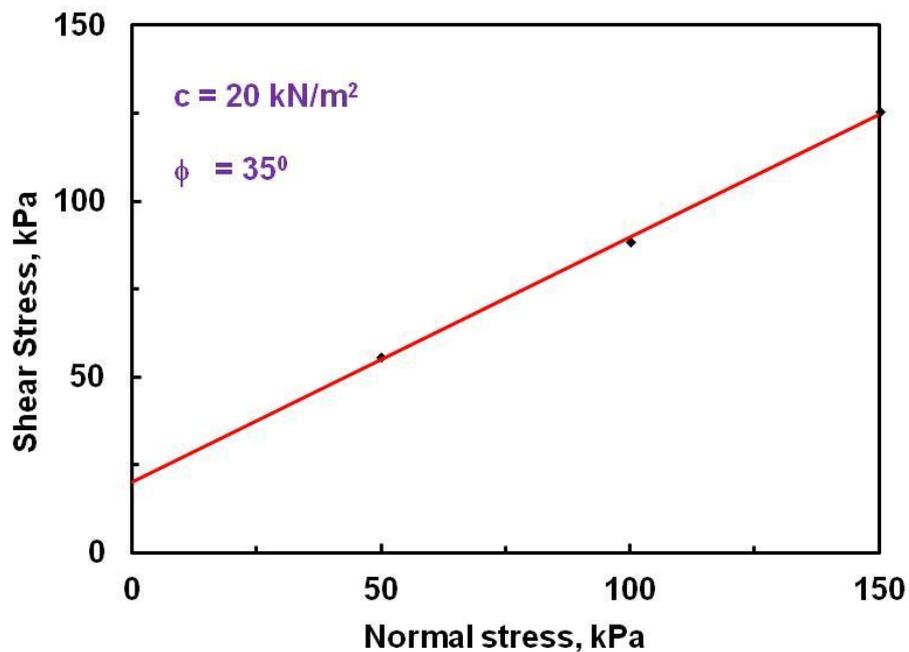


Fig.29:- Shear parameters of Municipal Solid Waste

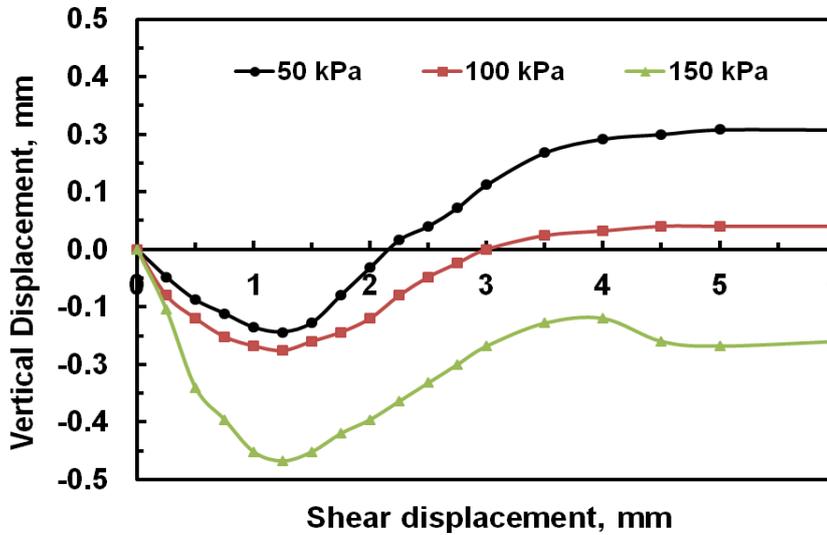


Fig. 30:- Volumetric behaviour of Municipal Solid Waste

Table 8:- Results of Direct shear test for different samples of MSW

Sl.No.	5 Years		10 Years		15 Years	
	c kN/m ²	Φ^0	c kN/m ²	Φ^0	c kN/m ²	Φ^0
1	20	35	25	28	10	38
2	Shear displacement @failure= 2.5mm-3.5mm					

5.6 Consolidation Test: Consolidation test was carried out as per IS:2720-Part 15. in an Oedometer for a specimen of 60 mm diameter and 20 mm thickness under double drainage conditions. Remoulded samples of MSW (passing 4.75 mm sieve) was prepared at Maximum Dry Density and OMC. Samples were saturated for 24 hours at an initial seating stress of 0.025 kN/m². Seating load was maintained for 24 hours. The specimen was then consolidated under initial stress of 5 kN/m² and settlement dial gauge reading was recorded at 0, 0.25, 1, 2.25, 4, 6.25, 9, 16, 25, 36,

49, 64, 81, 100, 121, 144, 169, 196, 225, 256, 289, 324, 361, 400, 500, 600, and 1440 minutes or until equilibrium is reached. The procedure was repeated for different normal stress viz. 9.8, 19.6, 39.2, 79, 157, 314, and 628 kN/m² and for each normal stress time settlement reading was recorded up to 24 hours. Fig 31 indicates e-log p curve as determined for MSW (10 Years).

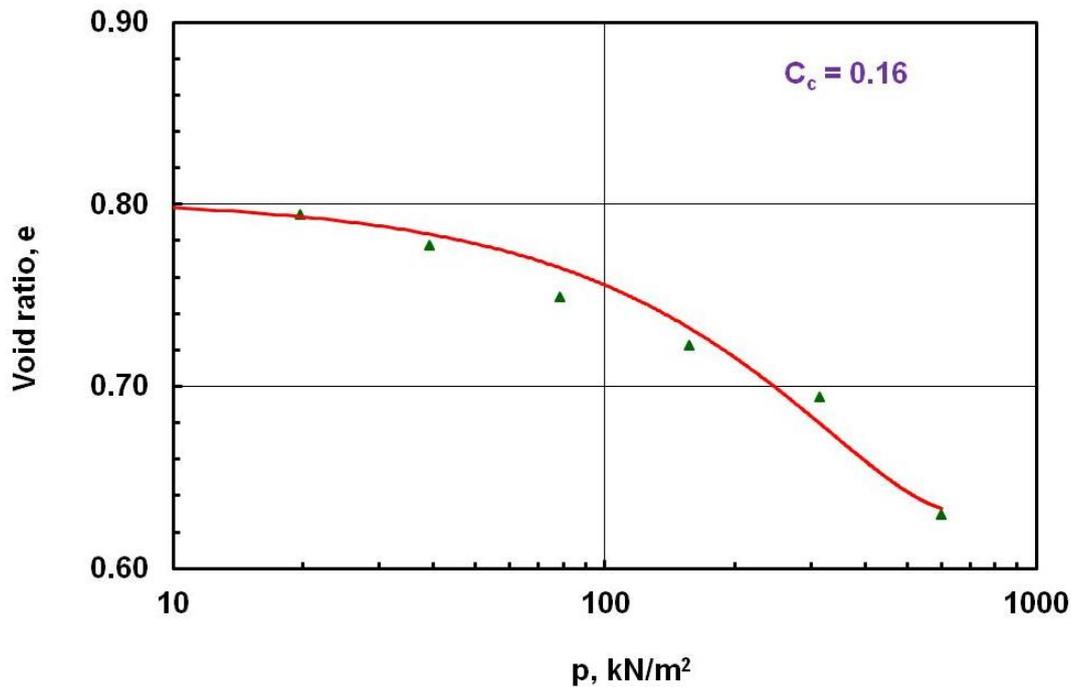


Fig. 31 e –log p curve for Municipal Solid Waste

The value of coefficient of compression index is estimated as 0.16. The value indicates that MSW material is a low to medium compressible soil. Fig.32 shows compression of MSW with time at different normal stresses. The average value of coefficient of consolidation in the stress range 79-628 kN/m² is estimated as 4.14×10^{-6} m²/sec which is similar to that of conventional silty soils.

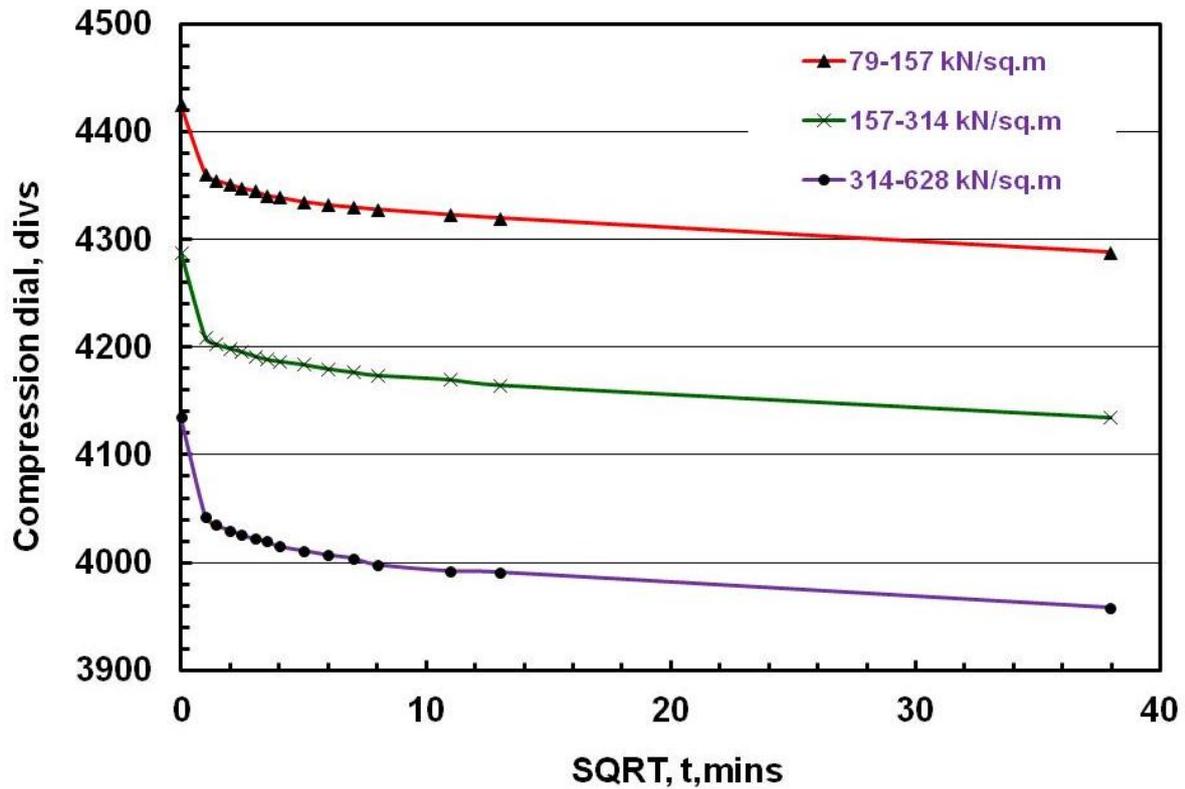


Fig 32. Compression-time curves for MSW

Table.9 Results of consolidation test for different samples of MSW

Sl.No.	5 Years		10 Years		15 Years	
	C_c m^2/kN	C_v m^2/sec	C_c m^2/kN	C_v m^2/sec	C_c m^2/kN	C_v m^2/sec
1	0.141	$2.43 \cdot 10^{-6}$	0.160	$4.14 \cdot 10^{-6}$	0.190	$5.56 \cdot 10^{-6}$

5.7 Permeability Test

Permeability test was carried out as per Indian standard procedure (IS 2710 Part 17). Remoulded samples of size 100 mm diameter and 127.3 mm height in cylindrical mould were prepared at 95 % of MDD and OMC. Samples were first

saturated and water was allowed to flow through the samples. Time in second was measured for flow of water from height h_1 to h_2 . Permeability was determined using equation. 1.

$$k = 2.3 \frac{aL}{At} \log_{10} \left[\frac{h_1}{h_2} \right] \quad (1)$$

Where,

L - Length of specimen, cm

A - Cross sectional area of specimen, cm^2

t - Time interval, sec.

h_1 - Initial head, cm

h_2 - Final head, cm

a - Cross sectional area of stand pipe, cm^2

The results of Permeability test of different types of MSW have been summarised in Table 10.

Table 10:- Results of permeability test

Sl.No.	Permeability, cm/s		
	5 Years	10 Years	15 Years
1	1.21×10^{-6}	1.55×10^{-7}	2.13×10^{-7}

The Permeability of different types of the MSW varies in the range 1.55×10^{-7} to 1.21×10^{-6} cm/s. The low value of the Permeability observed is due to presence of plastics, rubber etc in the MSW mix which obstructed the flow of water through the mix. So it is required to provide a intermediate suitable layer for the proper drainage of MSW embankment. Summary of geotechnical characteristics of different samples of Municipal Solid Wastes has been summerized in Table 11.

Table :- 11 Summary of Geotechnical characteristics of Municipal Solid Wastes (MSW)

Property	5 Years Old	10 Years Old	15 Years Old
<i>Grain size analysis</i>			
Gravel (%)	39	38	31
Sand (%)	32.50	30	37
Silt (%)	24	27	27
Clay (%)	4.5	5	5
<i>Atterberg limit test</i>			
Liquid limit (%)	34	33	32
Plastic limit (%)	NA	NA	NA
Plasticity index	NP	NP	NP
<i>Free Swell Index test</i>			
FSI (%)	24	14	12
<i>Modified Proctor test</i>			
MDD (kN/m ²)	16.7	16	15.5
OMC (%)	19	15	17
<i>Direct shear test (saturated)</i>			
c (kN/m ²)	20	25	10
φ (degree)	35	28	38
<i>Permeability test</i>			
Coefficient of permeability (cm/sec)	1.21 x 10 ⁻⁶	1.55 x 10 ⁻⁷	2.13 x 10 ⁻⁷
<i>Consolidation test</i>			
C _c (m ² /kN)	0.141	0.160	0.190
C _v (m ² /sec)	2.43X10 ⁻⁶	4.14X10 ⁻⁶	5.56X10 ⁻⁶

6.0 DESIGN OF MUNICIPAL SOLID WASTE EMBANKMENT

The design of embankment with MSW is similar to earthen embankments. It has been proposed by NHAI, that the Municipal Solid Waste needs to be tried in the widening of NH-24 in East Delhi. The existing 6 lane is proposed to be widened to 14 lanes. Based on the cross section details provided by NHAI, the material could be effectively used in Package 1 of the project (Hazarat Nijamuddin to UP Gate) . The height of embankment varied in the range 2m – 4m. Typical designs have been suggested for 3m and 5m high MSW embankment.

The Municipal Solid Waste embankment is designed as a composite structure with MSW in the core and a cover of good earth cover on either side. It is proposed to provide 2 m thick soil cover (Measured horizontally) of local non plastic Delhi silt, to prevent the possible erosion of MSW due to heterogeneity in the mix and to protect the local inhabitants from bad odour. This would also add stability to the MSW embankment. Two intermediate soil layers of 200 mm each compacted thickness are proposed to be provided for MSW embankment more than 3m height. Apart from practical feasibility this would provide good drainage in the MSW embankment. A 500 mm thick local Delhi soil is also proposed on top of the MSW embankment, which will not only acts as a top cover but will also form the sub-grade for pavement construction.

As the MSW embankment is to be used in the widened portion (4 lanes on either side of an existing 6 lane road), large amount of surface water is expected to flow over the embankment slope and may result in its erosion. Considering this phenomenon, a 0.3m thick stone pitching over a 0.2m designed filter media is proposed on the slope of the MSW embankment. Considering the critical condition of flood in the river Yamuna, it is also proposed to provide a toe retaining wall for both 3m height and 5m height MSW embankment. This will also prevent under cutting of the toe of the MSW embankment during possible flood. However towards the built up area, no toe retaining wall is required.

6.1 Stability analysis

The MSW embankment of height 3 m and 5 m with side slope of 2 horizontal to 1 vertical, was analyzed for its slope failure. The shear strength parameters (c and ϕ), bulk density (γ_{bulk}), of different fill materials viz. MSW, cover soil and sub soil, as determined from the laboratory/field tests were used for stability analysis. The MSW embankment was analyzed under partially saturation, saturation up to H.F.L and under sudden draw down conditions. The traffic and other live loads on the top of embankment are considered as 24 kN/m^2 .

Analysis was carried out considering with and without the seismic forces separately for 3m and 5m height MSW embankment and also with and without Toe retaining wall. The basic seismic coefficients considered in the analysis are $\alpha_h = 0.05$ (horizontal) and $\alpha_v = 0.025$ (vertical) as per BIS code. Analysis was carried out using a computer software. Typical stability analysis for 3m & 5m MSW embankments is shown in Figures 33 to 36 respectively. Final cross sections for field construction is shown in Figures are shown in Figures 41 to 44 respectively.

Factor of safety values determined for different heights of MSW embankments are shown in Table 12 and 13. It is observed that Factor of safety values for critical draw down conditions under seismic conditions varied in the range 1.64 to 1.79 which is more than the minimum value of 1.25 required as per IRC-75 specifications.

Table:- 12 Factor of safety values for MSW embankment without Toe Retaining Wall (Built up area)

Compacted condition of embankment	Embankment height			
	3m		5m	
	Without seismic	With seismic	Without seismic	With seismic
Partially saturated	2.78	2.41	2.39	2.11
Fully saturated	2.66	2.11	2.49	1.98
Draw Down Condition	2.33	1.98	2.09	1.79

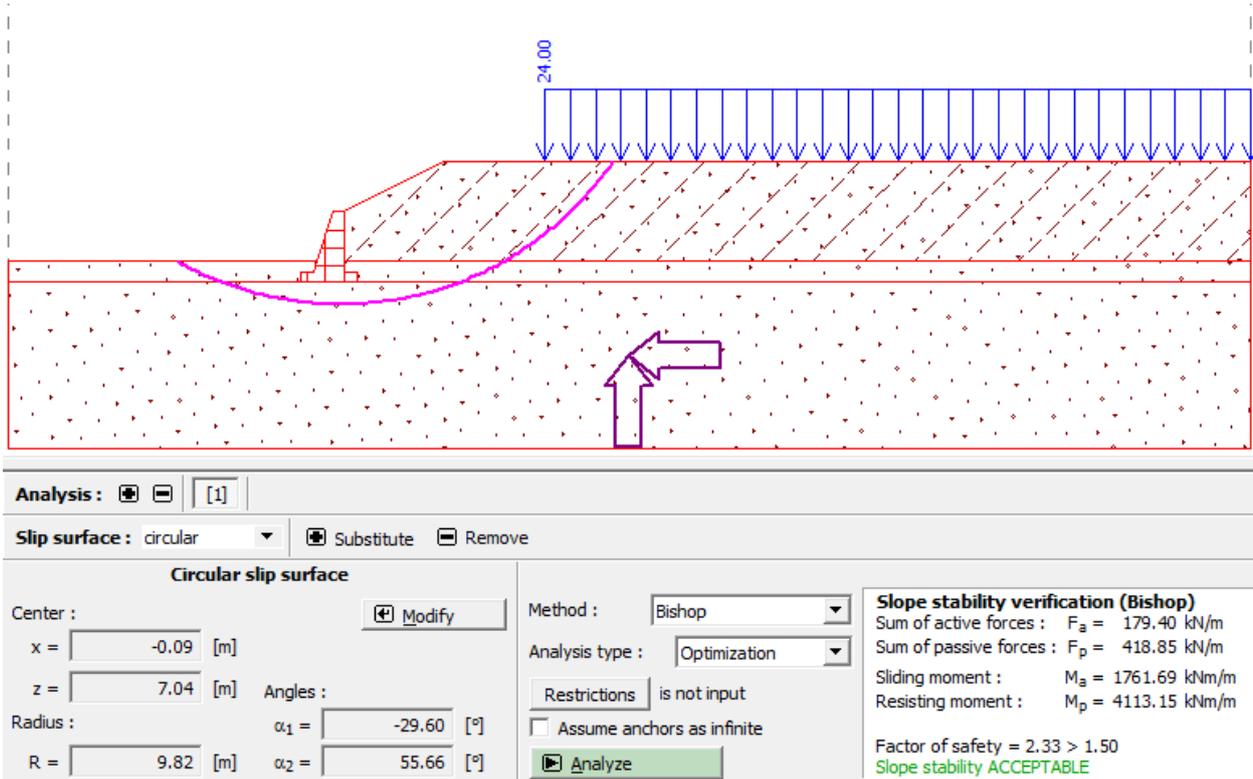


Fig.33 Typical result of stability analysis for a 3m Height MSW embankment (River side)

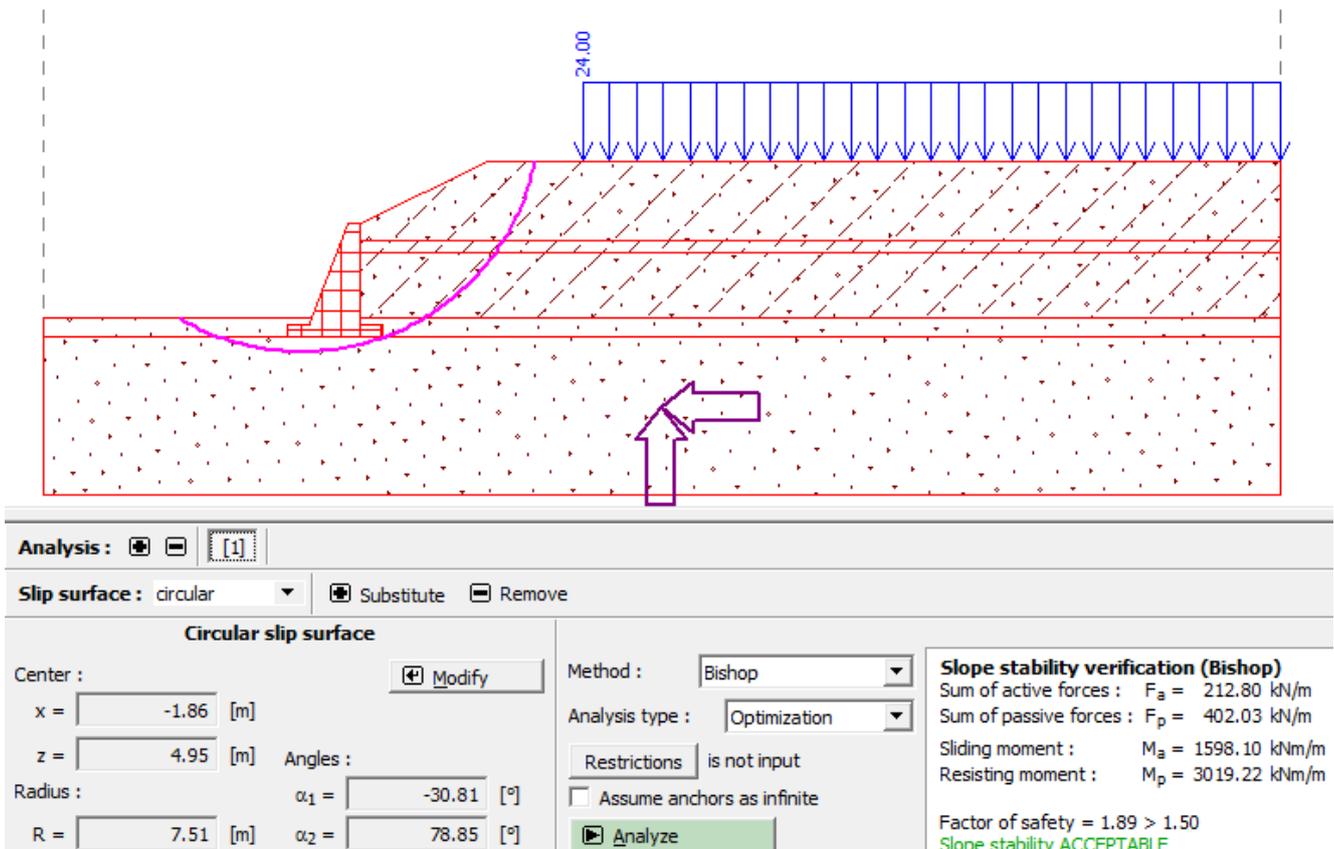


Fig.34 Typical result of stability analysis for a 5m Height MSW embankment (River side)

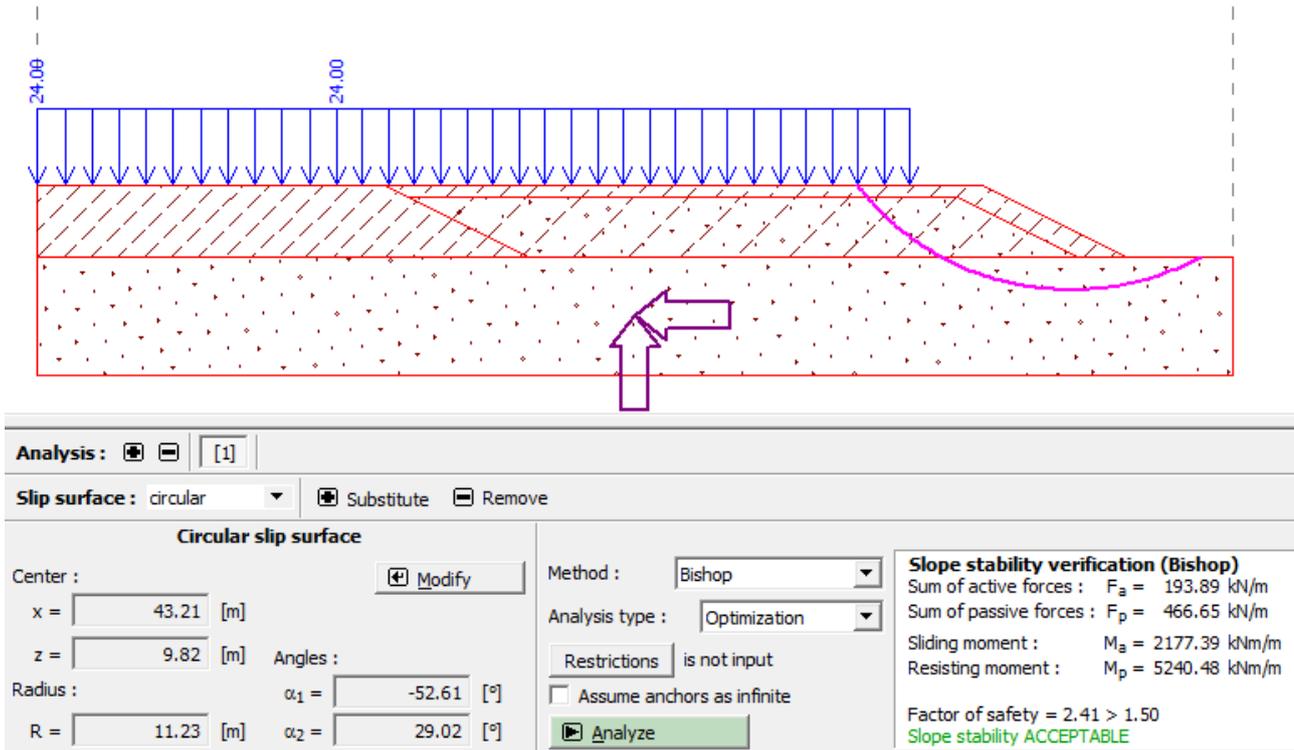


Fig.35 Typical result of stability analysis for a 3m Height MSW embankment (Built up area)

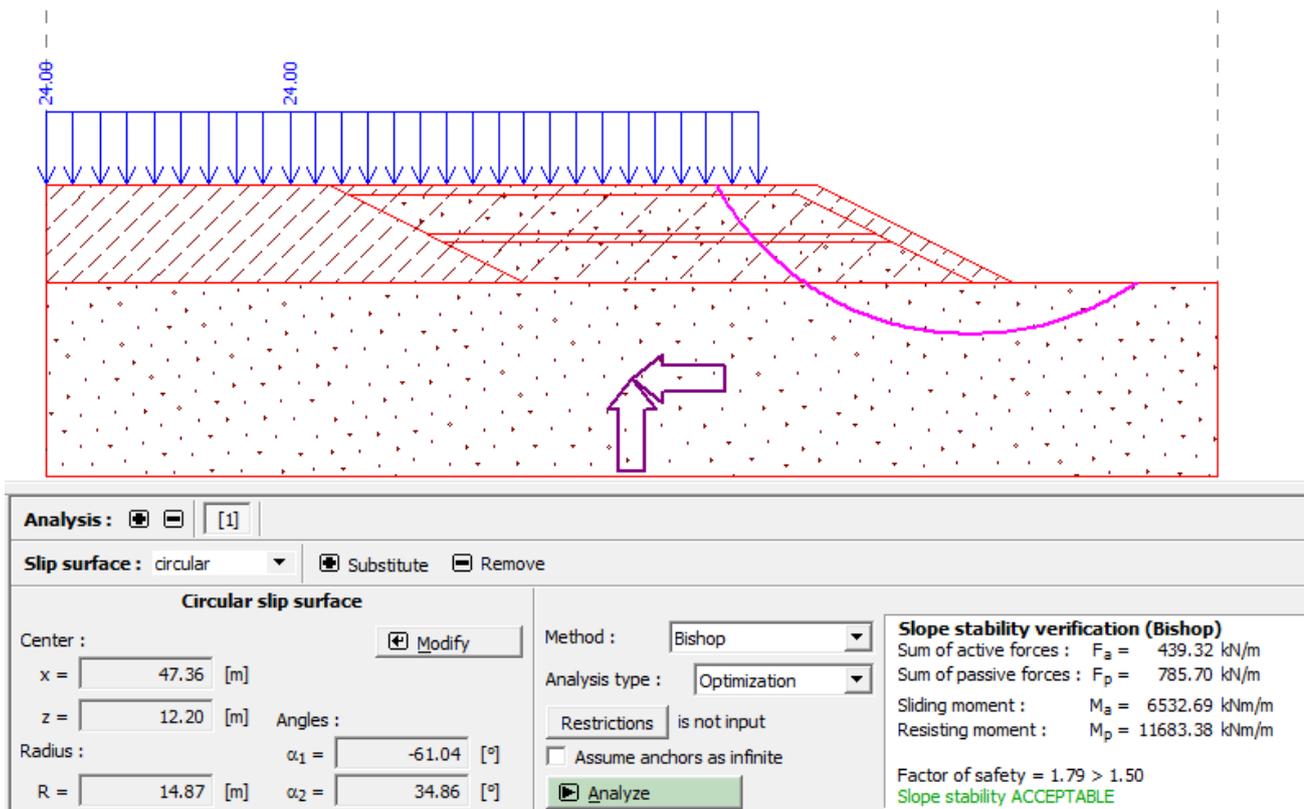


Fig.36 Typical result of stability analysis for a 5m Height MSW embankment (Built up area)

Table:-13 Factor of safety values for MSW embankment with Toe Retaining Wall (River Side)

Compacted condition of embankment	Embankment height			
	3m		5m	
	Without seismic	With seismic	Without seismic	With seismic
Partially saturated	2.66	2.33	2.05	1.89
Fully saturated	2.28	1.95	1.98	1.70
Draw Down Condition	2.26	1.93	1.83	1.64

7.0 SETTLEMENT ANALYSIS

Prediction of total settlement is very important in the case of MSW embankment fill. Total settlement is estimated as sum of (1) Settlement of MSW embankment fill itself (2) Settlement of sub soil. In both the cases, both Primary and secondary consolidation settlement was considered in the analysis. In the case of determination of secondary settlement of MSW embankment the long term compression associated with creep and biodegradation was also considered. Details of calculations are given below.

7.1 Primary Consolidation settlement

The Primary consolidation settlement of MSW was calculated using using equation 1 as given below.

$$S = \frac{H}{1+e_0} C_c \log \frac{\sigma_0 + \Delta\sigma}{\sigma_0} \quad (2)$$

S = Primary compression occurring in the layer under consideration, m

H = Initial thickness of the MSW/subsoil layer under consideration, 3 m and 5m

e_0 = Initial void ratio of the layer, 0.85 (MSW), 0.55 (Sub soil)

C_c = Primary compression index from consolidation test ($C_c=0.16$ (MSW), $C_c=0.1$ (Sub soil))

σ_0 = Existing overburden pressure acting at the middle level of the embankment/ sub soil layer

$\Delta\sigma$ = increment of overburden pressure at the middle level of the layer, 24 kN/m² (MSW), 116 kN/m² (Sub soil)

7.2 Secondary Settlement

Generally, it is observed that land fill settlement varies significantly depending on specific waste types and placement methods. The long-term compression associated with creep and biodegradation phenomena is expressed in terms of the secondary settlement/ compression index C_α in which a decrease in the void ratio during the secondary compression is related to the time elapsed between the initial time t_1 and the final time t_2 . The MSW may decompose due to moist condition and may increase with time (Sowers, 1973). Secondary settlement was calculated by using Sowers (1973) equation 3 as given below.

$$S_s = \frac{H}{1+e_0} C_\alpha \log \frac{t_2}{t_1} \quad (3)$$

S_s = Secondary compression occurring in layer under consideration

C_α = Secondary compression index = 0.04 C_c for inorganic silt, 0.06 C_c for organic silt

t_1 = starting time for the long-term time period under consideration = 1 month

t_2 = ending time for the long-term time period under consideration = $20 \times 12 = 240$ months.

H = 3m & 5m,

$e_0 = 0.85$ (MSW), 0.55 (Sub soil)

The results of settlement analysis have been summarised in Table 14. It is observed that the total settlement estimated theoretically for both 3m and 5m MSW embankment ranges between 244 mm to 304 mm. The analysis was also carried out using computer software as shown in Figures 37 to 40. The total settlement was estimated as 303 mm and 461 mm for 3m and 5m respectively.

However these settlements are much less than the allowable settlement of 300 mm to 600 mm considered for Road embankment. The total settlement shall be uniform and shall occur slowly over a period of time.

Table:-14 Results of Settlement analysis

Sl. No	Height of Embankment	Municipal Solid Waste		Sub-soil	Total Settlement
		Primary Consolidation Settlement mm	Secondary Consolidation Settlement mm	Primary Consolidation Settlement mm	
1	3m	71	37	136	244
2	5m	79	52	173	304

Final Cross sections for field construction for 3m & 5m high embankment for both River side and Built up area are shown in Figures 41 to 44.

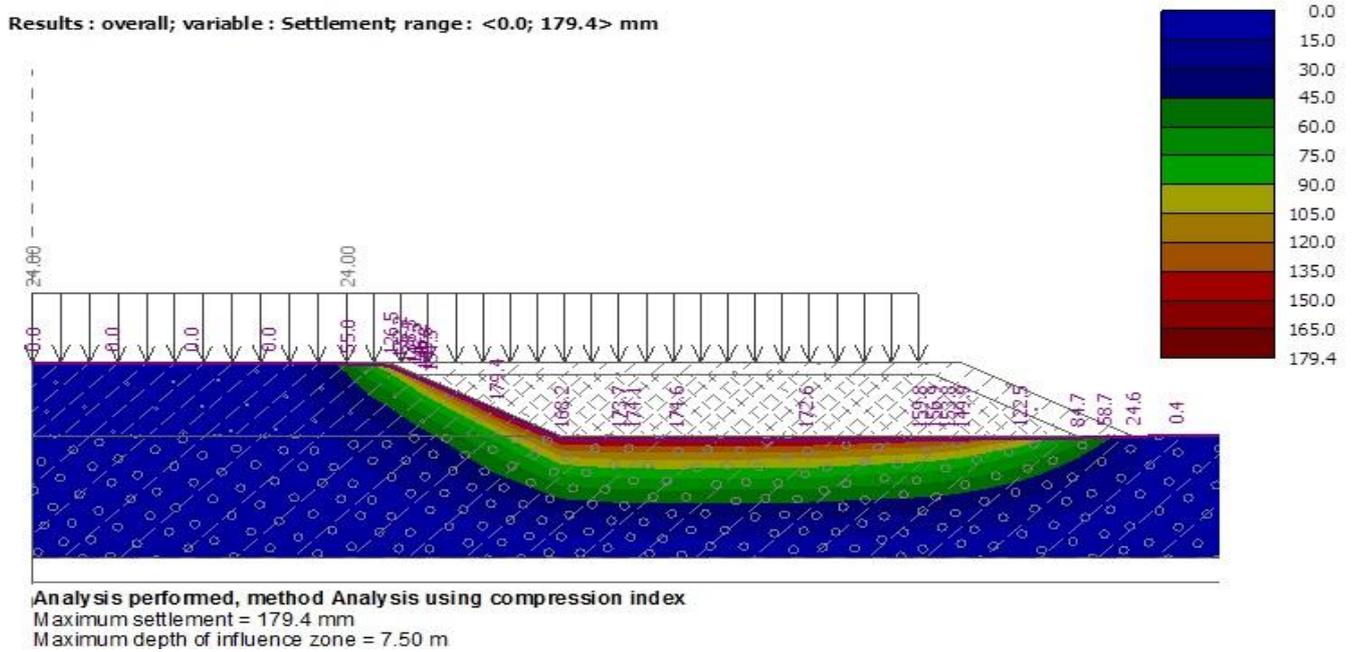


Figure 37: Settlement profile of sub soil for 3m MSW embankment

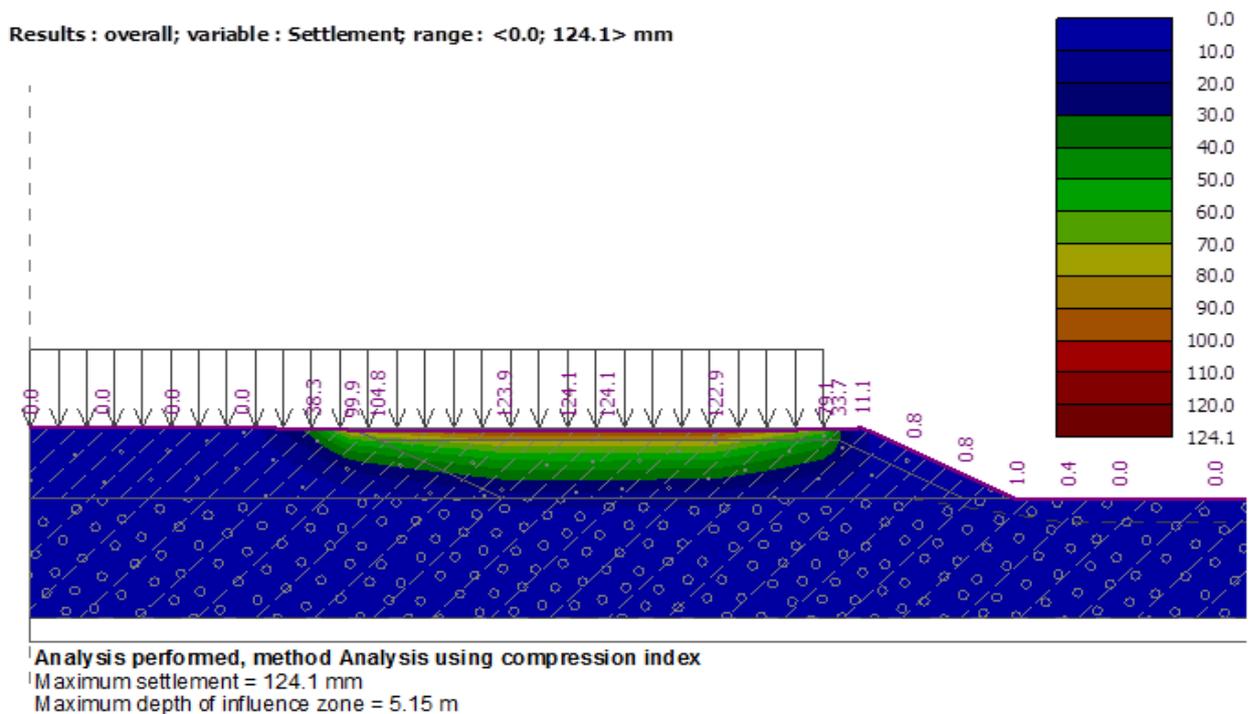


Fig.38 Settlement profile of 3m MSW embankment compression fill

Results : overall; variable : Settlement; range : <0.0; 321.3> mm

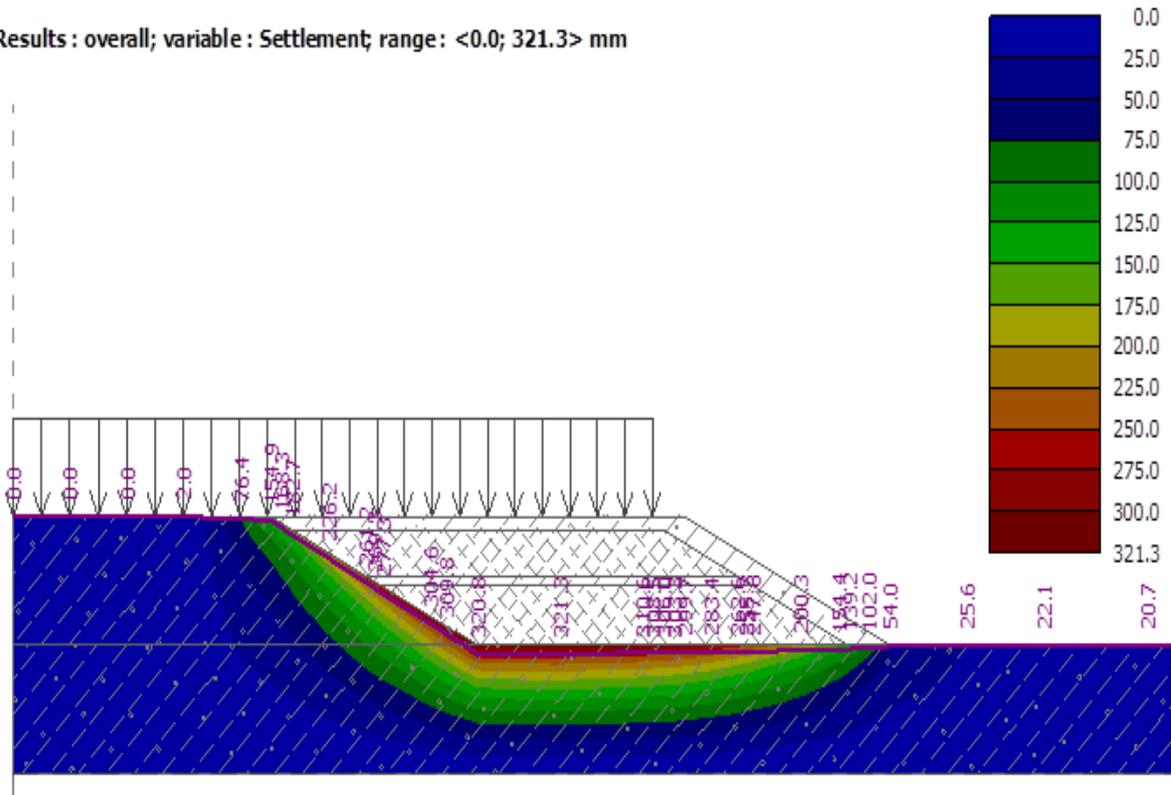


Fig.39: Settlement profile of sub soil for 5m MSW embankment

Results : overall; variable : Settlement; range : <0.0; 140.4> mm

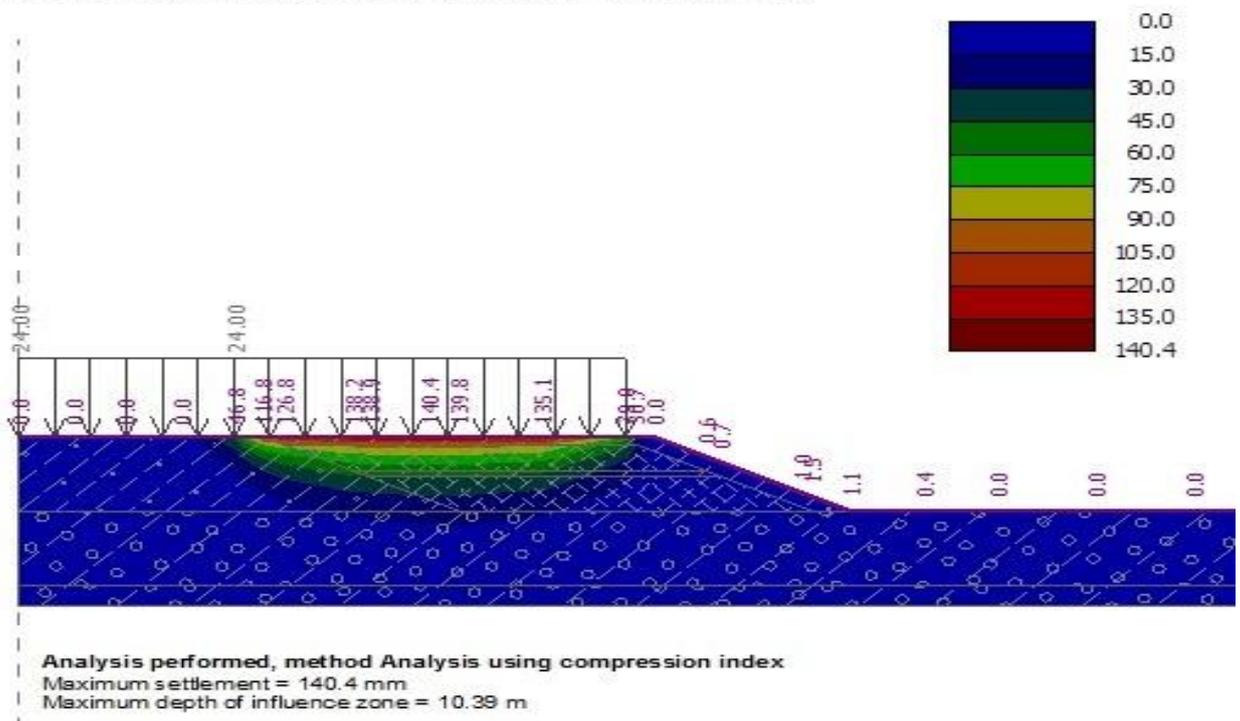


Fig.40: Settlement profile for 5m MSW embankment compression fill

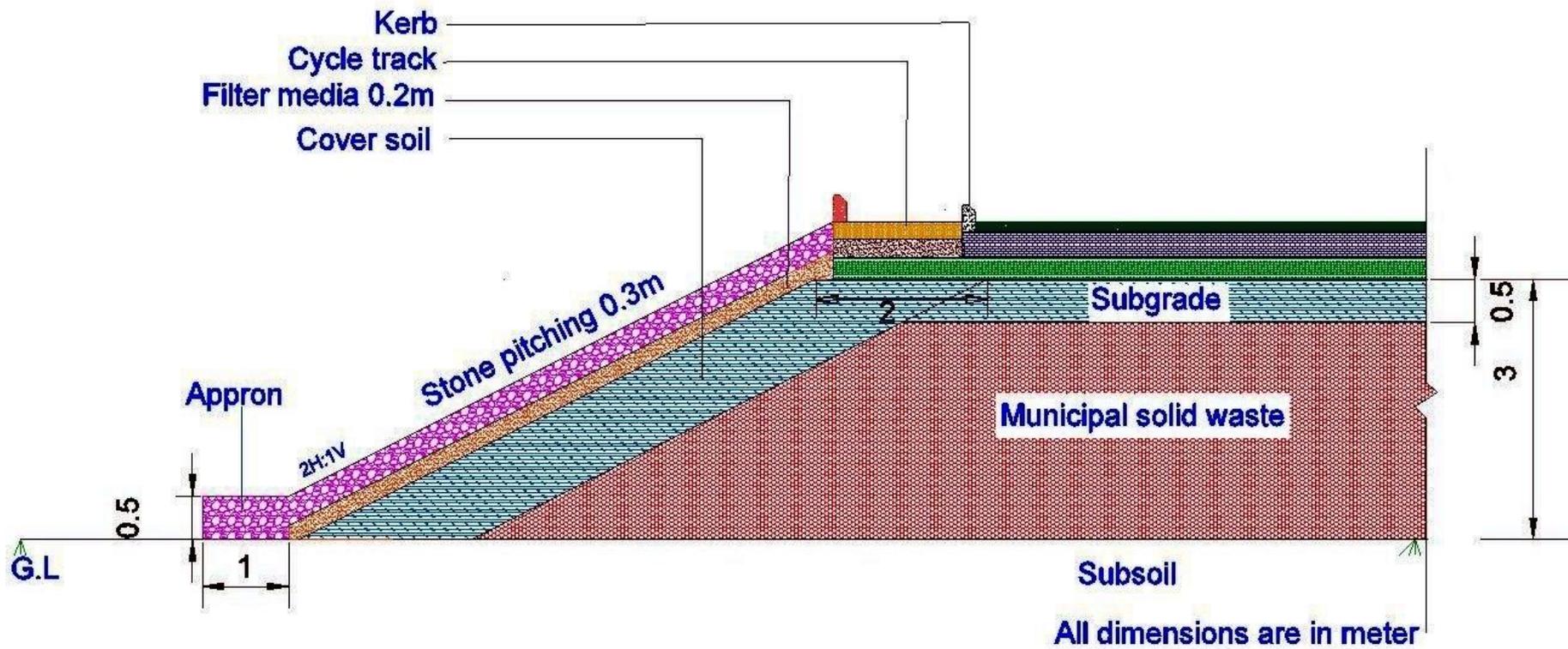


Fig. 41 Cross –section for construction of 3m Height MSW embankment (Built up Area)

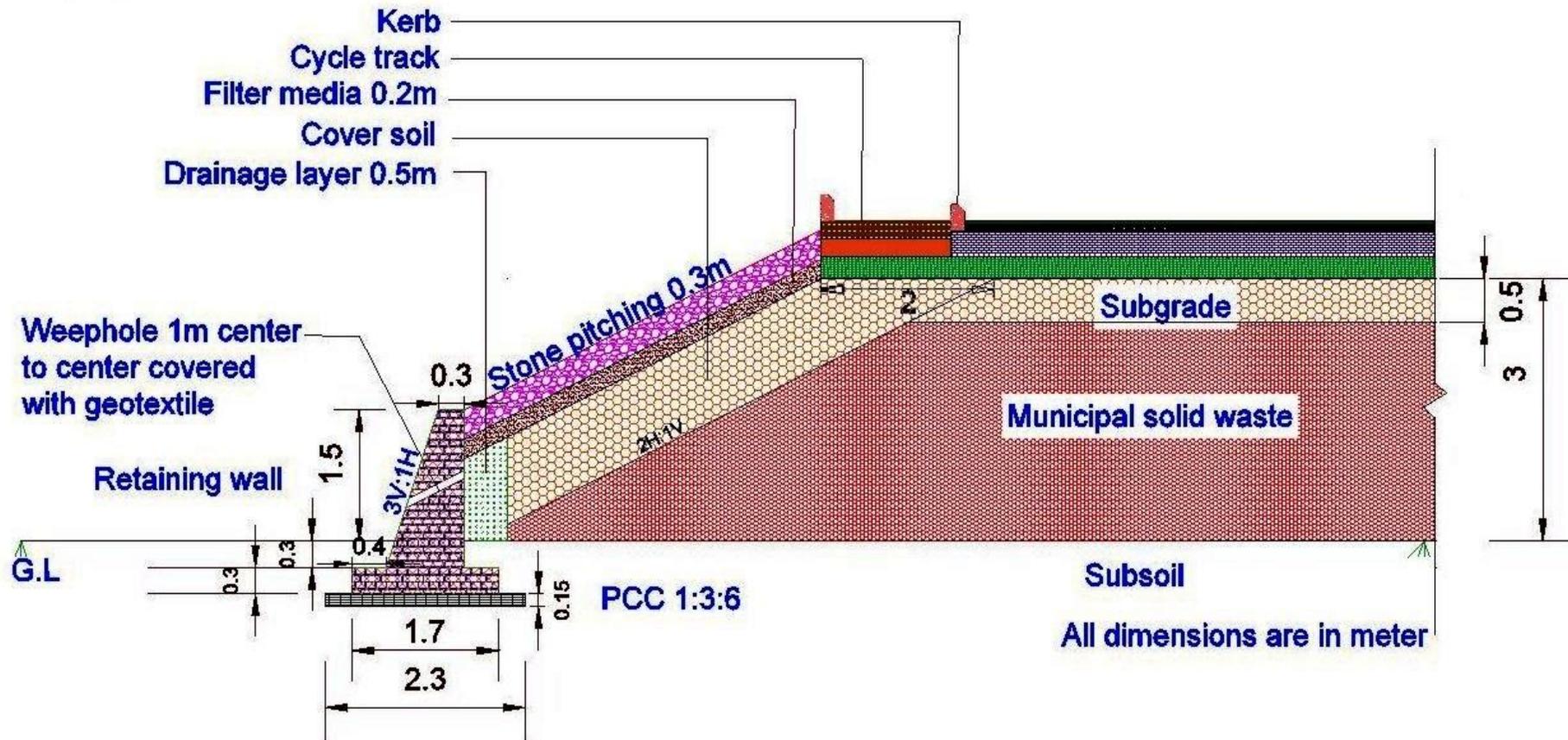


Fig. 42 Cross –section for construction of 3m Height MSW embankment (River side)

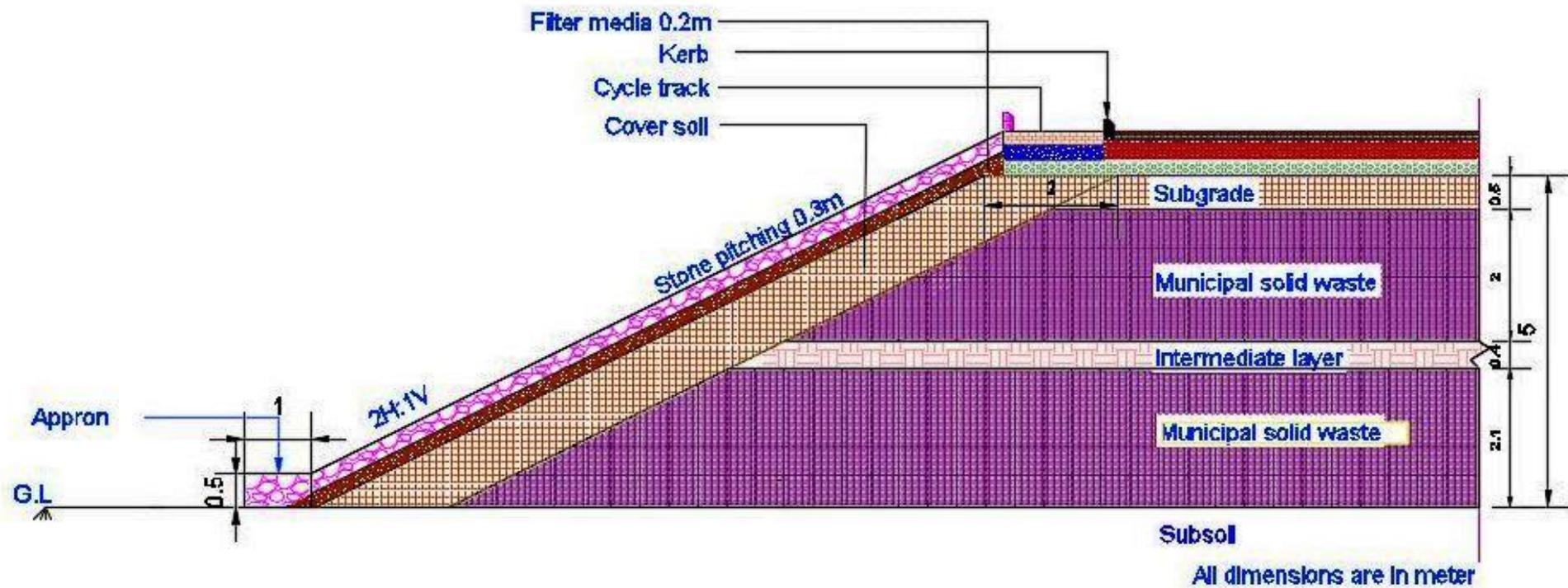


Fig. 43 Cross –section for construction of 5m Height MSW embankment (Built up area)

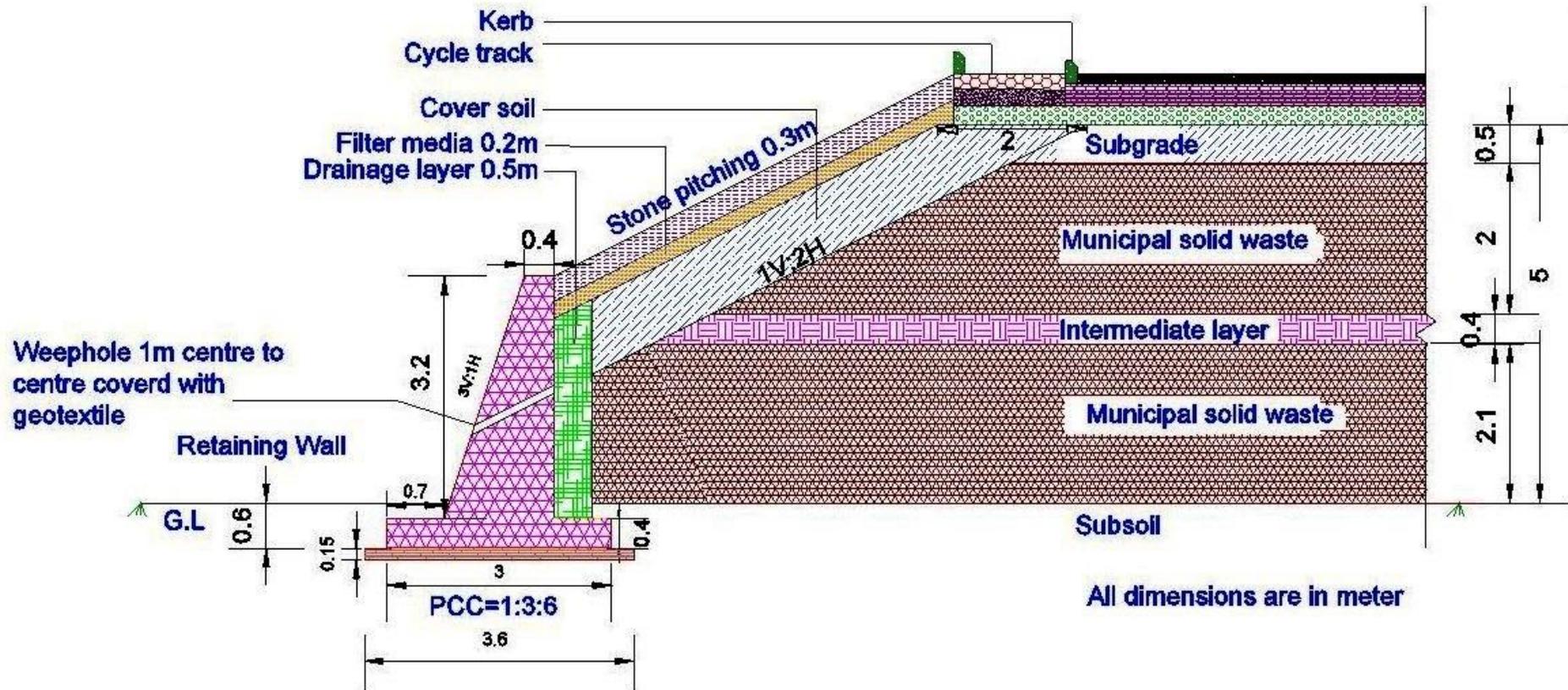


Fig. 44 Cross –section for construction of 5m Height MSW embankment (River side)

8 .CONCLUSIONS

A detailed study was carried out to investigate the possibility of utilizing the Municipal Solid Waste (MSW) collected from Ghazipur, East Delhi as an embankment fill material. The MSW is proposed to be utilized in the widening of NH-24 from 4 lane to 16 lane. About 200 tons of Municipal Solid Waste was collected from Ghazipur and was segregated into different sizes in the existing compost plant. The different fractions were studied for their suitability for use in embankment construction. A segregation methodology is proposed in the study. The segregated MSW is then characterised for its Geotechnical characteristics. Design cross-sections were arrived at for 3m and 5m height MSW embankments based on detailed stability analysis. Settlement analysis was also carried out to investigate its feasibility for embankment construction. Conclusions drawn from the study are summerized below;

1. About 65-75% of segregated Municipal Solid wastes can be used for embankment construction.
2. Other than soil, plastics and textiles were observed to be major constituents in different segregated MSW (The percentage content of metals, wood, paper, rubber, glass is observed to be less than 1% in different segregated MSW). There is no variation in the soil content or other constituents with the age of the MSW.
3. Leachate studies indicate that MSW is a non hazardous material as concentration of heavy metals is within the permissible limit.
4. The fraction passing 16mm sieve shows a minimal amount of plastics. Considering the higher percentage of this material in the MSW (44-48%), and the fact that its MDD satisfying the MORTH specification, this fraction can be directly used for embankment construction. This should be mixed with material retained on 37.5mm and 16mm after air blowing (at plant) to get the final material for use in embankment construction.

5. The final MSW selected for embankment construction is a non plastic, non swelling coarse grained material and classified as GM,i.e a silty gravel material.
6. The angle of shearing resistance values of MSW ranged between 28° and 35° indicating its suitability for embankment construction.
7. The Permeability of the different types of MSW varies in the range 1.55×10^{-9} to 1.21×10^{-8} m/s. The low value of the permeability observed may be because of presence of plastics, and rubber in the MSW mix which obstructs the flow of water through the mix.
8. The value of compression index ranged between 0.14 and 0.19 indicating a low to medium compressible soil. The average value of coefficient of consolidation in the stress range of 79-628 kN/m² is estimated as 4.14×10^{-6} m²/sec which is similar to that of conventional silty soils.
9. Total settlement for 3m and 5 m MSW embankment including primary and secondary consolidation 244 mm and 304 mm respectively. However these settlements are much less than the allowable settlement of 300 mm to 600 mm considered for Road embankment. The total settlement shall be uniform and shall occur slowly over a period of time.
10. Stability analysis indicated factor of safety values for critical draw down conditions under seismic conditions in the range 1.64 to 1.79 which is more than the minimum value of 1.25 required as per IRC-75 specifications

9. RECOMMENDATION

1. Though the study indicated feasibility of segregated MSW wastes for embankment construction, construction of an experimental test track, instrumentation and performance monitoring for a minimum period of 2 years is needed to arrive at conclusions, before recommending the same for large scale field applications.
2. During construction in the field, it is suggested that necessary safety measures shall be adopted for the staff engaged in construction as per IRC and other relevant standards.

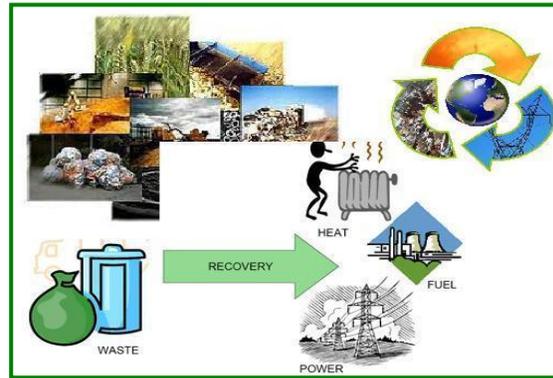
REFERENCES

1. G.S.R 395 (E) (2016). Hazardous and Other Wastes Management and Transboundary Movement) Rules.
2. MORTH (2013). Specifications for Road and Bridge Works. Indian Road Congress, New Delhi.
3. NCHRP Report (2004). Guideline and recommended standard for Geofoam applications in highway embankments. Transportation Research Board, report no. 529.
4. Sowers, G. F. (1973). Settlement of waste disposal fills. Proceedings of 8th international conference on soil mechanics and foundation engineering.

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STUDIES ON QUANTIFICATION AND CHARACTERIZATION OF MUNICIPAL SOLID WASTE IN MUNICIPAL CORPORATION OF GREATER MUMBAI (MCGM), MUMBAI REGION

Sponsor: Municipal Corporation of Greater Mumbai,
Govt. of Maharashtra



**CSIR-National Environmental Engineering
Research Institute, Nehru Marg, Nagpur - 440 020**



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1.1 Introduction about Municipal Corporation of Greater Mumbai

Municipal Corporation of Greater Mumbai (MCGM) is one of the biggest Municipalities in sea coastal cities of India. Municipal solid waste management (MSWM) attracts top most priority in infrastructural development for the city. The Mumbai Metropolis has a historic tradition of strong civic activism dedicated to the cause of a better life for all its citizens in Mumbai region. The primary agency responsible for urban governance in Greater Mumbai is MCGM. In Mumbai, MSW is openly disposed off at Deonar and Mulund dumping grounds which are located along the Thane creek. The unprocessed MSW is dumped at the Deonar and Mulund Dumpsites. The Municipal Corporation of Mumbai was developed in 1865. Presently, Municipal Corporation of Mumbai is known as Brihanmumbai Mahanagar Palika or the Municipal Corporation of Greater Mumbai and which has as its motto “Yato Dharmastato Jaya”(Where there is Righteousness, there shall be Victory), inscribed on the banner of its ‘Coat of Arms’. It is said to be the largest civic organization in the country and covers an area of 437 square kilometer. MCGM divides the Mumbai city in 6 zones and 4 to 5 wards are situated in each zone.

The MCGM, as the primary agency responsible for urban governance, has also signed an “MOU” with “NGO” Council to work closely with NGOs in the fields of education, public health, creation of urban amenities, art & culture and heritage conservation.

1.2 Functions of Municipal Corporation of Greater Mumbai

MCGM, Mumbai Region is responsible for civic and infrastructure needs of the metropolis including maintenance of roads, street, flyovers, public municipal schools, water supply and purification, hospitals, street lighting, light house, maintenance of parks and open local spaces, sewage treatment and disposal, garbage disposal, street cleanliness, cemeteries and crematoriums, registering of births and deaths in the city and prevention of epidemic out breaks. The corporation has 42 departments which provide various services to the citizens. The annual budget of MCGM, Mumbai Region is US\$ 4667.32 million.

The collection and transportation of the huge quantity of waste is a matter of concern for any ward. MCGM, Mumbai Region operates a huge fleet of 983 municipal and private vehicles for collection of waste making 1396 number of trips each day.

1.3 Background and Need of the Study

Solid waste management (SWM) is an integral part of urban and environmental management of each city. Mumbai is one of the largest populated cities in India. The amount of municipal solid waste (MSW) is quite high. The piled up waste is threatening to the health, environment and well being of the Mumbai city. One can feel the scenic beauty of Mumbai city on one side and unbearable dumpsites of Mulund and Deonar on other side. The amount of MSW has become a mammoth task to handle.

To achieve the “CLEAN UP! MUMBAI” and understand the problems and perspectives associated with the SWM of the city, the MCGM of Mumbai Region approached CSIR-NEERI to quantify and characterize MSW of Mumbai Region seasonally so as to design a sustainable system for its better management.

1.4 Objective and Scope of the Study

The major objectives of the study are to carry out quantification study and assessment of characteristics of MSW samples collected from significant locations in the MCGM, Mumbai Region. Another objective is to study location wise and seasonal variation in the composition and quality of MSW so as to delineate an appropriate MSW management plan leading to clean and hygienic environment with possible resource recovery.

The study would cover sampling and analysis of MSW at various significant location/collection centers in 24 wards of MCGM, Mumbai Region along with 2 MSW dumpsites located in the region.

1.5 Work Elements

The following work elements were envisaged to meet the said objectives. The work elements are as follows:

- Collections of MSW sample from different sampling locations and dumping sites;
- Quantification of MSW wherever weighing facility is available.
- Physical and chemical characterization of approximately 224 samples which include proximate and ultimate analysis.

Proximate Analysis

- i) Moisture Content*
- ii) Total Solid*
- iii) Total Volatile Solid*
- iv) Total Organic Carbon*
- v) Ash*

Ultimate Analysis

- i) pH*
 - ii) Phosphorus*
 - iii) Nitrogen*
 - iv) Sulphur*
 - v) Sodium*
 - vi) Potassium*
 - vii) Carbon/Nitrogen*
 - viii) Calorific Value*
 - ix) Heavy Metals*
- Statistical analysis of the quantification and characteristics data's to make useful projections and interferences;
 - Evaluation of existing MSW management practices in MCGM, Mumbai region;
 - Delineation of appropriate MSW processing options based on detailed MSW characterization, composition on the basis of ranking exercise;
 - Recommendation of most suitable/ sustainable technology option based on ranking analysis.

2

SOLID WASTE MANAGEMENT SYSTEM

2.1 Introduction about Solid Waste

A waste is viewed as a discarded material, which has no consumer value to the person abandoning it. According to World Health Organization (WHO), the term 'solid waste' is applied to unwanted and discarded materials from houses, street sweepings, commercial and agricultural operations arising out of mass activities. Solid waste is the term used to describe non-liquid materials arising from domestic, trade, commercial, agricultural and industrial activities and from public services. It is commonly known as garbage, refuse, rubbish or trash. Its main sources are residential premises, business establishments, and street sweepings. It is a mixture of vegetable and organic matter; inert matters, such as glass, metal, stones, ashes, cinders, textiles wood, grass etc. According to the percentage of the ingredient, it would be highly compostable, or combustible, biodegradable or inert.

2.2 Sources and Classification of Solid Waste

Solid wastes are classified into many categories based on their source, origin, and type of waste. In a nut-shell, different types and sources of solid waste are presented in **Table 2.1**.

Table 2.1
Types and Sources of Solid Waste

Domestic Waste	Household waste-kitchen, house cleaning, old papers, packing, bottles, crockery wares, furnishing materials, garden trimmings etc.
Commercial Waste	Waste generated at business premises, shops, offices, markets, departmental stores (paper, packing material, spoiled, discarded goods) organic, inorganic, chemically reactive and hazardous waste
Institutional Waste	Schools, colleges, hospitals, large hotels and restaurants, markets selling vegetables, fruits, fish etc., community halls, religious places, function sites etc.
Street Sweeping	Unconcerned throwing, littering made by pedestrian traffic, vehicular traffic, stray animals, roadside tree leaves, rubbish, from drain cleaning, debris etc.

Industrial/Trade Waste	Waste generated through manufacturing and material processing
Debris or Construction Rejects	Comprises earth, brickbats, stones, wooden logs etc.
Municipal Solid Waste	Comprises house hold waste, street sweeping waste such as plastic, paper, metal, glasses, rags, vegetable waste etc.
Biomedical Waste	Animal waste, such as animal tissues, organs, body parts, car-casses, bleeding parts, fluid, blood, waste generated by veterinary hospitals, colleges, discharge from hospitals, animal houses and Microbiology/ biotechnology laboratories, Waste sharps viz., needles, syringes, scalpels, blades, glass etc. that may cause puncture and cuts. This includes both used and unused sharps etc.
Hazardous Waste	Waste with properties that make it dangerous or potentially harmful to human health or the environment. Waste listed in Hazardous Waste management Rules 1989 (batteries, cleaning fluids, pesticides etc.)
Sewage Waste	Sewage is the liquid waste containing some solids produced by humans which typically consists of washing water, faeces, urine, laundry waste and other material

2.3 Brief about Municipal Solid Waste

Solid Waste Management (SWM) pertains to generation, storage, collection, segregation transportation, processing and disposal of solid waste using the best principle and practices of public health, economics, engineering, aesthetics and environmental conservation. MSWM is one of the important obligatory functions of Urban Local Bodies (ULBs) in India. It is also one of the primary responsibilities of the municipal authorities. Over the years, the quantum of waste generated by different category of waste producers (Households, Commercial centers, Institutions, Industries etc) has been increasing with increase in urbanization, population growth and associated activities. The characteristics of the waste generated have also been varying with the living habits of the society. SWM is a part of public health and sanitation, and according to the Indian Constitution, it falls within the purview of the State list. Since this activity is non-exclusive, non-rival and essential, the responsibility for providing the service lies within the public domain. The activity being of a local nature is entrusted to the ULBs. The ULB undertakes the task of solid waste service delivery with its own staff, equipment and funds. In a few cases, part of the said work is contracted out to private enterprises.

2.4 Salient Features of MSW (Management and Handling) Rules, 2000

In view of the serious environmental degradation resulting from the unscientific disposal of MSW, the Ministry of Environment and Forests (MoEF), Government of India, notified the 'Municipal Solid Waste (Management and Handling) Rules, 2000 and its revision is under process making it mandatory for ULBs to improve the systems of SWM as envisaged in the rules. These rules dictate the procedure for waste collection, segregation, storage, transportation, processing and disposal. Further, the rules mandate that all cities must set-up suitable waste treatment and disposal facilities. These rules also specify standards for compost quality and health control. Compliance criteria for each and every stage of waste management *i.e.*, collection, segregation at source, transportation, processing and final disposal are also prescribed in MSW Rules. The important guidelines of the MSW rules are as follows:

a	Parameters	Compliance Criteria
1.	Collection of MSWs	<p>1. Littering of MSW shall be prohibited in cities, towns and in urban areas notified by the State Governments. To prohibit littering and facilitate compliance, the following steps shall be taken by the municipal authority, namely :</p> <ul style="list-style-type: none"> i. Organizing house-to-house collection of MSWs through any of the methods, like community bin collection (central bin), house-to-house collection, collection on regular pre-informed timings and scheduling by using bell ringing of musical vehicle (without exceeding permissible noise levels); ii. Devising collection of waste from slums and squatter areas or localities including hotels, restaurants, office complexes and commercial areas; iii. Wastes from slaughter houses, meat and fish markets, fruits and vegetable markets, which are biodegradable in nature, shall be managed to make use of such wastes; iv. Bio-medical wastes and industrial wastes shall not be mixed with MSWs and such wastes shall follow the rules separately specified for the purpose; v. Collected waste from residential and other areas shall be transferred to community bin by hand-driven containerized carts or other small vehicles; vi. Horticultural and construction or demolition wastes or debris shall be separately collected and disposed off following proper norms. Similarly, wastes generated at dairies shall be regulated in accordance with the State laws; vii. Waste (garbage, dry leaves) shall not be burnt; viii. Stray animals shall not be allowed to move around waste storage facilities or at any other place in the city or town and shall be managed in accordance with the State laws.

2. The municipal authority shall notify waste collection schedule and the likely method to be adopted for public benefit in a city or town.

3. It shall be the responsibility of generator of wastes to avoid littering and ensure delivery of wastes in accordance with the collection and segregation system to be notified by the municipal authority as per para 1(2) of this Schedule.

2. Segregation of MSWs

In order to encourage the citizens, municipal authority shall organize awareness programmes for segregation of wastes and shall promote recycling or reuse of segregated materials.

The municipal authority shall undertake phased programme to ensure community participation in waste segregation. For this purpose, regular meetings at quarterly intervals shall be arranged by the municipal authorities with representatives of local resident welfare associations and non-governmental organizations.

3. Storage of MSWs

Municipal authorities shall establish and maintain storage facilities in such a manner as they do not create unhygienic and insanitary conditions around it. Following criteria shall be taken into account while establishing and maintaining storage facilities, namely :

- i. Storage facilities shall be created and established by taking into account quantities of waste generation in a given area and the population densities. A storage facility shall be so placed that it is accessible to users;
- ii. Storage facilities to be set-up by municipal authorities or any other agency shall be so designed that wastes stored are not exposed to open atmosphere and shall be aesthetically acceptable and user-friendly;
- iii. Storage facilities or bins shall have easy to operate design for

handling, transfer and transportation of waste. Bins for storage of bio-degradable wastes shall be painted green. Those for storage of recyclable wastes shall be printed white and those for storage of other wastes shall be printed black;

- iv. Manual handling of waste shall be prohibited. If unavoidable due to constraints, manual handling shall be carried out under proper precaution with due care for safety of workers.

4. Transportation of MSWs

Vehicles used for transportation of wastes shall be covered. Waste should not be visible to public, nor exposed to open environment preventing their scattering. The following criteria shall be met, namely:

- i. The storage facilities set-up by municipal authorities shall be daily attended for clearing of wastes. The bins or containers wherever placed shall be cleaned before they start overflowing;
- ii. Transportation vehicles shall be so designed that multiple handling of wastes, prior to final disposal, is avoided.

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- 5. Processing of MSWs** Municipal authorities shall adopt suitable technology or combination of such technologies to make use of wastes so as to minimize burden on landfill. Following criteria shall be adopted, namely:
- (i) The biodegradable wastes shall be processed by composting, vermicomposting, anaerobic digestion or any other appropriate biological processing for stabilization of wastes. It shall be ensured that compost or any other end product shall comply with standards as specified in Schedule-IV;
 - ii. Mixed waste containing recoverable resources shall follow the route of recycling. Incineration with or without energy recovery including pelletisation can also be used for processing wastes in specific cases. Municipal authority or the operator of a facility wishing to use other state-of-the-art technologies shall approach the Central Pollution Control Board (CPCB) to get the standards laid down before applying for grant of authorization.
- 6. Disposal of MSWs** Land filling shall be restricted to non-biodegradable, inert and other wastes that are not suitable either for recycling or for biological processing. Land filling shall also be carried out for residues of waste processing facilities as well as pre-processing rejects from waste processing facilities. Land filling of mixed waste shall be avoided unless the same is found unsuitable for waste processing. Under unavoidable circumstances or till installation of alternate facilities, land filling shall be done following proper norms. Landfill sites shall meet the specifications as given in Schedule III.

2.5 New MSW Draft Rule 2015

(1.) Storage of Segregated Solid Waste at Source

- (i) Littering and open burning of solid waste shall be prohibited by all ULBs within the area covered under their jurisdiction within six months from the date of the notification of the rule.

(ii) To facilitate compliance, the following steps shall be taken by the ULB, namely:

(a) Create public awareness on:

- Reducing the generation of waste;
- Reusing the waste material to the extent possible;
- Processing food waste through home composting or community composting;
- Separately store bio-degradable wastes or wet waste and non bio-degradable including recyclable and combustible wastes or dry waste;
- Encouraging waste pickers to take away segregated recyclable material stored at source;
- Wrapping securely sanitary napkins/pads, tampons, infant and adult diapers, condoms, and menstrual cups before putting in domestic bin meant for non bio-degradable waste;
- Storing separately domestic hazardous wastes, such as contaminated paint drums, pesticide cans, compact florescent lamps, tube lights, used Ni. Cd batteries, used needles and syringes and health care waste;
- Storing separately construction and demolition waste at the source of waste generation.

(b) Mandate citizens to store segregated wastes at source in separate domestic or trade bins and hand over these wastes separately to designated waste collectors for recycling, processing and disposal of solid waste.

(2) Collection of Solid Wastes

- Organize door-to-door collection of segregated bio-degradable or wet and non bio-degradable or dry solid wastes on a daily basis at pre-informed timings from all residential and non-residential premises including slums and informal settlements using motorized vehicles or containerized tricycles, handcarts or any other device which is suitable for collection of segregated waste without necessitating deposition of waste on the ground and multiple handling of waste;
- Bio-degradable wastes from fruits and vegetable markets, meat and fish markets, horticulture waste from parks and gardens, shall be collected separately and to the extent feasible market waste may be processed or treated within the market area and horticulture

waste within parks and gardens to make optimum use of such wastes and minimize the cost of collection and transportation of such waste;

- Large institutional premises, residential complexes shall be motivated and incentivized to process bio-degradable waste within their campus to the extent it is feasible to do so;
- Construction and demolition wastes or debris shall be separately collected and processed by the ULB or agency appointed by it for the purpose of its processing and disposal without mixing the same with bio-degradable, recyclable or non- recyclable combustible wastes that shall be collected from the door step;
- Dairy waste shall be collected separately and regulated as may be prescribed in the municipal bye-laws;
- Appropriate user fees or charges shall be levied from the waste generator for sustainability of operations of SWM.

(3) Sweeping of Street and Cleaning of Surface Drains

- ULB shall arrange for cleaning of roads, streets, lanes, bye lanes, surface drains and public places at regular intervals and use containerized tricycles, containerized handcarts, and suitable motorized or non-motorized devices for collection of such waste;
- Synchronize with the system of secondary storage and transportation of such waste without necessitating deposition on the ground;
- The waste shall not be mixed at any stage with the solid waste collected from the doorstep.

(4) Secondary Storage

- Segregated solid waste collected from the door step shall, as far as practicable, be transported directly to respective waste processing facility having facility of sorting and recovery of recyclable waste and in absence of such arrangement, the waste collected from the doorstep shall be taken to waste storage depots for secondary storage of waste;
- Waste depots shall have covered containers for separate storage of bio-degradable or wet waste and non bio-degradable or dry waste collected from the doorstep;

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- The street sweepings and silt collected from the surface drains shall not be left or accumulated on roadsides and shall be transported directly to waste disposal facility or shall be temporarily stored in covered bins or containers kept separately for secondary storage of inert wastes at suitable locations for facilitating onward transportation of such waste to the disposal site; if the street sweepings contain bio-degradable or recyclable waste, such waste shall be segregated and sent to respective processing facility;
 - The secondary storage vehicles or containers shall synchronize with transportation system to avoid multiple handling of waste;
 - Secondary storage of waste in open spaces on the roadsides or open plots or in cylindrical concrete bins or open masonry bins shall be dispensed with;
 - ULBs shall where necessary, establish and maintain covered secondary storage facilities in such a manner as they do not create unhygienic and insanitary conditions around it and the following criteria shall be taken into account while establishing and maintaining storage facilities;
 - a) Storage facilities shall be created and established by taking into account quantities of waste generation in a given area and distance required to be travelled by the waste collectors to deposit the waste at the storage facilities;
 - b) Storage facility shall be so placed that it is accessible to users;
 - c) Storage facilities to be set up by ULBs or any other agency shall be so designed that waste stored is not exposed to open atmosphere and shall be aesthetically acceptable and user-friendly and shall not be accessible to stray animals and birds;
 - d) Storage facilities shall be covered bins or containers of appropriate design including flaps and shall have 'easy to operate' design for handling, transfer and transportation of waste and handling during evacuation of waste should be user friendly and not cumbersome;
 - e) Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be painted blue and those for storage of street sweepings and silt shall be painted black;
 - f) The design shall be developed in accordance with local practices and material available to ensure minimal impact on health and the environment;

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- g) Manual handling of waste shall be minimized and waste handlers shall be given personal protection equipment to avoid direct contact with the waste;
 - h) Construction & demolition waste shall be separately stored in enclosed areas or containers separately without mixing these waste with waste collected from doorstep or street sweepings;
 - i) Bio-medical wastes, industrial wastes, e-waste and domestic hazardous wastes shall not be brought to the secondary waste storage depots or mixed with solid wastes and such wastes shall be handled as specified in specific rules framed for management of such wastes and domestic hazardous waste may be handled as directed by the State Pollution Control Board or Pollution Control Committee;
 - j) Secondary storage bins if placed shall be cleaned at regular intervals at least once in a month and shall be painted at least once in a year;

(5) Material Recovery Facilities

The ULB shall designate temporary storage spaces and set-up material recovery facility (MRF) where non bio-degradable or recyclable solid waste collected from the doorstep shall be temporarily stored by the ULB or operator of the facility before solid waste processing or disposal is taken up in order to facilitate segregation, sorting and recovery of various components of recyclable waste by informal sector of waste pickers or any other staff or agency engaged by the ULB for the purpose and such sorting facilities shall be so designed that the solid waste stored is not exposed to open atmosphere and shall be user-friendly.

(6) Transportation of Solid Wastes

- Waste collected from the doorstep in motorized vehicles shall be directly transported to the processing facility through MRF to be set-up at the waste processing site or to the transfer station or transfer point or waste storage depots for facilitating, sorting and bulk transfer of waste to the processing facility in large hauling vehicles or containers;
- Vehicles used for transportation of wastes shall be covered and shall have a facility to prevent waste spillage and leachate dropping from the vehicles on the ground en-route to the processing or disposal facility;

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- Waste shall not be visible to public, nor exposed to open environment preventing their scattering;
 - Waste stored at the secondary waste storage depots in covered bins or containers shall be attended daily and waste picked up before container start overflowing;
 - Bio-degradable waste stored in green and recyclable and combustible and domestic inert waste stored in blue containers at the waste storage depots shall be transported to respective processing facilities in a segregated manner and the inerts, street sweepings and silt collected from the drains shall be stored in black containers and shall not be allowed to be mixed with the waste collected from the doorstep or those stored in green or blue containers and such inert waste shall be directly taken to waste disposal facility or to the processing facility, if and when created for processing;
 - Separate transportation of domestic hazardous waste shall be arranged as directed by the State Pollution Control Board or the Pollution Control Committee, as the case may be;
 - Construction and demolition waste shall be transported in covered vehicles separately to construction and demolition waste processing facility; and transportation vehicles shall be covered and so designed that multiple handling of wastes, prior to final disposal, is avoided.

(7) **Processing of Solid Wastes**

ULBs shall adopt suitable technology or combination of appropriate technologies, with emphasis on decentralized processing to make use of all components of wastes that can be processed so as to minimize burden on landfill.

Following criteria shall be adopted:

- Biodegradable wastes shall be processed by bio-methanation, composting, vermi-composting, anaerobic digestion or any other appropriate biological processing for stabilization of wastes;
- It shall be ensured that composting or any other end product shall comply with standards as specified in Schedule-II and also ensure that no damage is caused to the environment during this process;

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- To the extent feasible, market waste may be processed or treated within the market area and horticulture waste within parks and gardens to make optimum use of such wastes and minimize the cost of collection and transportation of such waste;
 - Dairy waste shall be used for bio-methanation or vermi-composting or aerobic composting, either separately or with other bio-degradable solid waste;
 - Arrangement shall be made to provide segregated recyclable material to the recycling industry through waste pickers or any other agency engaged or authorized by the ULB for the purpose;
 - Residual combustible wastes shall be utilized for supplying as a feedstock for preparing refuse derived fuel (RDF) or for generating energy or power from the waste by adopting proven waste to energy technologies for which emission standards as well as standards for dioxins and furans have been prescribed by the CPCB, New Delhi;
 - Non-recyclable plastics and other high calorific content waste may be utilized for co-processing in cement kilns or for polymer or fuel production or manufacturing of products, such as door panels and the like nature;
 - Construction and demolition and other inert wastes shall be utilized for making bricks, pavement blocks, construction materials, such as aggregates;
 - ULB or the operator of a facility planning to use other state-of-the-art technologies shall approach the CPCB to get the standards laid down before applying for grant of authorization.

(7.) Disposal of Solid Wastes

- Land filling or dumping of mixed waste shall be stopped soon after the timeline as specified under for setting up and operationalization of sanitary landfill is over;
- Landfill shall only be permitted for non-usable, non-recyclable, non-biodegradable, non-combustible and non-reactive inert waste and other wastes, such as residues of waste processing facilities as well as preprocessing rejects from waste processing facilities and the landfill sites shall meet the specifications as given in Schedule-I, of the rule however every effort shall be made to recycle or reuse the rejects to achieve the desired objective of zero waste going to landfill;

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- Landfill site shall provide an appropriate facility for sorting, storing and transportation of recyclable material to the processing facility and ensure that such wastes do not get land filled;
 - All old open dumpsites and existing operational dumpsites shall be carefully investigated and analyzed about their potential of bio-mining and bio-remediation and actions shall be taken accordingly in cases where such course of action is found feasible;
 - In absence of potential of bio-mining and bio-remediation of dumpsite, it shall be scientifically capped as per landfill capping norms to prevent further damage to the environment.

3

PREVAILING SCENARIO OF MUNICIPAL SOLID WASTE MANAGEMENT IN MUNICIPAL CORPORATION OF GREATER MUMBAI

3.1 Current Status of Municipal Solid Waste Management (MCGM)

In MCGM, Mumbai Region, there are 7 islands in city and 4 islands in suburbs. It accommodates 20.7 million people (census 2011). Presently, Mumbai has MSW generation to the tune of 11198.1 MT according to field study carried out by CSIR-NEERI, Nagpur. It also produces nearly 2500 tons debris of construction and demolition (C&D) waste per day (Workshop on Metropolitan Governance and Planning Experience of Mumbai and Rio de Janeiro 29th June, 2012 MCGM) and MCGM takes active responsibility in managing the problems of solid waste in their respective jurisdictions. They involve local people for sanitation works. They also keep a strong vigil over the SWM activities carried out by UD&PAD within their jurisdictions, and report to the sanitation officer for improvements.

3.2 MSW Quantification

The population of greater Mumbai is in million, generating huge amount of waste, thus quantification of waste is a must for a city which has a huge population of this size. Waste generation is a factor of population, lifestyle and level of urbanization, the quantification process has been linked with population multiplied by the waste generation factor of the urban area.

The quantification of the waste has been done by monitoring 'total waste generation' to the population of the city at a given time. Accordingly waste generation factor comes out as 0.54 kg/capita/day.

Table 3.1
Waste Quantification

Population of Mumbai (million)	MSW reaching landfill (MT/day)	Dry Waste* (MT/day)	Total Waste generation (MT)	Waste generation (kg/capita/day)
20.7	9969.94	1228.169643	11198.1	0.54

*Depends on physical characteristics of 24 wards (3.74 % plastics are generated in all season).

3.3 Mode of Collection

MSW is generally collected by street sweeping, dumped MSWs on the roadsides. Door-to-door collection methods are also carried out at most of the places in Greater Mumbai. Collections from slums are mainly handled by NGOs as well as MCGM, Mumbai Region. Sweepers deployed by UD&PAD load the waste collected onto the trucks. Generally, total generation of MSW is 11198.1 MT/ day and MSW reaching to the landfill site is 9969.94 MT/ day which indicated that 89% of the MSW is collected by the MCGM (As per the field study carried out by CSIR-NEERI). The shift timings for waste collection are normally from 6.00 AM to 2 PM and 2.00 PM to 10.00 PM and 10.00 PM to 6 AM. Figure 3.1 depicts a picture showing collection of MSW.



Figure 3.1: Picture showing Collection of MSW

3.4 Segregation of MSW

Waste segregation is practiced at Deonar and Mulund disposal sites in Mumbai. In addition, waste from hospital/nursing homes, industries, and construction activity also gets mixed with MSW. Sometimes, these all are segregated at the dumpsites. Figure 3.2 depicts a picture showing segregation of MSW.



Figure 3.2: Picture showing Segregation of MSW

3.5 Transportation of MSW

Waste collected is transported through uncovered refuse vehicles, which lead to waste spillage. The loading and unloading of refuse vehicles is done manually by sweepers and sanitary workers. Manual loading and unloading is a time consuming process which reduces waste carrying efficiency. This practice also increases health risk to the workers. There are 6 types of vehicles, namely Big Compactor, Small Compactor, Small Tipper having 1 ton capacity, Dumper placer (skip vehicle), Tipper having 8 ton capacity and Stationary Compactor are in operation. 3 transfer stations at Mahalaxmi, Kurla and Versova support intermediate transfer of waste from the surrounding area up to the Mulund and Deonar dumping ground. The pictorial view of a compactor transporting MSW is shown in Figure 3.3



Figure 3.3: Pictorial View of a compactor used for Transportation of MSW in MCGM, Mumbai Region

3.6 Processing and Disposal of MSW

MSW collected is dumped at Deonar and Mulund, Mumbai. The Deonar dump site is in use since 1927. Mulund dump site is used since 1968. A picture showing dumping of MSW at Mulund Dumping site is depicted in Figure 3.4.



Figure 3.4: Picture showing Dumping of MSW at Mulund Dumping Site

4

APPROACH & METHODOLOGY

4.1. Approach

The approach adopted to carry out the study is as follows:

- Collection of Maps of Greater Mumbai city, Deonar and Mulund Dumpsites.
- Collection of secondary data.
- Primary visit to all 24 wards of MCGM and the Dumpsites.
- Identification of sampling locations in greater Mumbai.
- Collection of MSW sample in different wards of MCGM for Pre-monsoon, Monsoon and Post-monsoon season.
- Physical and chemical characterization of MSW.
- Statistical analysis of data collected and finally selection of appropriate processing technology for MSWM Region.

4.2 Study Area

The study area of the project is Greater Mumbai City along with the two Dumpsites Deonar and Mulund. 24 Sampling locations were identified in the MCGM, Mumbai Region covering a larger size of population. These points were further classified into High Income Group (HIG), Medium Income Group (MIG), Commercial Area (CA) and slum, respectively for all the three seasons, (pre-monsoon, monsoon and post-monsoon). The sampling locations in different wards of MCGM regions are presented in Tables 4.1 through 4.3. The physical composition of MSW was determined at the site itself by w/w method.

Table 4.1**Sampling Locations in Different Wards of MCGM (Pre-monsoon Season), Mumbai Region**

Name of Ward	Locations	Area Name	Date of Sampling
Ward A	HIG	Dins Haw Kwacha Chowk	13/05/2014
	MIG	Ganesh Murti Nagar	13/05/2014
	LIG	Ajad Nagari	13/05/2014
	CA	Near Ajad Maidan	13/05/2014
Ward B	HIG	Champa Wadi	12/05/2014
	MIG	Near Bmc Ward Office	12/05/2014
	LIG	Lohar Chawl	12/05/2014
	CA	Near Minar Masjid	12/05/2014
Ward C	HIG	Cherai Road	12/05/2014
	MIG	Near Ward Office	12/05/2014
	LIG	Nanobhai Deshi Marg	12/05/2014
	CA	Mirza Galib	12/05/2014
Ward D	HIG	Mallabar Hill,Palkeshwar	13/05/2014
	MIG	Near Opera House	13/05/2014
	LIG	Girgaon	13/05/2014
	CA	Girgaon Market	13/05/2014
Ward E	HIG	Byculla West	13/05/2014
	MIG	Nariyal Wadi	13/05/2014
	LIG	Sauter Street	13/05/2014
	CA	Kela Market	13/05/2014
Ward F/S	HIG	Byculla East	15/05/2014
	MIG	Near Byculla Station	15/05/2014
	LIG	Ghodapdeo	15/05/2014
	CA	Market of Byculla	15/05/2014
Ward F/N	HIG	Sir Balchandra Road	15/05/2014
	MIG	Near Bmc Ward Office	15/05/2014
	LIG	Kalewadi	15/05/2014
	CA	Matuaga Area	15/05/2014
Ward G/S	HIG	Adarsh Nagar	15/05/2014
	MIG	Adarsh Nagar	15/05/2014
	LIG	Kamgar Nagar-1	15/05/2014
	CA	Lower Parel Market	15/05/2014
Ward G/N	HIG	Matunga West	15/05/2014
	MIG	Near Shivaji Park	15/05/2014

	LIG	Near BMC Office	15/05/2014
	CA	Matunga Market	15/05/2014
Ward H/E	HIG	Prabhat Colony	16/05/2014
	MIG	Near Bmc Ward Office	16/05/2014
	LIG	Aashadeep	16/05/2014
	CA	Santacruz East Market	16/05/2014
Ward H/W	HIG	Kartar Road	16/05/2014
	MIG	Near Mahim	16/05/2014
	LIG	Gajder Band	16/05/2014
	CA	Khan Market	16/05/2014
Ward K/E	HIG	BMC Quarters, Vile Parle East	19/05/2014
	MIG	Near Bmc Ward Office	19/05/2014
	LIG	Kaliakar Bari	19/05/2014
	CA	Mungibai	19/05/2014
Ward K/W	HIG	Near Bandra Bandstand	19/05/2014
	MIG	Near Bmc Ward Office	19/05/2014
	LIG	Ganesh Nagar	19/05/2014
	CA	Vile Parle West	19/05/2014
Ward P/S	HIG	Raheja Housing Complex	19/05/2014
	MIG	Near Film City	19/05/2014
	LIG	Workers Colony	19/05/2014
	CA	Near Shivaji Nagar	19/05/2014
Ward P/N	HIG	Adarsh Nagar	20/05/2014
	MIG	Near Bmc Ward Office	20/05/2014
	LIG	Liberty Garden	20/05/2014
	CA	Near Liberty Garden	20/05/2014
Ward R/S	HIG	LIC Colony	20/05/2014
	MIG	Near Bmc Ward Office	20/05/2014
	LIG	Patel Nagar	20/05/2014
	CA	Near Patel Nagar	20/05/2014
Ward R/C	HIG	Marlynd Complex	20/05/2014
	MIG	Near Bhavdevi Ground	20/05/2014
	LIG	Dahisar	20/05/2014
	CA	Market Near Dahisar	20/05/2014
Ward R/N	HIG	Ashok Van	20/05/2014
	MIG	Near BMC Ward Office	20/05/2014
	LIG	Ekta Nagar	20/05/2014
	CA	Market Near BMC Ward Office	20/05/2014

Ward L	HIG	Taximan Colony	16/05/2014
	MIG	Near BMC Ward Office	16/05/2014
	LIG	Near Kurla Station	16/05/2014
	CA	Jadav Market	16/05/2014
Ward M/E	HIG	Mysore Colony	20/05/2014
	MIG	Near BMC Ward Office	20/05/2014
	LIG	Bharat Nagar	20/05/2014
	CA	Near Bharat Nagar	20/05/2014
Ward M/W	HIG	Nagesh Patil Wadi	20/05/2014
			20/05/2014
	LIG	Near Deonar Dumpsite	20/05/2014
	CA	Near Nagesh Patil Wadi	20/05/2014
Ward N	HIG	Laxmi Nagar	16/05/2014
	MIG	Damodar Park	16/05/2014
	LIG	Ambedkar Nagar	16/05/2014
	CA	Hingwala Market	16/05/2014
Ward S	HIG	LIC Housing Colony	17/05/2014
	MIG	Near BMC Ward Office	17/05/2014
	LIG	Sajjan Wadi	17/05/2014
	CA	Near LIC Housing Colony	17/05/2014
Ward T	HIG	Vardhaman Nagar	17/05/2014
	MIG	Near BMC Ward Office	17/05/2014
	LIG	Near Mulund Station	17/05/2014
	CA	Near Mulund Dumpsite	17/05/2014

HIG-High Income Group

LIG-Low Income Group

CA-Commercial Area

MIG-Middle Income Group

Table 4.2**Sampling Locations in Different Wards of MCGM (Monsoon Season), Mumbai Region**

Name of Wards	Locations	Area Name	Date of Sampling
A	Market	Colaba Market	9/17/2014
B	MIG	Near Azad Maidan	9/17/2014
C	Market	Vimal Das Market	9/17/2014
D	HIG	Pedder Road	9/17/2014
E	MIG	Police Colony	9/19/2014
F/S	MIG	Railway Chwal	9/19/2014
F/N	HIG	Adasa Nagar	9/19/2014
G/S	HIG	Mahadevi Colony	9/19/2014
G/N	MIG	Nandini Park	9/19/2014
H/E	HIG	PNT Colony	9/18/2014
H/W	HIG	Union Park	9/18/2014
K/E	Market	Near Airport	9/20/2014
K/W	HIG	Gulmohor Colony	9/20/2014
P/S	LIG	Tilaknagar Area	9/22/2014
P/N	Market	Near Shivaji Road	9/22/2014
R/S	LIG	Panchseel Garden Area	9/22/2014
R/C	MIG	LIC Colony	9/22/2014
R/N	LIG	Near Lalbahadur Sastri Nagar	9/22/2014
L	MIG	Chandaveli	9/18/2014
N	MIG	Near Raheja Plaza	9/18/2014
M/E	MIG	Shivaji Nagar	9/18/2014
M/W	LIG	Ambedkar Nagar	9/18/2014
S	LIG	1 Pocket of Vidya Vihar Area	9/20/2014
T	MIG	Azad Nagar	9/20/2014
Deonar	Dunpsite		9/20/2014
Mulund	Dumpsite		9/20/2014

Table 4.3**Sampling Locations in Different Wards of MCGM (Post-monsoon Season), Mumbai Region**

Name of Ward	Different Locations	Area Name	Date of Sampling
Ward A	HIG	Dins Haw Kwacha Chowk	10/11/2014
	MIG	Ganesh Murti Nagar	10/11/2014
	LIG/Slum	Ajad Nagari	10/11/2014
	CA	M.J Phule Market	10/11/2014
Ward B	HIG	J.J Gate Collection	10/11/2014
	MIG	Dongri	10/11/2014
	LIG/Slum	Raichur	10/11/2014
	CA	Near Minar Masjid	10/11/2014
Ward C	HIG	Cherai Road	10/11/2014
	MIG	Grant Medical Gymkana	10/11/2014
	LIG	Nanobhai Deshi Marg	10/11/2014
	CA	Mirza Galib	
Ward D	HIG	Mallabar Hill,Palkeshwar	11/11/2014
	CA	Girgaon Market	11/11/2014
	LIG/Slum	Jaganath Shanker Seth Road	11/11/2014
	MIG	Near Opera House	11/11/2014
Ward E	HIG	Morland Aparment Road	11/11/2014
	MIG	Near BMC Office	11/11/2014
	LIG/Slum	Maulana Azad Road	11/11/2014
	CA	Byculla Market	11/11/2014
Ward F/S	HIG	Dosti Flamingo Apartment	11/11/2014
	MIG	Market Of Byculla	11/11/2014
	LIG	Ghodapdeo	11/11/2014
	CA	Parel Near Tata Institute	11/11/2014
Ward F/N	HIG	Sir Balchandra Road	18/11/2014
	MIG	Near BMC Ward Office	18/11/2014
	LIG/Slum	Kalewadi	18/11/2014
	CA	Matuaga Area	18/11/2014
Ward G/S	HIG	Poshkanwala Tin Top	18/11/2014
	MIG	Adarsh Nagar	18/11/2014
	LIG/Slum	Worli Kholi Wada Slum	18/11/2014
	CA	Worli Kholi Wada Market	18/11/2014
Ward G/N	HIG	Near Shivaji Park	18/11/2014
	MIG	Near BMC Ward Office	18/11/2014
	LIG	Gul Mohar Ward	18/11/2014

	CA	Knj Market	18/11/2014
Ward H/E	HIG	Prabhat Colony	12/11/2014
	MIG	NEAR BMC Ward Office	12/11/2014
	LIG	Garib Nagar	12/11/2014
	CA	Santacruz East Market	12/11/2014
Ward H/W	HIG	Kartar Road	12/11/2014
	CA	Khan Market	12/11/2014
	LIG	Gajder Band	12/11/2014
	MIG	Near Mahim	12/11/2014
Ward K/E	HIG	BMC Quarters, Vile Parle East	17/11/2014
	MIG	Near BMC Ward Office	17/11/2014
	LIG/Slum	Vichare Vamsha	17/11/2014
	CA	Mungibai	17/11/2014
Ward K/W	HIG	Lokhandwala Yamuna Nagar	17/11/2014
	MIG	Near BMC Ward Office	17/11/2014
	LIG/SLUM	Ganesh Nagar	17/11/2014
	CA	Charbangla Market	17/11/2014
Ward P/S	HIG	Raheja Housing Complex	17/11/2014
	MIG	Near Film City	17/11/2014
	LIG/Slum	M.G.Road	17/11/2014
	CA	Vapista	17/11/2014
Ward P/N	HIG	Adarsh Nagar	17/11/2014
	MIG	Near BMC Office	17/11/2014
	LIG/Slum	Malvani	17/11/2014
	CA	Atm Station Road Market	17/11/2014
Ward R/S	HIG	LIC Colony	13/11/2014
	MIG	Near BMC Office	13/11/2014
	LIG	Patel Nagar	13/11/2014
	CA	Patel Nagar Market	13/11/2014
Ward R/C	HIG	Marlynd Complex	13/11/2014
	MIG	Yoji Nagar Near Ajmer High School	13/11/2014
	LIG/Slum	Gori Bridge	13/11/2014
	CA	Market Near Dahisar	13/11/2014
Ward R/N	HIG	Ashokvan	13/11/2014
	MIG	Near BMC Ward Office	13/11/2014
	LIG	Ekta Nagar	13/11/2014
	CA	Market Near BMC Ward Office	13/11/2014
Ward L	HIG	Taximan Colony	19/11/2014
	MIG	Near BMC Ward Office	19/11/2014

	LIG	Near Kurla Station	19/11/2014
	CA	Jadav Market	19/11/2014
Ward M/E	HIG	Mysore Colony	15/11/2014
	MIG	Near Bmc Ward Office	15/11/2014
	LIG/Slum	Bharat Nagar	15/11/2014
	CA	Market Near Bharat Nagar	15/11/2014
Ward M/W	HIG	Nagesh Patil Wadi	19/11/2014
	MIG	Near Ward Office	19/11/2014
	LIG	Near Deonar Dumpsite	19/11/2014
	CA	Market Near Nagesh Patil Wadi	19/11/2014
Ward N	HIG	Laxmi Nagar	19/11/2014
	MIG	Near Bmc Ward Office	19/11/2014
	LIG	Ambedkar Nagar	19/11/2014
	CA	Hingwala Market	19/11/2014
Ward S	HIG	LIC Housing Colony	14/11/2014
	MIG	Near Ward Office	14/11/2014
	LIG/Slum	Sajjan Wadi	14/11/2014
	CA	Market Near LIC Housing Colony	14/11/2014
Ward T	HIG	Vardhaman Nagar	14/11/2014
	MIG	Near Bmcward Office	14/11/2014
	LIG	Near Mulund Station	14/11/2014
	CA	Near BMC Ward Office	14/11/2014
	Deonar		15/11/2014
	Mulund		15/11/2014

4.3 Methods Adopted for Sampling of MSW

The sampling was done as per the Central Public Health and Environmental Engineering Organization (CPHEEO) guidelines 2000. Approximately, 20 kg of grab samples were collected from the identified collection points in each of the above-mentioned categories. In each of the categories, MSW samples were collected at 4 different collection points. Care was taken to ensure, that the composite sample collected from these pre-determined locations was not less than 20 kg by weight.

For Physical and chemical analysis, the collected sample was manually mixed (on a tarpaulin) using a shovel to make its characteristics more uniform. A conical heap was prepared of this mixed sample and randomly one quarter of a portion was selected using Cone and Quartering method. For physical analysis, the waste was segregated into biodegradable/compostable matter (food and vegetable waste), paper, plastic, metal & glass and inerts and then the result was concluded by (w/w) method.

For Physico-chemical analysis, 5 kg of the representative mixed waste sample was collected and brought to NEERI laboratory. Samples collected were coded prior to transporting them to NEERI, Nagpur Laboratory. Laboratory analysis work for physical and chemical analysis has been done as per Standard Methods; US EPA SWM 846 Methods.

4.4 Methods adopted for Seasonal Variations of Physico-chemical Characteristics of MSW and its Statistical Analysis (Pre-monsoon, Monsoon, Post-monsoon Seasons)

For interpretation of seasonal variations and statistical analysis of physico-chemical characteristics of MSW (Pre-monsoon, Monsoon, Post-monsoon Seasons), Minitab 15 software was used.

The following procedure was used to analyze the data:

a) One Way ANOVA

One way ANOVA is used to compare the average values of the parameter in the 3 groups of datasets i.e. Pre-monsoon, Monsoon and Post-monsoon seasons.

In one-way ANOVA, degree of freedom, sum of squares, f static value, p value, 95% confidence level were taken into consideration.

b) HSU's MCB Test

Hsu's MCB test procedure is used after an ANOVA to more precisely analyze differences between averages. A multiple comparison method that is to identify factor levels that are the best, insignificantly different from the best, and those that are significantly different from the best. "Best" is defined as either the highest or lowest averages.

It can be helpful to specify the parameters that were:

- statistically significant
- parameters satisfying the null hypothesis
- parameters that gave tighter CIs in HSU's MCB
- to provide probable reasons for the same.

c) Box plot Interpretation

The plot represents the median, lower and upper quartile and lower and upper extremes in the distribution, making it ideal for comparing distributions. The ends of the box represent the upper and lower quartiles, thus the box spans in the inter-quartile ranges. The median is marked by the horizontal line in the box. The whiskers outside the box mark the highest and lowest observations in the dataset.

5.1 Pre-monsoon Season

A total of 24 MSW samples were collected from the identified HIG, MIG, LIGs, CAs, as well as both landfill site (Mulund & Deonar). Physical characteristics of MSW were carried out at all the sampling points. Physical characteristics of MSW comprised of food waste, papers, plastics, metals & glasses and inerts.

5.1.1 Physical Characterization of MSW

Physical Characteristics of MSW for the Pre-monsoon season of 24 wards including two dumpsites are presented in Tables 5.1 through 5.27. Graphical representation for physical characterization of MSW for the Pre-monsoon season is shown in Figures 5.1 through 5.27.

Table 5.1

Physical Characteristics of MSW of Ward “A” (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	97.00	94.00	85.5
Paper	5.00	2.00	3.50
Plastics	4.00	3.16	3.58
Metals and glasses	1.00	0.80	0.90
Inerts	8.10	4.90	6.50

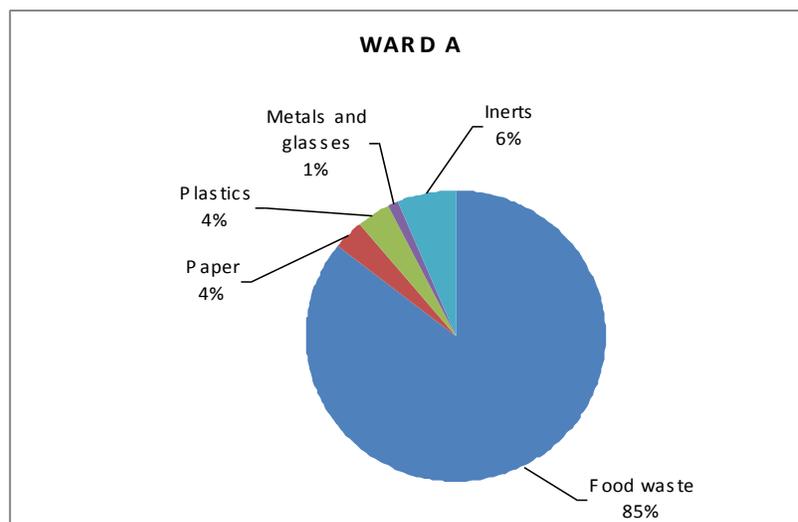


Figure 5.1: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward A

Table 5.2

Physical Characteristics of MSW of Ward B (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	91.20	74.40	82.8
Paper	3.50	1.80	2.65
Plastics	4.80	3.20	4.00
Metals and glasses	3.10	1.10	2.10
Inerts	9.40	7.40	8.40

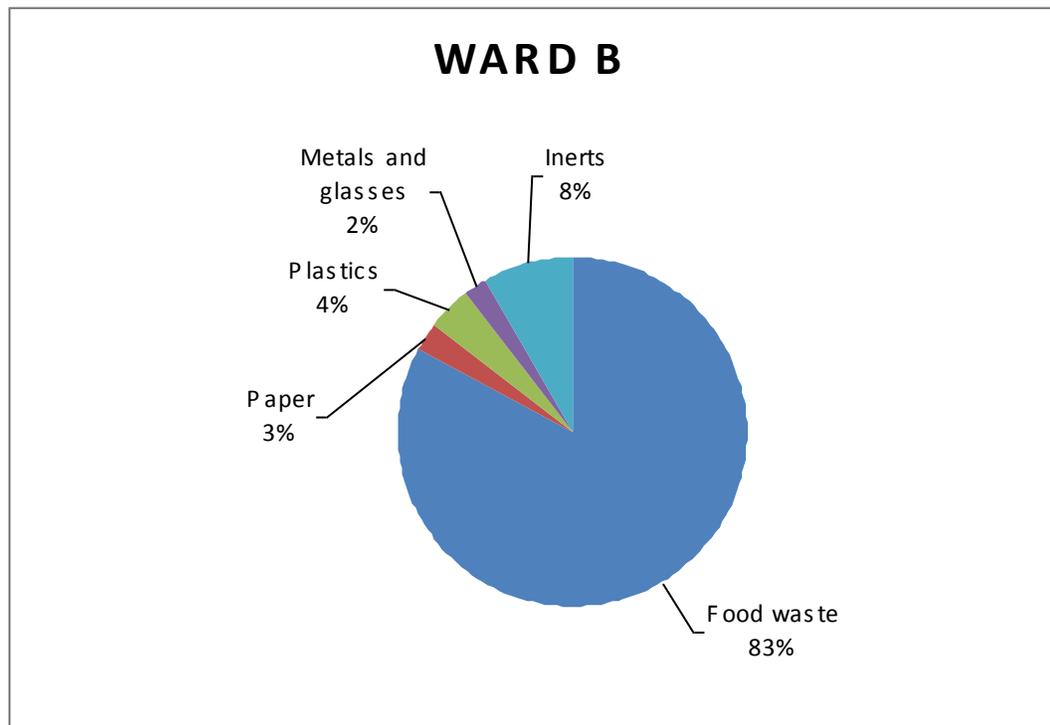


Figure 5.2: Graphical Representation of Physical Characteristics (Pre-monsoon season) of MSW of Ward B

Table 5.3

Physical Characteristics of MSW of Ward C (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	88.20	67.40	77.80
Paper	4.20	2.90	3.55
Plastics	6.70	4.80	5.75
Metals and glasses	5.10	2.10	3.60
Inerts	10.90	7.60	9.25

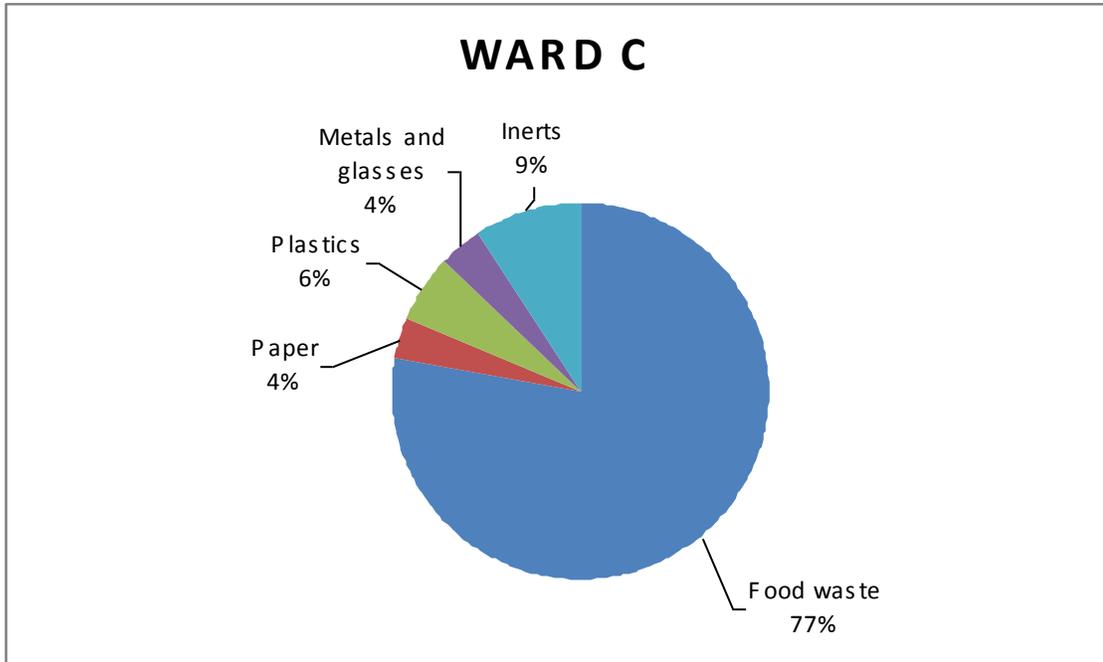


Figure 5.3: Graphical Representation of Physical Characteristics (Pre-monsoon season) of MSW of Ward C

Table 5.4

Physical Characteristics of MSW of Ward D (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	85.02	64.65	74.84
Paper	4.70	2.60	3.65
Plastics	5.90	4.60	5.25
Metals and glasses	2.40	1.80	2.10
Inerts	16.24	12.00	14.12

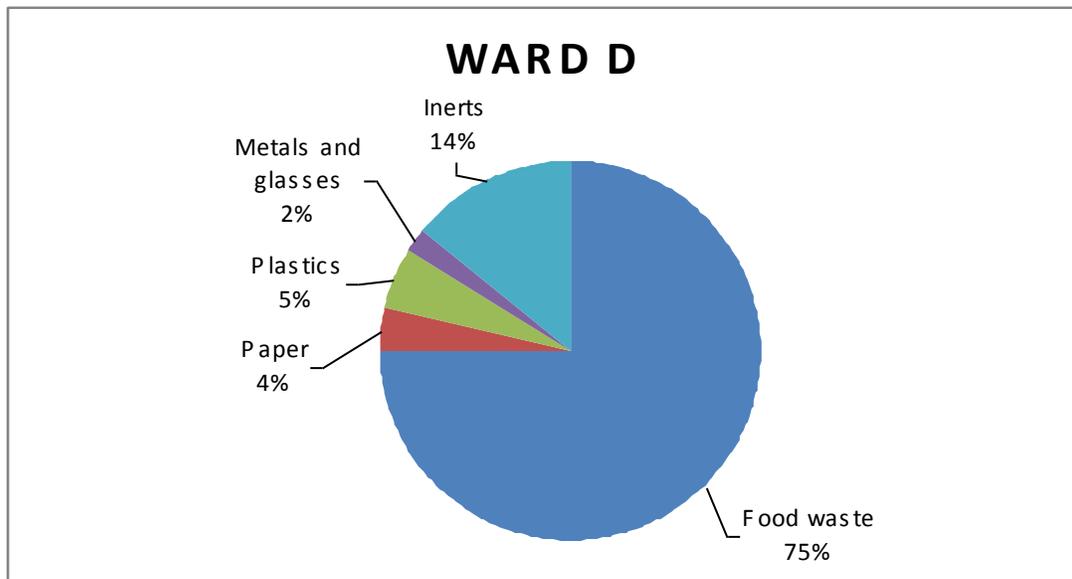


Figure 5.4: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward D

Table 5.5

Physical Characteristics of MSW of Ward E (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	89.53	70.21	79.88
Paper	4.21	2.34	3.28
Plastics	2.17	1.86	2.02
Metals and glasses	3.20	1.90	2.55
Inerts	15.46	9.14	12.30

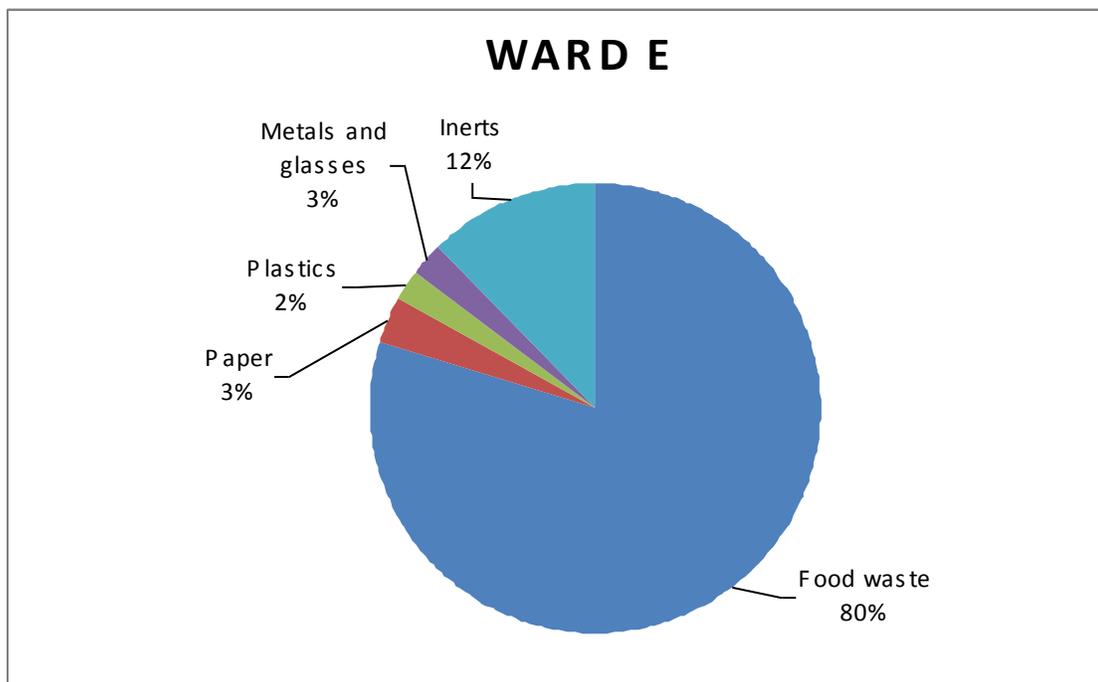


Figure 5.5: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward E

Table 5.6

Physical Characteristics of MSW of Ward F/S (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	82.62	73.06	77.5
Paper	4.17	1.48	2.83
Plastics	2.24	1.48	1.86
Metals and glasses	2.69	1.73	2.21
Inerts	18.41	12.18	15.30

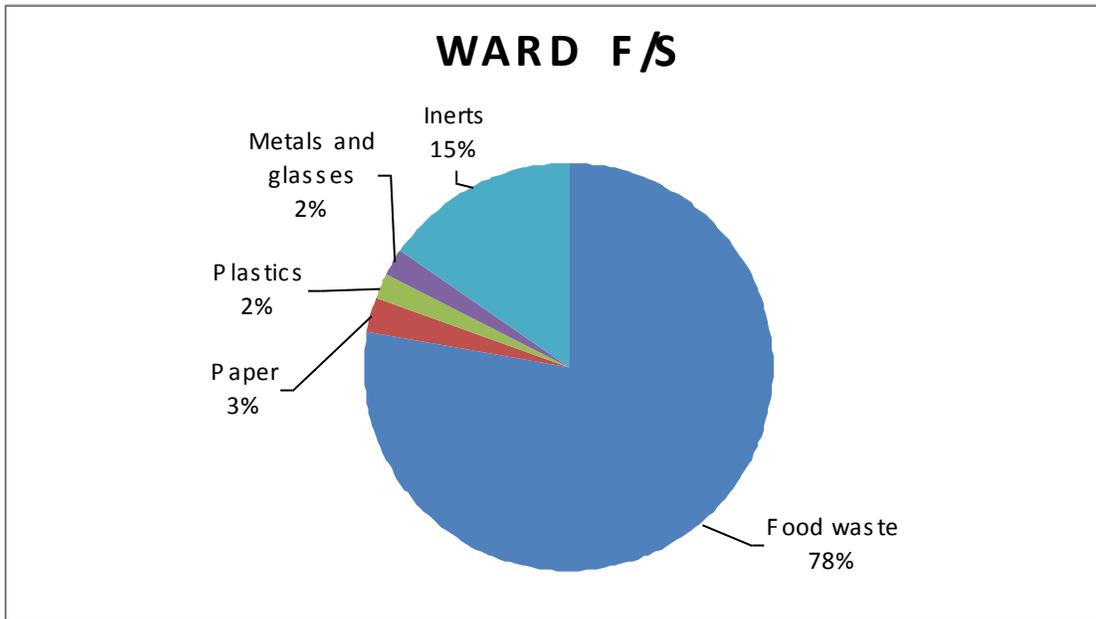


Figure 5.6: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward F/S

Table 5.7

Physical Characteristics of MSW of Ward F/N (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	93.31	65.93	79.62
Paper	4.16	2.07	3.12
Plastics	2.69	1.52	2.11
Metals and glasses	2.21	1.05	1.63
Inerts	15.42	11.73	13.58

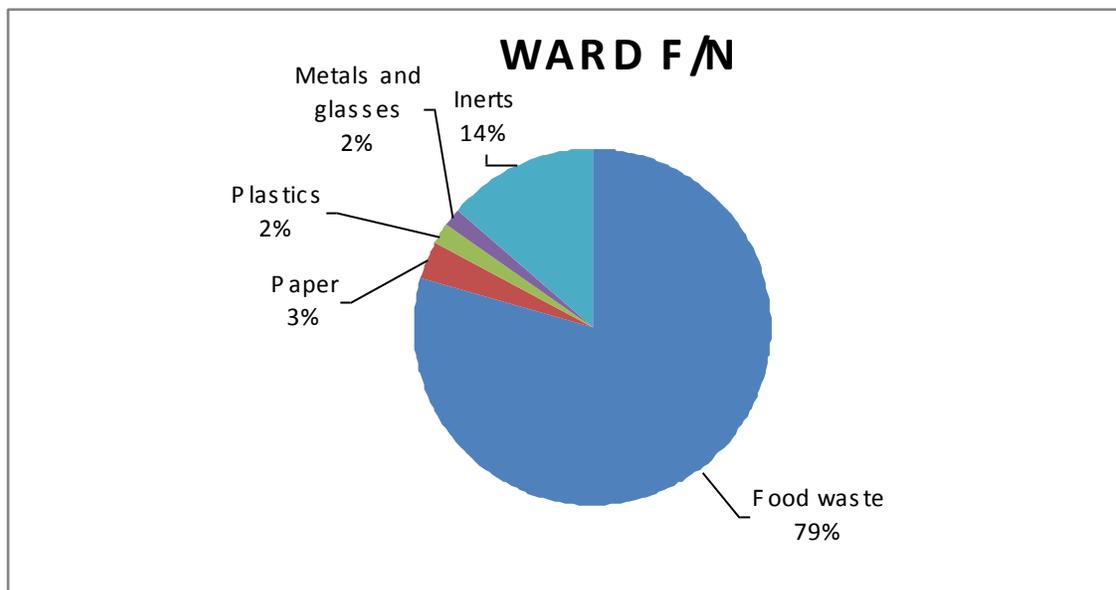


Figure 5.7: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward F/N

Table 5.8

Physical Characteristics of MSW of Ward G/S (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	84.34	67.36	75.99
Paper	5.47	4.16	4.82
Plastics	3.49	2.51	3.00
Metals and glasses	3.24	1.10	2.17
Inerts	14.72	13.24	13.98

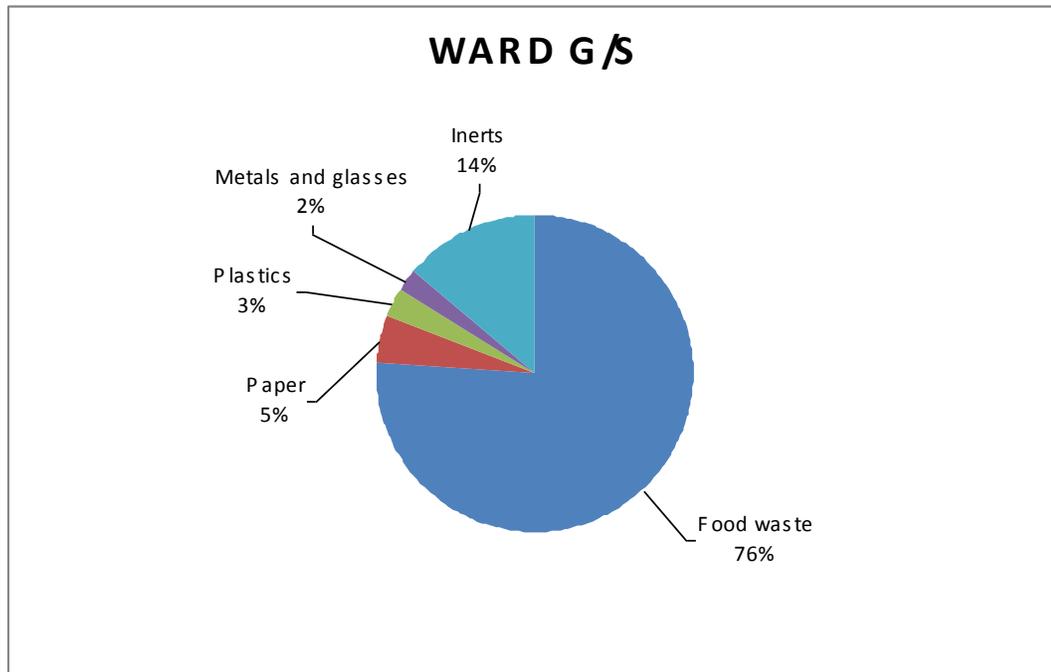


Figure 5.8: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of G/S

Table 5.9

Physical Characteristics of MSW of Ward G/N (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	81.61	60.47	71.05
Paper	6.42	4.67	5.55
Plastics	4.83	2.43	3.63
Metals and glasses	4.86	3.46	4.16
Inerts	18.43	12.76	15.60

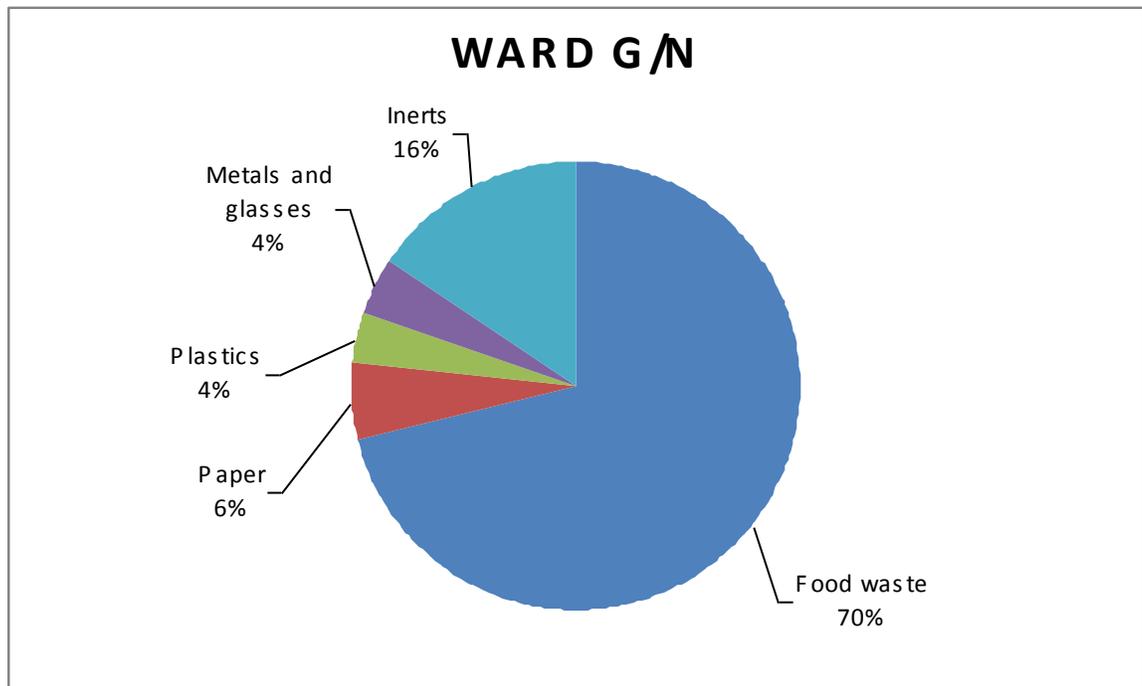


Figure 5.9: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward G/N

Table 5.10

Physical Characteristics of MSW of Ward H/E (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	88.9	63.3	76.1
Paper	4.67	2.82	3.75
Plastics	3.16	1.82	2.49
Metals and glasses	2.85	1.24	2.05
Inerts	19.47	11.75	15.61

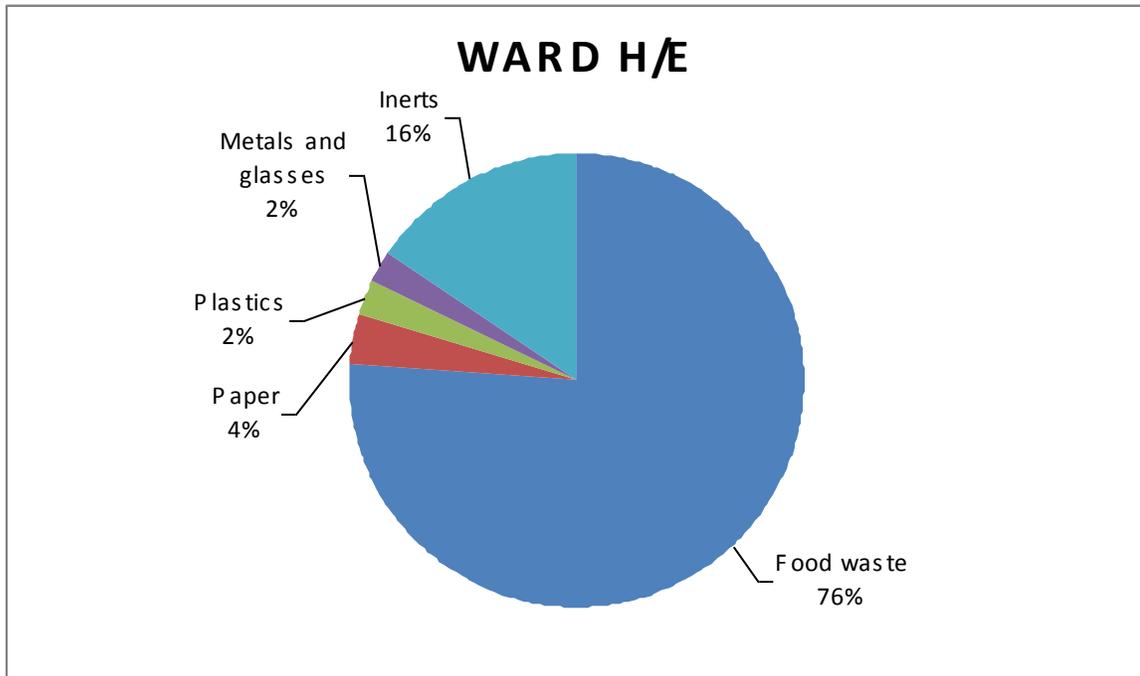


Figure 5.10: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward H/E

Table 5.11

Physical Characteristics of MSW of Ward H/W (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	87.84	68.41	78.13
Paper	4.23	2.31	3.27
Plastics	2.84	1.47	2.16
Metals and glasses	2.50	1.17	1.84
Inerts	19.65	14.88	17.27

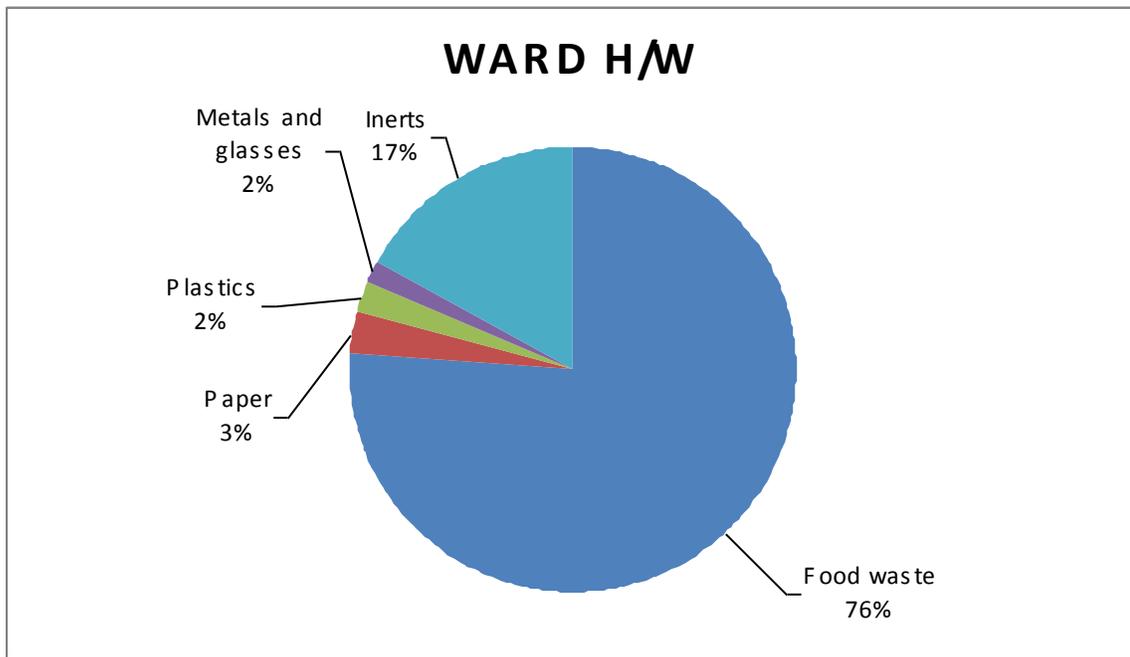


Figure 5.11: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward H/W

Table 5.12

Physical Characteristics of MSW of Ward K/W (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	88.24	65.16	76.7
Paper	2.96	1.52	2.24
Plastics	1.76	1.30	1.53
Metals and glasses	2.15	1.03	1.59
Inerts	23.18	13.65	18.42

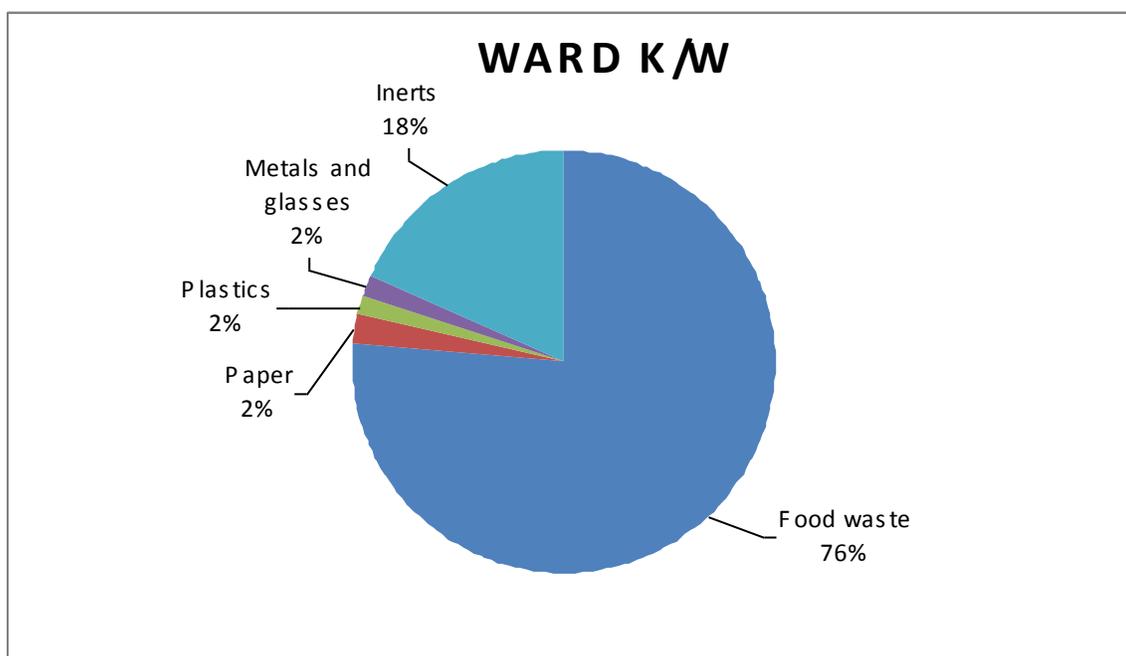


Figure 5.12: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward K/W

Table 5.13

Physical Characteristics of MSW of Ward P/S (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	80.9	61.00	70.95
Paper	6.33	3.60	4.97
Plastics	3.77	1.49	2.63
Metals and glasses	6.16	3.27	4.72
Inerts	20.66	12.47	16.57

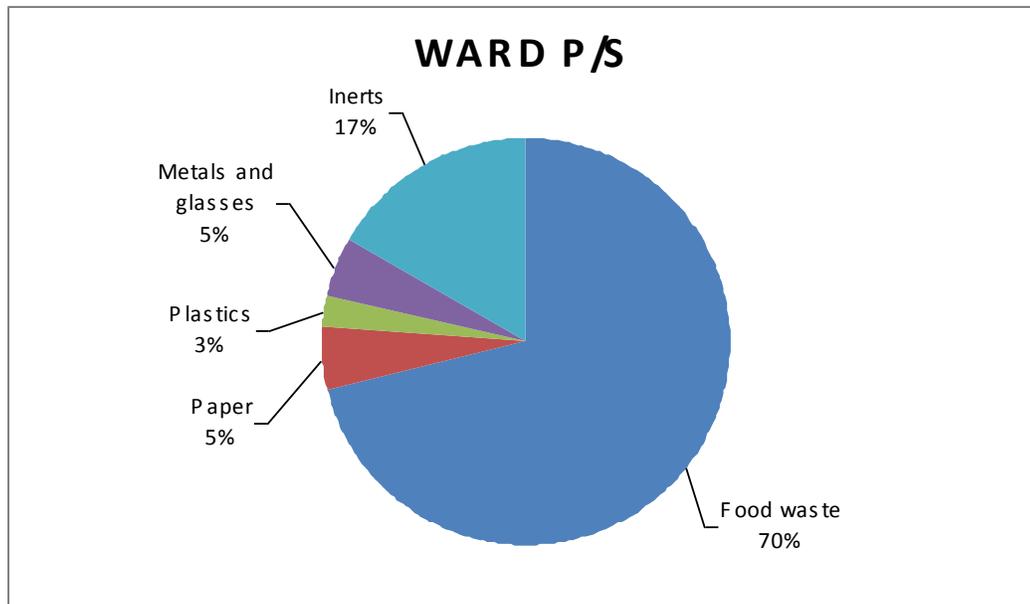


Figure 5.13: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward P/S

Table 5.14

Physical Characteristics of MSW of Ward P/N (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	81.52	70.11	75.82
Paper	2.86	1.34	2.10
Plastics	1.87	1.20	1.54
Metals and glasses	1.52	0.82	1.17
Inerts	25.76	13.45	19.61

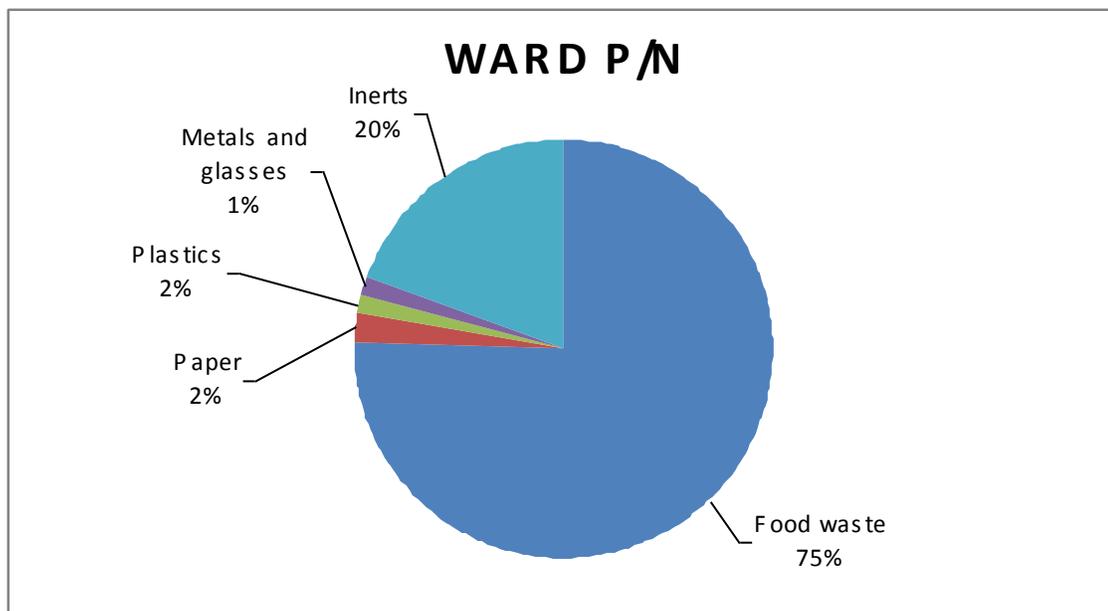


Figure 5.14: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward P/N

Table 5.15

Physical Characteristics of MSW of Ward R/S (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	83.81	66.47	75.14
Paper	5.21	3.09	4.15
Plastics	2.65	1.38	2.02
Metals and glasses	3.68	1.26	2.47
Inerts	19.22	14.15	16.69

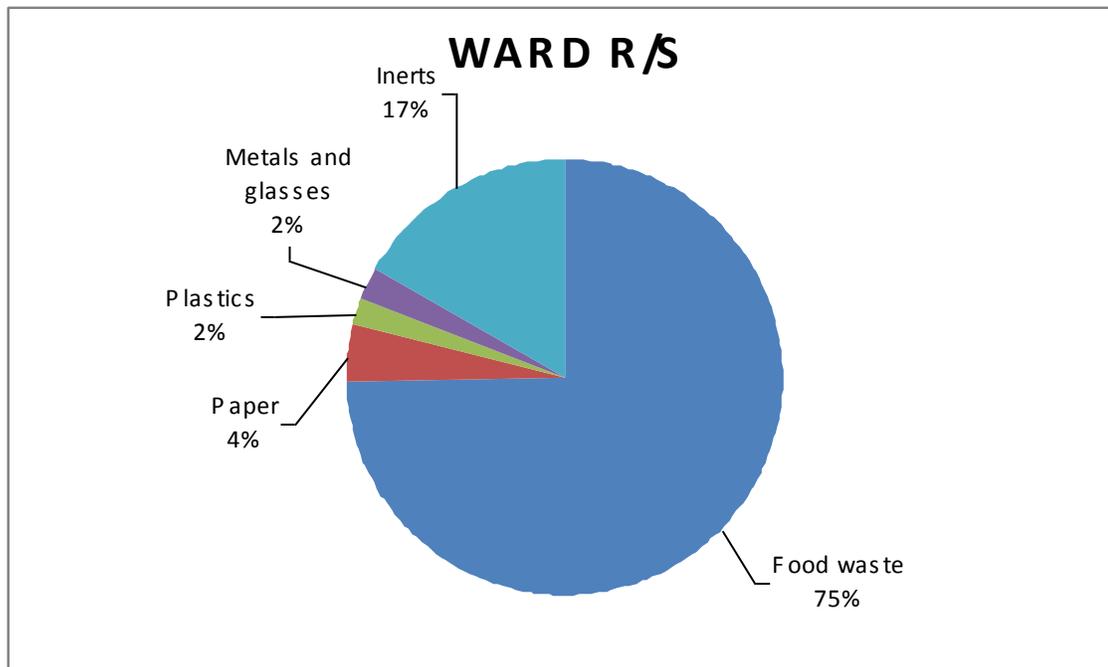


Figure 5.15: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward R/S

Table 5.16

Physical Characteristics of MSW of Ward R/C (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg.(%)
Food waste	86.73	67.07	76.1
Paper	3.68	2.81	3.25
Plastics	2.59	1.45	2.02
Metals and glasses	5.67	2.76	4.22
Inerts	16.45	11.65	14.05

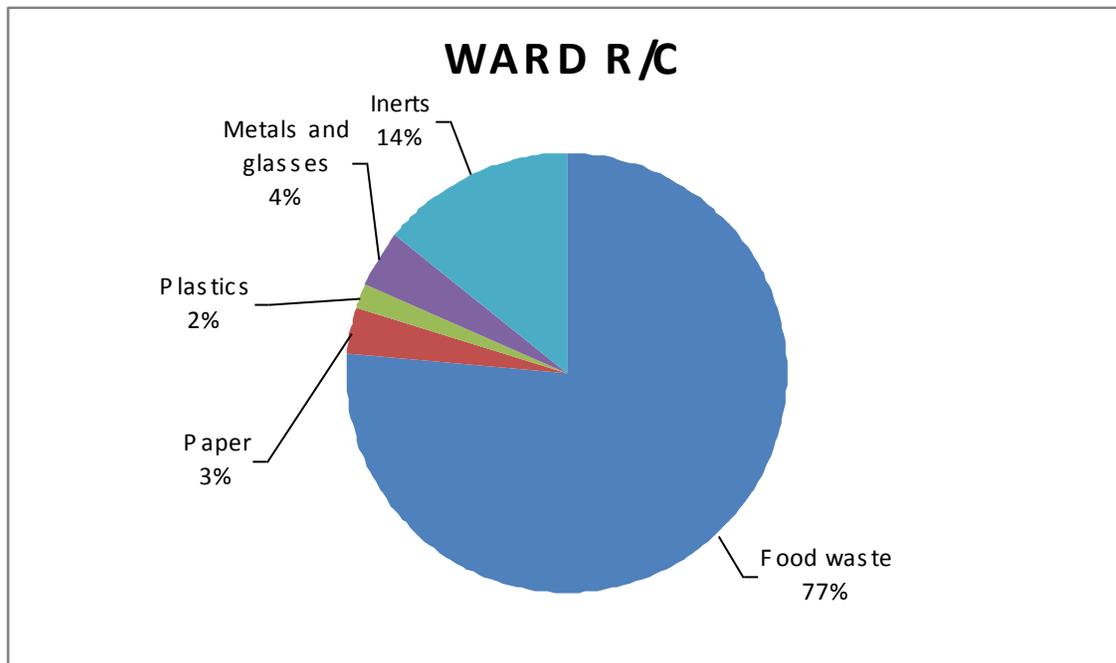


Figure 5.16: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward R/C

Table 5.17

Physical Characteristics of MSW of Ward R/N (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	82.1	62.94	72.52
Paper	4.86	1.98	3.42
Plastics	3.52	1.65	2.59
Metals and glasses	5.72	3.77	4.75
Inerts	18.33	15.39	16.86

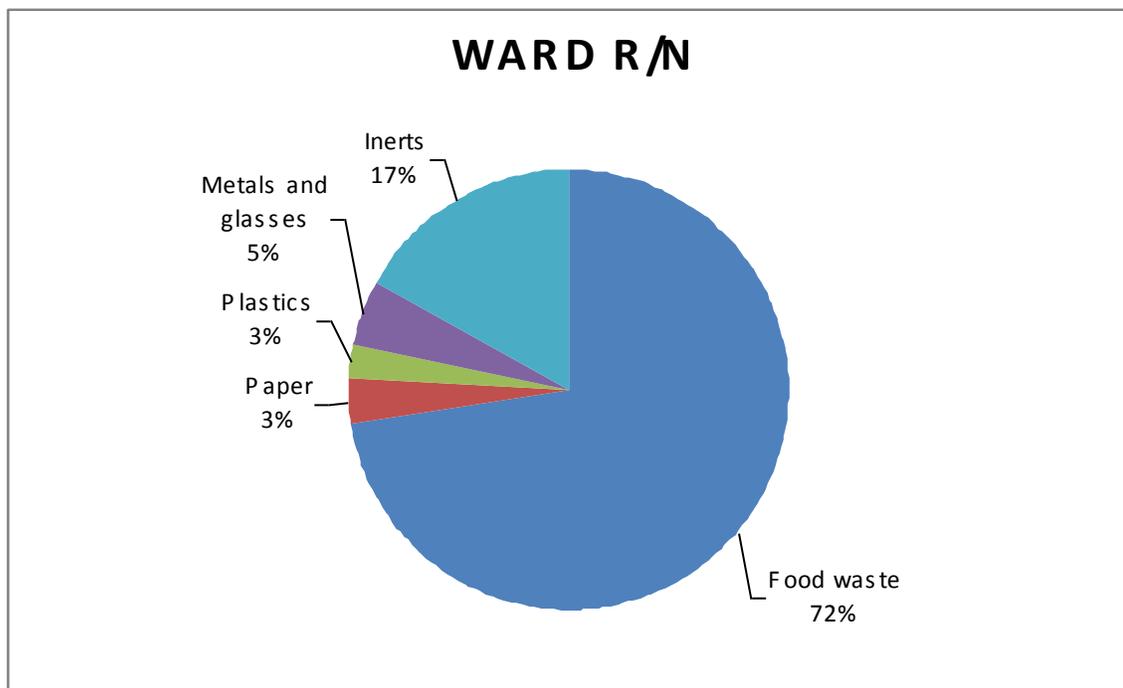


Figure 5.17: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward R/N

Table 5.18

Physical Characteristics of MSW of Ward L (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	78.44	67.64	73.05
Paper	4.26	2.99	3.63
Plastics	3.69	2.67	3.18
Metals and glasses	2.34	1.55	1.95
Inerts	19.26	17.38	18.32

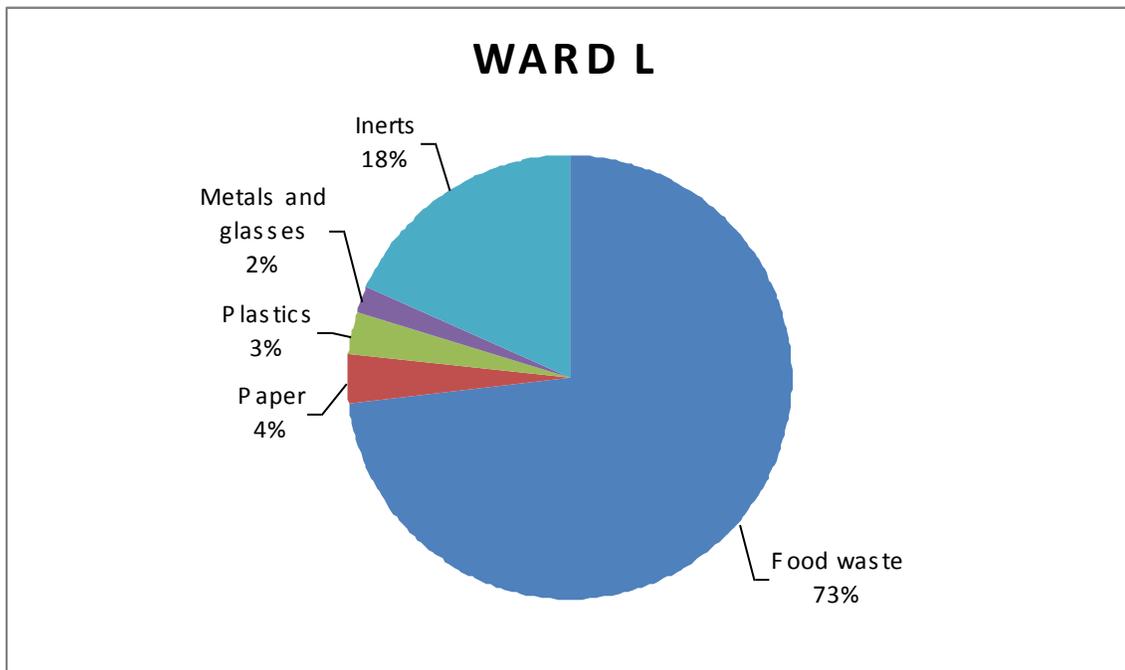


Figure 5.18: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward L

Table 5.19

Physical Characteristics of MSW of Ward M/E (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	83.84	59.27	71.59
Paper	4.56	2.15	3.36
Plastics	2.65	1.54	2.10
Metals and glasses	3.52	1.38	2.45
Inerts	25.66	16.13	20.90

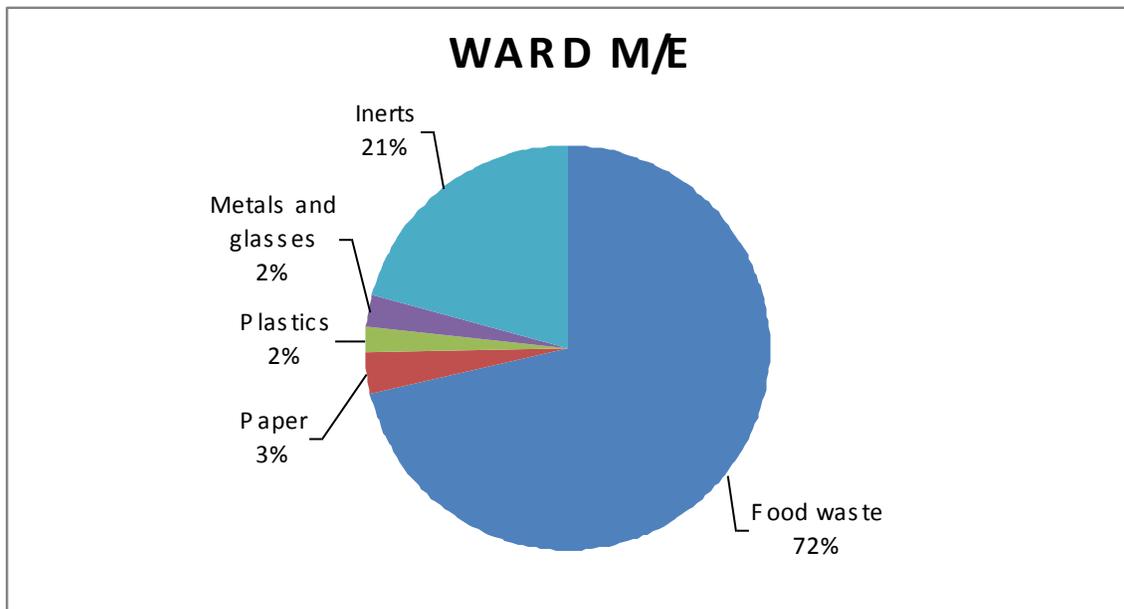


Figure 5.19: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward M/E

Table 5.20

Physical Characteristics of MSW of Ward M/W (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	85.04	58.24	71.23
Paper	5.76	1.32	3.54
Plastics	3.46	1.25	2.36
Metals and glasses	3.18	1.67	2.43
Inerts	22.67	17.33	20.00

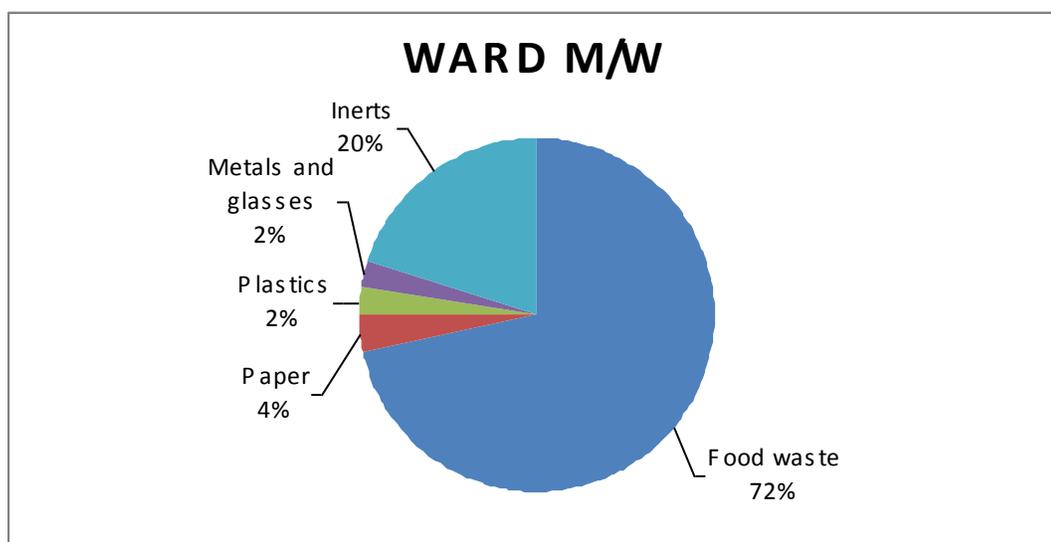


Figure 5.20: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward M/W

Table 5.21

Physical Characteristics of MSW of Ward N (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	82.03	57.72	69.88
Paper	6.38	3.74	5.06
Plastics	5.75	2.66	4.21
Metals and glasses	3.87	2.16	3.02
Inerts	20.85	15.38	18.12

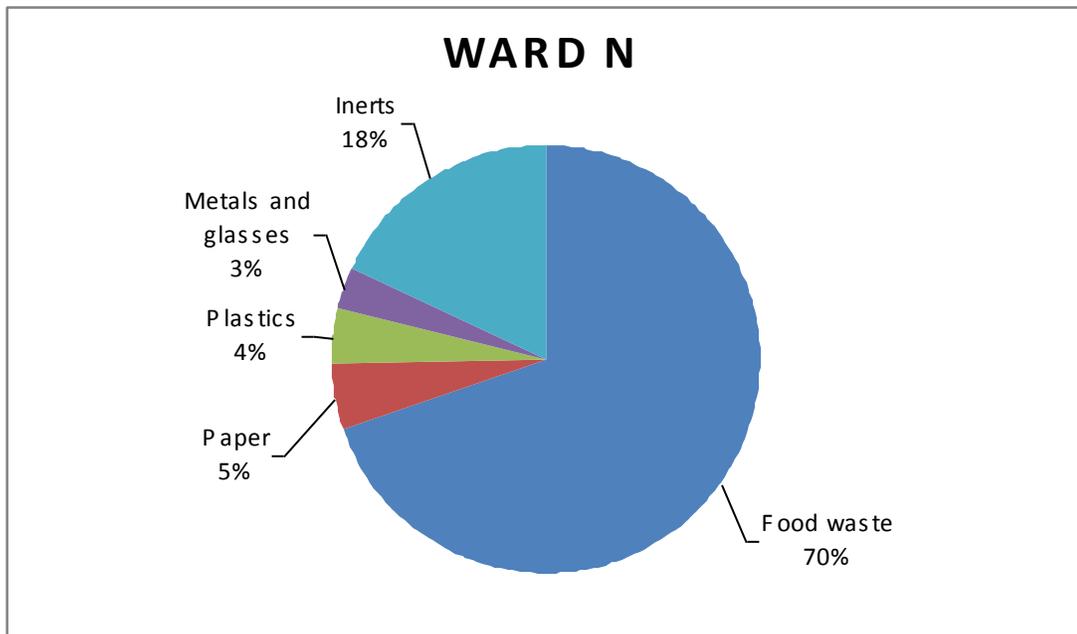


Figure 5.21: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward N

Table 5.22

Physical Characteristics of MSW of Ward S (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	81.67	57.72	69.88
Paper	3.70	1.36	2.53
Plastics	3.44	2.61	3.03
Metals and glasses	2.32	1.40	1.86
Inerts	23.70	13.98	18.84

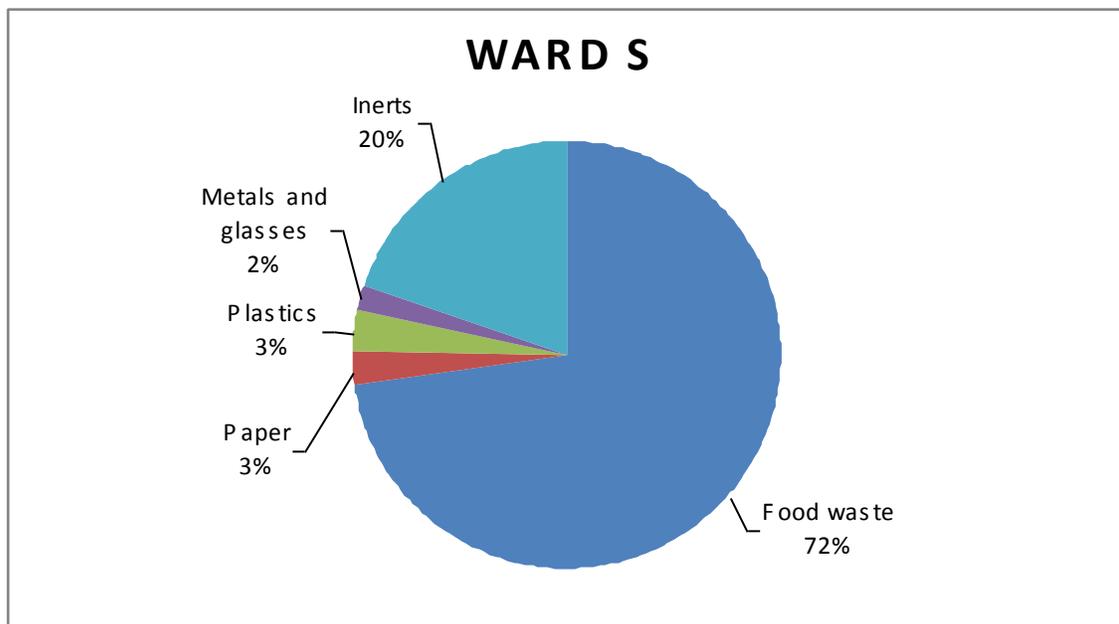


Figure 5.22: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward S

Table 5.23

Physical Characteristics of MSW of Ward T (Pre-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	77.97	66.14	72.96
Paper	5.33	1.10	3.22
Plastics	2.38	1.90	2.14
Metals and glasses	3.80	2.04	2.92
Inerts	22.36	14.33	18.35

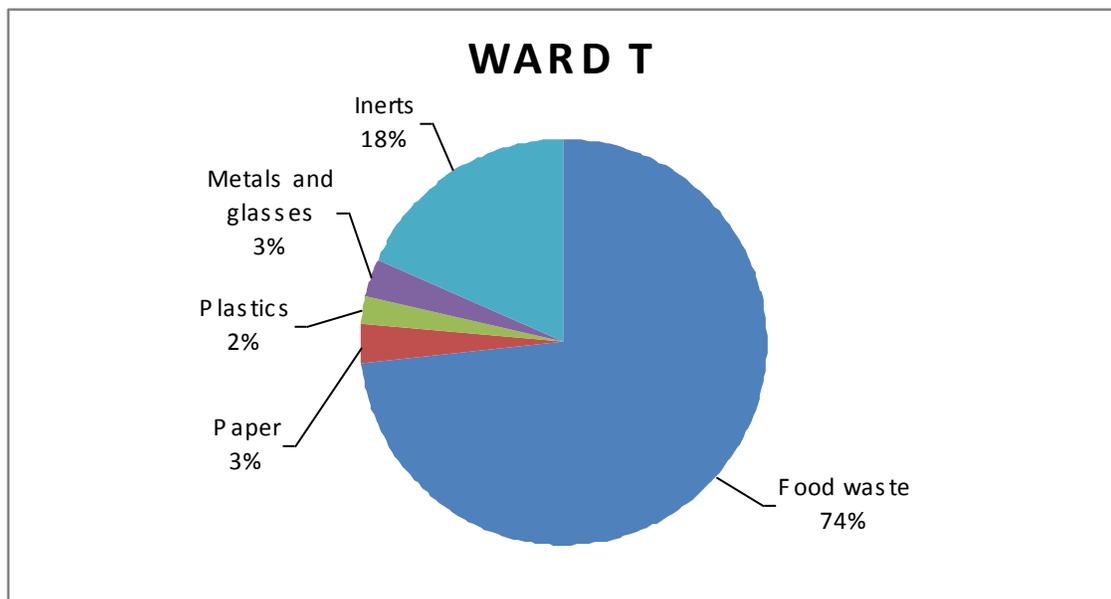


Figure 5.23: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Ward T

Table 5.24

Physical Characteristics (Pre-monsoon season) of MSW of Deonar Dumpsite (Old Dumped Waste)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	56.98	33.82	45.61
Paper	2.58	1.55	2.07
Plastics	8.44	4.63	6.54
Metals and glasses	16.47	10.87	13.67
Inerts	39.45	24.71	32.08

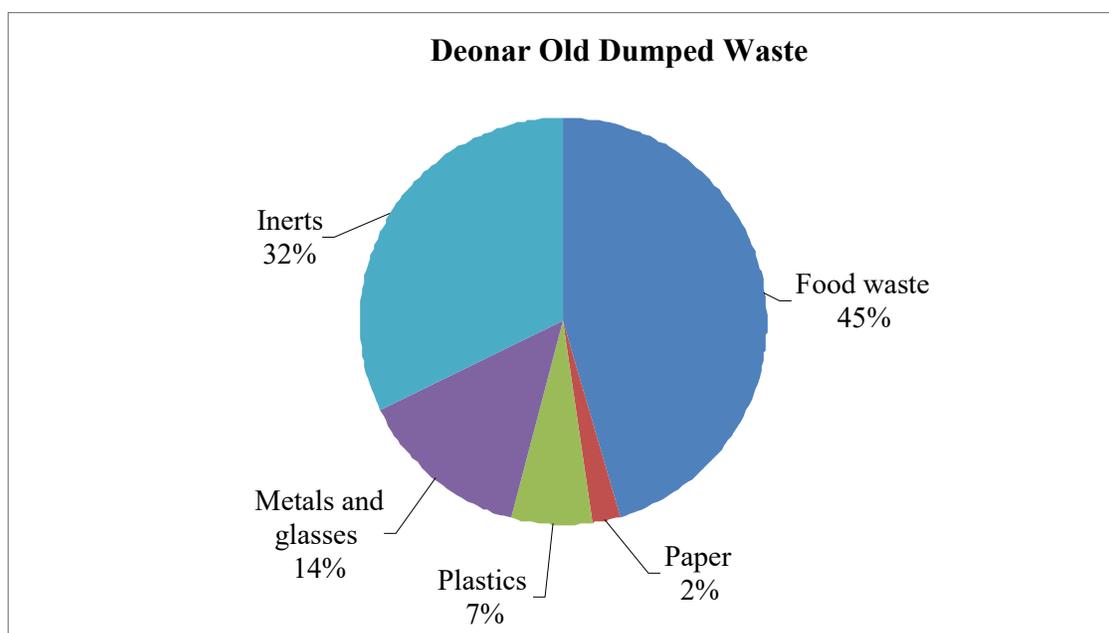


Figure 5.24: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Deonar Old Dumped Waste

Table 5.25

Physical Characteristics (Pre-monsoon Season) of MSW of Deonar New (Freshly Dumped Waste)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	70.79	53.35	61.76
Paper	5.69	4.12	4.91
Plastics	7.58	3.93	5.76
Metals and glasses	4.26	2.44	3.35
Inerts	27.44	21.48	24.46

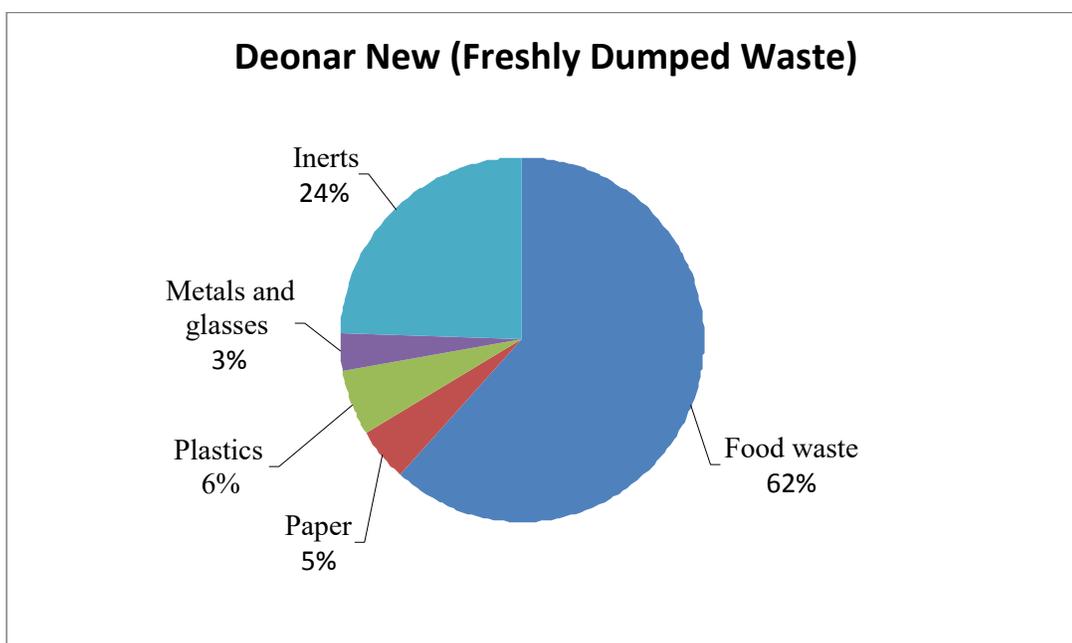


Figure 5.25: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Deonar New (Freshly Dumped Waste)

Table 5.26

Physical Characteristics (Pre-monsoon Season) of MSW of Mulund (Old Dumped Waste)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	47.00	27.21	37.61
Paper	5.65	3.57	4.61
Plastics	8.46	5.89	7.18
Metals and glasses	14.70	8.36	11.53
Inerts	45.28	33.24	39.26

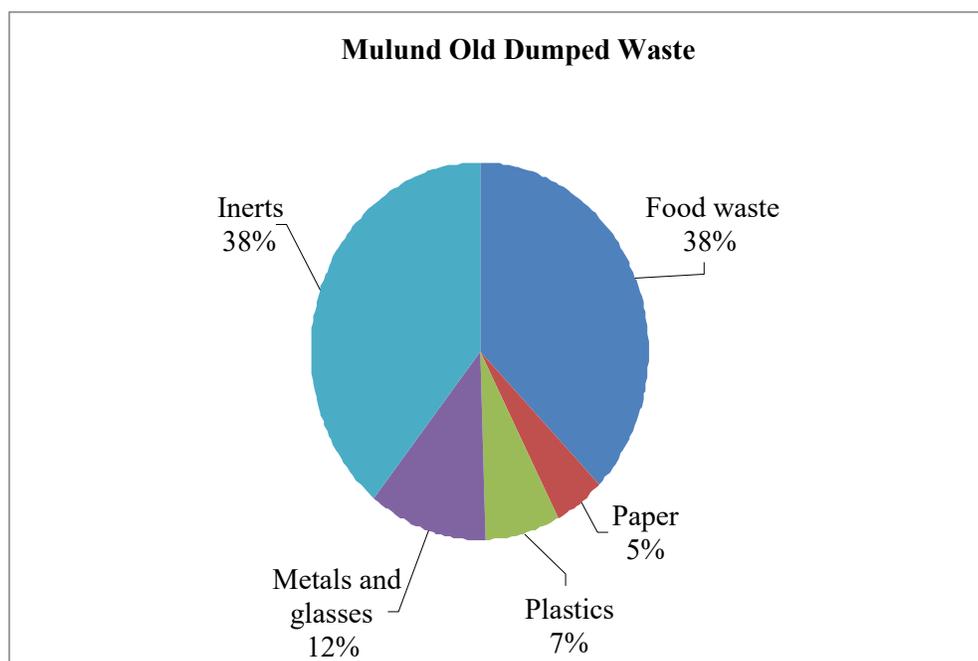


Figure 5.26: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Mulund Old Dumped Waste

Table 5.27

Physical Characteristics (Pre-monsoon Season) of MSW of Mulund New (Freshly Dumped Waste)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	84.69	61.63	73.07
Paper	4.33	2.10	3.22
Plastics	4.67	3.25	3.96
Metals and glasses	4.65	3.04	3.85
Inerts	18.33	13.43	15.88

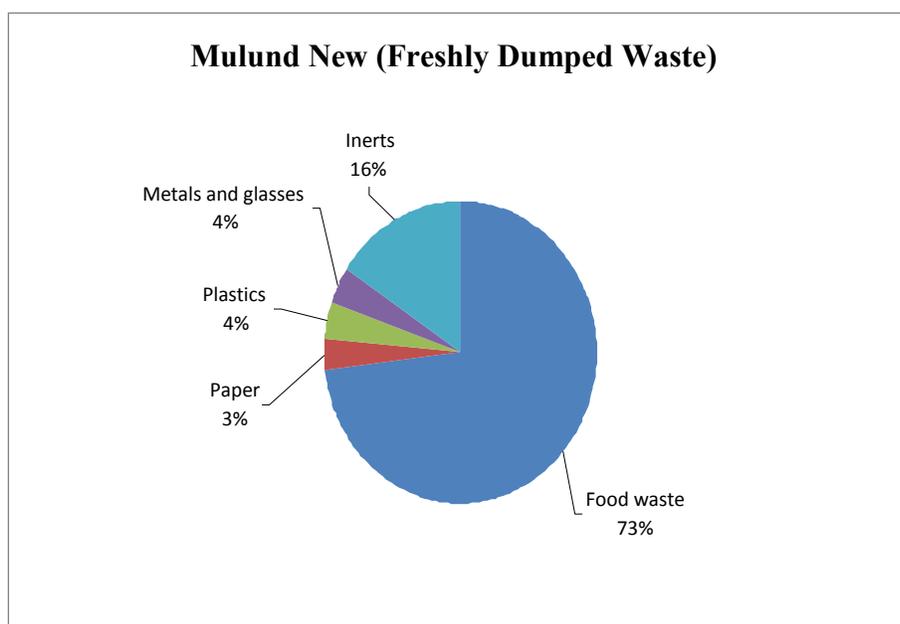


Figure 5.27: Graphical Representation of Physical Characteristics (Pre-monsoon Season) of MSW of Mulund New (Freshly Dumped Waste)

Table 5.28 presents overall pre-monsoon physical characteristics of MSW in 24 Wards of MCGM (including two Dump Sites) and also overall graphical representation in 24 wards of MCGM (including two Dump Sites) is shown in Figure 5.28.

Table 5.28

Overall Physical Characteristics of MSW (Pre monsoon Season) of Different Ward of MCGM, including Two Dumpsites Mumbai Region

Component	Max %	Mini %	Avg. %
Food waste	88.4	37.61	72.6
Paper	5.55	2.07	3.51
Plastics	7.18	1.58	3.24
Metal and glasses	13.67	0.89	3.28
inerts	39.26	6.5	17.37

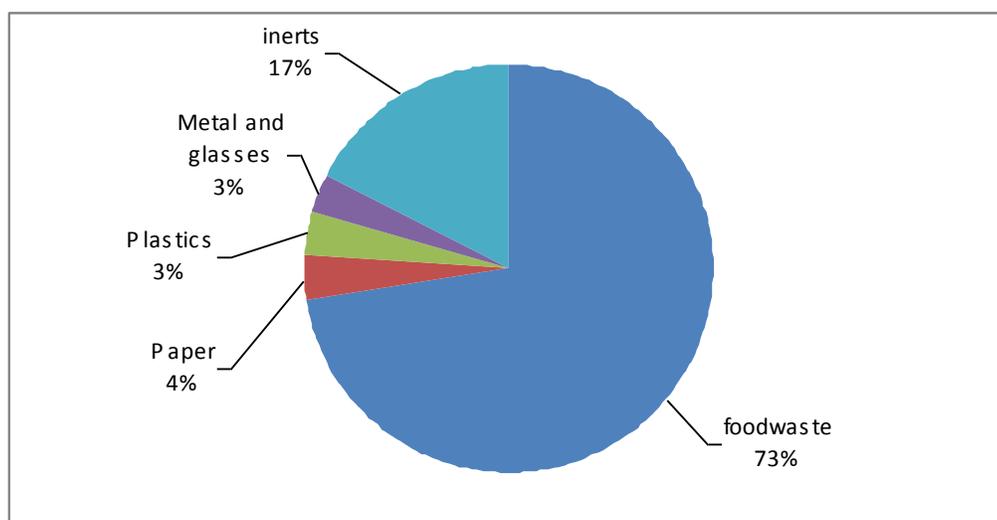


Figure 5.28: Overall Graphical Representation of Physical Characteristics (Pre-monsoon Season) of 24 Wards (including Two Dumpsites) of MCGM

5.1.2 Physico-chemical Characterization of MSW (Pre-monsoon Season)

The MSW samples were analyzed in CSIR-NEERI laboratory for various parameters, such as pH, moisture content, total solids, loss on Ignition, ash, Carbon, calorific value, nitrogen, C/N ratio, sulphur, phosphorous, potassium, etc. Chemical characteristics of MSW for the Pre-monsoon Season of 24 wards including two dump sites are presented in Tables 5.29 through 5.40.

Table 5.29

**Physico-chemical Analysis (pH) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region
(Pre-monsoon Season)**

Wards Name	pH Value		
	Max.	Min.	Avg.
A	7.01	6.95	6.88
B	7.45	6.83	7.27
C	6.92	6.62	6.77
D	7.94	7.61	7.87
E	7.05	6.49	6.71
F/S	7.25	6.74	6.93
F/N	8.16	7.83	8.04
G/S	7.12	6.21	6.48
G/N	7.95	7.05	7.74
H/E	7.84	7.15	7.35
H/W	7.54	6.76	7.09
K/E	7.27	6.5	6.78
K/W	6.84	6.43	6.36
L	7.94	7.37	7.83
M/E	6.92	6.16	6.55
M/W	8.42	7.82	8.24
N	8.35	7.87	8.13
P/S	7.24	6.47	6.76
P/N	7.04	6.18	6.32
R/S	7.28	6.38	6.75
R/C	7.69	6.35	7.25
R/N	7.83	6.6	7.45
S	7.61	6.84	7.33
T	8.51	7.9	8.29
Deonar (Old Dumped Waste)	7.23	6.26	6.51
Deonar New (Freshly Dumped Waste)	7.94	6.75	7.22
Mulund (Old Dumped Waste)	8.04	6.58	7.36
Mulund New (Freshly Dumped Waste)	8.21	7.18	7.98

Table 5.30**Physico-Chemical Analysis (Moisture Content) of MSW of 24 Wards including Two Dump sites of MCGM, Mumbai Region (Pre- monsoon season)**

Wards Name	Moisture Content		
	Max. (%)	Min. (%)	Avg. (%)
A	82	71.6	76.8
B	84.87	65.54	75.205
C	75.44	67.11	71.28
D	78.58	68.45	73.52
E	71.27	67.46	69.37
F/S	71.27	66.74	69.00
F/N	76.22	64.11	70.17
G/S	71.27	59.88	65.58
G/N	83.79	70.54	77.17
H/E	77.25	66.94	72.10
H/W	80.68	69.55	75.12
K/E	78.66	72.19	75.42
K/W	79.55	72.14	75.84
L	80.64	72.16	76.40
M/E	75.46	70.06	72.76
M/W	76.16	70.89	73.52
N	75.16	65.46	70.31
P/S	78.5	65.44	71.97
P/N	76.44	67.11	71.77
R/S	79.16	66.59	72.87
R/C	76.44	71.46	73.95
R/N	77.61	73.1	75.35
S	76.49	68.44	72.46
T	77.55	70.16	73.85
Deonar (Old Dumped Waste)	70.48	60.49	65.48
Deonar New (Freshly Dumped Waste)	75.43	68.42	71.92
Mulund (Old Dumped Waste)	71.78	62.15	66.96
Mulund New (Freshly Dumped Waste)	83.49	74.68	79.08

Table 5.31**Physico-Chemical Analysis (Total Solids) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Pre- monsoon season)**

Total solids			
Ward name	Max. (%)	Min. (%)	Avg. (%)
A	28.4	18	23.2
B	34.46	15.13	24.795
C	32.89	24.56	28.73
D	31.55	21.42	26.49
E	32.54	28.73	30.64
F/S	33.26	28.73	31.00
F/N	35.89	23.78	29.83
G/S	40.12	28.73	34.42
G/N	29.46	16.21	22.83
H/E	33.06	22.75	27.90
H/W	30.45	19.32	24.89
K/E	27.81	21.34	24.58
K/W	27.86	20.45	24.16
L	27.84	19.36	23.60
M/E	29.94	24.54	27.24
M/W	29.11	23.84	26.48
N	34.54	24.84	29.69
P/S	34.56	21.5	28.03
P/N	32.89	23.56	28.23
R/S	33.41	20.84	27.13
R/C	28.54	23.56	26.05
R/N	77.61	73.1	75.35
S	31.56	23.51	27.54
T	29.84	22.45	26.15
Deonar (Old Dumped Waste)	39.51	29.52	34.52
Deonar New (Freshly Dumped Waste)	31.58	24.57	28.08
Mulund (Old Dumped Waste)	37.85	28.22	33.04
Mulund New (Freshly Dumped Waste)	25.32	16.51	20.92

Table 5.32**Physico-Chemical Analysis (Loss on Ignition) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Pre- monsoon season)**

Loss on Ignition			
Ward name	Max. (%)	Min. (%)	Avg. (%)
A	90.11	78.22	84.17
B	91.25	72.11	81.68
C	84.75	75.33	80.04
D	91.95	81.40	86.68
E	83.26	74.13	78.70
F/S	81.24	74.06	77.65
F/N	80.06	72.19	76.13
G/S	86.68	70.55	78.62
G/N	82.89	74.32	78.61
H/E	90.44	74.06	82.25
H/W	83.1	77.16	80.13
K/E	84.1	74.46	79.28
K/W	81.26	76.23	78.74
L	86.03	72.11	79.07
M/E	79.1	70.02	74.56
M/W	80.14	76.12	78.13
N	74.11	68.86	71.48
P/S	81.66	72.75	77.21
P/N	84.16	72.91	78.54
R/S	79.55	71.46	75.51
R/C	76.22	71.3	73.76
R/N	91.1	72.06	81.58
S	81.29	77.19	79.24
T	76.59	68.11	72.35
Deonar (Old Dumped Waste)	61.65	48.34	55.00
Deonar New (Freshly Dumped Waste)	82.46	76.43	79.45
Mulund (Old Dumped Waste)	64.48	47.88	56.18
Mulund New (Freshly Dumped Waste)	80.46	73.85	77.16

Table 5.33**Physico-Chemical Analysis (Ash) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Pre- monsoon season)**

Ash			
Ward name	Max. (%)	Min. (%)	Avg. (%)
A	21.78	9.89	15.84
B	27.89	8.75	18.32
C	24.67	15.25	19.96
D	18.60	8.05	13.32
E	25.87	16.74	21.3
F/S	25.94	18.76	22.35
F/N	27.81	19.94	23.87
G/S	29.45	13.32	20.8
G/N	25.68	17.11	21.4
H/E	25.94	9.56	17.75
H/W	22.84	16.9	19.87
K/E	25.54	15.9	20.72
K/W	23.77	18.74	21.26
L	27.89	13.97	20.07
M/E	29.98	20.9	25.44
M/W	23.88	19.86	21.87
N	31.14	25.89	28.52
P/S	27.25	18.34	22.8
P/N	27.09	15.84	21.47
R/S	28.54	20.45	24.5
R/C	28.7	23.78	26.24
R/N	27.94	8.9	18.42
S	22.81	18.71	20.47
T	31.89	23.41	27.65
Deonar (Old Dumped Waste)	51.66	38.35	45.01
Deonar New (Freshly Dumped Waste)	23.57	17.54	20.56
Mulund (Old Dumped Waste)	52.12	35.52	43.82
Mulund New (Freshly Dumped Waste)	26.15	19.54	22.85

Table 5.34**Physico-chemical Analysis (Carbon) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Pre-monsoon Season)**

Carbon			
Ward Name	Max. (%)	Min. (%)	Avg. (%)
A	52.26	45.37	48.82
B	27.89	8.75	18.32
C	49.16	43.69	46.43
D	53.34	47.22	50.28
E	48.29	42.99	45.65
F/S	49.11	43.78	46.45
F/N	46.44	41.87	44.16
G/S	50.28	40.92	45.6
G/N	48.08	43.11	45.59
H/E	55.01	42.16	48.59
H/W	55.39	46.2	50.80
K/E	48.78	43.19	45.99
K/W	47.13	44.25	45.66
L	49.9	41.83	45.86
M/E	45.88	40.61	43.25
M/W	46.48	44.15	45.31
N	42.99	39.94	41.46
P/S	47.37	42.2	44.78
P/N	48.82	42.29	45.55
R/S	46.14	41.45	43.8
R/C	44.21	41.35	42.78
R/N	52.84	41.8	47.32
S	47.15	44.77	45.96
T	44.42	39.51	41.96
Deonar (Old Dumped Waste)	35.76	28.04	31.9
Deonar New (Freshly Dumped Waste)	47.83	44.33	46.08
Mulund (Old Dumped Waste)	37.4	27.77	32.59
Mulund New (Freshly Dumped Waste)	46.67	42.84	44.75

Table 5.35**Physico-chemical Analysis (Nitrogen) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Pre-monsoon Season)**

Nitrogen			
Ward name	Max. (%)	Min. (%)	Avg. (%)
A	1.75	1.41	1.58
B	3.1	1.7	2.4
C	2.41	1.18	1.8
D	2.01	1.13	1.57
E	2.64	1.41	2.03
F/S	3.16	1.42	2.29
F/N	3.1	1.14	2.12
G/S	2.06	1.89	1.2
G/N	2.15	1.28	1.72
H/E	2.03	1.41	1.72
H/W	2.09	1.42	1.76
K/E	2.46	1.54	2
K/W	2.66	1.22	1.94
L	2.19	1.46	1.83
M/E	1.89	1.04	1.465
M/W	2.09	1.42	1.76
N	1.65	1.37	1.51
P/S	2.09	1.42	1.76
P/N	2.41	1.29	1.85
R/S	2.06	1.71	1.885
R/C	2.13	1.68	1.91
R/N	2.16	1.4	1.78
S	2.09	1.41	1.75
T	1.97	1.48	1.725
Deonar (Old Dumped Waste)	1.46	1.08	1.27
Deonar New (Freshly Dumped Waste)	2.61	1.42	2.015
Mulund (Old Dumped Waste)	1.15	0.72	0.935
Mulund New (Freshly Dumped Waste)	2.06	1.72	1.89

Table 5.36**Physico-chemical Analysis (Calorific Value) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Pre-monsoon Season)**

Calorific value			
Ward Name	Max. (kcal/kg)	Min. (kcal/kg)	Avg. (kcal/kg)
A	4092	3980	4036
B	3995	3985	3990
C	4088	3870	3979
D	4180	3879	4029.5
E	4182	3769	3975.5
F/S	3899	3697	3798
F/N	4005	3895	3950
G/S	4095	3879	3985.5
G/N	4065	3983	4024
H/E	3997	3789	3893
H/W	3959	3683	3821
K/E	4011	3986	3998.5
K/W	4012	3876	3944
L	4056	3693	3874
M/E	4075	3609	3842
M/W	3922	3697	3809.5
N	3900	3875	3887.5
P/S	3913	3879	3896
P/N	3904	3987	3945.5
R/S	4021	3789	3905
R/C	4013	3786	3899
R/N	4038	3658	3848
S	4076	3905	3990.5
T	4038	3998	4018
Deonar (Old Dumped Waste)	4027	3780	3903.5
Deonar New (Freshly Dumped Waste)	4079	3850	3964.5
Mulund (Old Dumped Waste)	4089	3756	3922.5
Mulund New (Freshly Dumped Waste)	4180	3685	3932.5

** Calorific value of MSW was higher in most of the wards due to presence of enormous amount of rice straw, baggasses, coconut husk and good quality of plastics and paper.

Table 5.37**Physico-chemical Analysis (Sulphur) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Pre-monsoon Season)**

Sulphur			
Ward Name	Max. (%)	Min. (%)	Avg. (%)
A	2.77	1.63	2.2
B	2.88	1.92	2.4
C	3.22	1.76	4.98
D	2.93	1.88	2.41
E	2.56	1.35	1.96
F/S	3.25	1.82	2.53
F/N	3.77	2.16	2.96
G/S	3.62	2.32	2.97
G/N	3.98	1.79	2.88
H/E	3.54	1.54	2.54
H/W	3.76	2.34	3.05
K/E	2.94	1.58	2.76
K/W	3.56	1.84	2.7
L	2.97	1.73	2.35
M/E	3.21	2.35	2.78
M/W	3.28	1.83	2.55
N	3.61	2.31	2.96
P/S	3.47	2.16	2.81
P/N	3.89	2.11	3
R/S	3.56	1.94	2.75
R/C	4.15	2.06	3.16
R/N	3.25	1.72	2.49
S	2.58	1.84	2.21
T	4.26	2.03	3.14
Deonar (Old Dumped Waste)	3.33	2.41	3.87
Deonar New (Freshly Dumped Waste)	4.02	2.28	3.15
Mulund (Old Dumped Waste)	3.45	1.74	2.6
Mulund New (Freshly Dumped Waste)	3.46	1.22	2.34

Table 5.38**Physico-chemical Analysis (Phosphorus) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Pre-monsoon Season)**

Phosphorus			
Ward Name	Max. (%)	Min. (%)	Avg. (%)
A	1.78	1.18	1.48
B	3.1	1.22	2.16
C	1.46	0.85	1.155
D	1.03	0.48	0.76
E	1.51	0.71	1.11
F/S	1.65	0.76	1.21
F/N	1.43	0.84	1.135
G/S	0.95	0.54	0.75
G/N	1.46	0.36	0.91
H/E	1.66	0.73	1.2
H/W	1.64	1.01	1.33
K/E	1.44	0.87	1.16
K/W	1.69	0.81	1.25
L	1.43	0.88	1.16
M/E	1.49	1.06	1.28
M/W	1.81	0.91	1.36
N	1.42	1.03	1.23
P/S	1.65	0.89	1.27
P/N	1.21	1.07	1.14
R/S	1.16	1.08	1.12
R/C	1.04	0.78	0.91
R/N	1.41	1.05	1.23
S	1.43	0.78	1.11
T	1.17	1.08	1.13
Deonar (Old Dumped Waste)	2.67	1.74	2.21
Deonar New (Freshly Dumped Waste)	1.52	0.95	1.235
Mulund (Old Dumped Waste)	2.18	1.96	2.07
Mulund New (Freshly Dumped Waste)	1.54	1.106	1.32

Table 5.39**Physico-chemical Analysis (Potassium) of MSW of 24 Wards including Two Dumpsites of MCGM Region (Pre-monsoon Season)**

Potassium			
Ward Name	Max. (%)	Min. (%)	Avg. (%)
A	8.8	4.2	6.5
B	10.5	7.9	9.2
C	10.6	7.1	8.9
D	7.6	1.6	4.6
E	8.6	6.4	7.5
F/S	9.4	5.8	7.6
F/N	8.2	7.7	8
G/S	5.8	2.4	4.1
G/N	10.4	4.6	7.5
H/E	9.9	6.1	8
H/W	10.2	5.3	7.8
K/E	10.5	5.7	8.4
K/W	9.5	8.4	9
L	10.9	6.1	8.5
M/E	6.7	5.1	5.9
M/W	10.6	4.1	7.4
N	9.2	4.8	7
P/S	8.9	4.6	7.6
P/N	7.8	7.3	6.8
R/S	8.1	4.7	7.5
R/C	8.5	6.4	6.4
R/N	10.4	6.5	8.5
S	8.5	7.1	7.8
T	7.8	6.1	7
Deonar (Old Dumped Waste)	14.6	11.2	11.4
Deonar New (Freshly Dumped Waste)	7.2	4.8	7.2
Mulund (Old Dumped Waste)	12.7	10.08	12.9
Mulund New (Freshly Dumped Waste)	8.7	5.6	6

Table 5.40**Physico-chemical Analysis (C/N) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Pre-monsoon Season)**

C/N			
Ward Name	Max. (%)	Min. (%)	Avg. (%)
A	32.18	29.87	31.02
B	24.6	17.07	20.84
C	37.03	20.4	28.71
D	41.78	26.53	34.16
E	30.5	18.29	24.39
F/S	30.83	15.54	23.18
F/N	36.73	14.98	25.86
G/S	24.41	21.65	23.03
G/N	33.68	22.36	28.02
H/E	29.9	27.1	28.5
H/W	29.62	26.89	28.22
K/E	28.05	19.83	23.94
K/W	36.24	17.71	26.98
L	28.65	22.79	25.72
M/E	39.05	24.28	31.66
M/W	31.1	22.24	26.67
N	29.15	26.05	27.6
P/S	29.72	22.66	26.19
P/N	32.78	20.26	26.52
R/S	24.24	22.4	23.32
R/C	24.62	20.76	22.69
R/N	29.86	24.46	27.16
S	31.75	22.56	27.16
T	26.69	22.55	24.62
Deonar (Old Dumped Waste)	35.76	28.02	31.9
Deonar New (Freshly Dumped Waste)	31.22	18.33	24.77
Mulund (Old Dumped Waste)	38.57	32.52	35.55
Mulund New (Freshly Dumped Waste)	24.9	22.66	23.78

Table 5.41 presents overall pre-monsoon chemical characteristics value of MSW in 24 wards of MCGM including two dump sites.

Table 5.41

Overall Average of Physico-chemical Characteristics of MSW in 24 Wards including Two Dump Sites of MCGM Region (Pre-monsoon Season)

Parameters	Max.	Min.	Avg.
Moisture content (%)	79.08	65.48	72.69
Total solids (%)	34.52	20.92	27.31
Loss on Ignition (%)	86.68	55	76.85
Ash content (%)	45.01	13.32	23.15
Carbon (%)	50.8	31.9	44.58
Calorific value (kcal/kg)	4036	3798	3930.77
Nitrogen (%)	2.4	0.94	1.8
C/N Ratio	35.55	20.84	26.63
Sulphur	4.98	1.96	2.8
Phosphorous	2.21	0.75	1.26
Potassium	1.29	0.41	0.77

5.1.3 Heavy Metals of MSW in Pre-monsoon Season

The MSW samples were analyzed in the NEERI laboratory for various heavy metals, such as cadmium, copper, iron, lead, nickel, zinc etc. Heavy metals of MSW for the Pre-monsoon season of 24 wards including two dumpsites are presented in Tables 5.42 through 5.51. Graphical presentation for Heavy metal of MSW in the Pre-Monsoon Season is shown in Figures 5.42 through 5.51.

Table 5.42

Heavy Metals Analysis (Cd) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Pre-monsoon Season)

Name of the Wards	Cd (mg/kg)
A	0.098
B	0.447
C	0.065
D	0.328
E	0.143
F/S	0.024
F/N	0.021
G/S	0.038
G/N	0.071
H/E	0.069
H/W	0.035
K/E	0.087
K/W	0.051
P/S	0.076
P/N	0.104
R/S	0.047
R/C	0.042
R/T	0.036
L	0.115
M/E	0.107
M/W	0.128
N	0.065
S	0.072
T	0.092
Deonar (Old dumped waste)	0.998
Deonar (Freshly dumped waste)	0.078
Mulund (Old dumped waste)	1.167
Mulund (Freshly dumped waste)	0.081

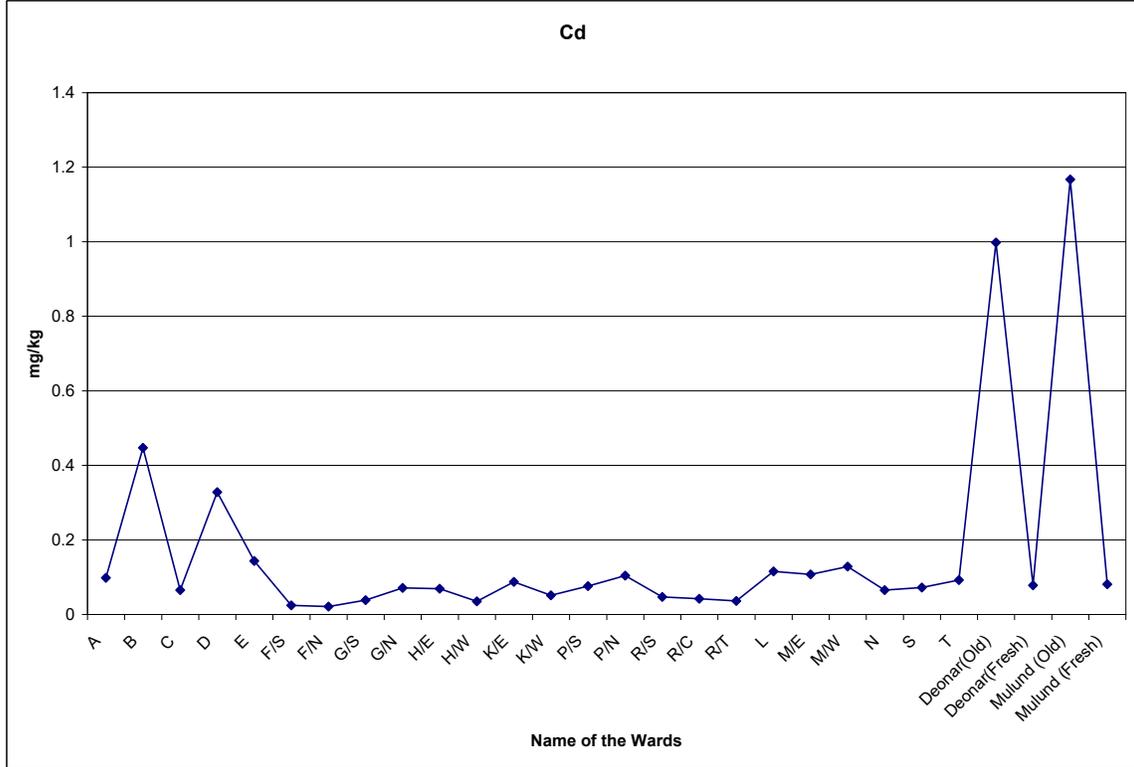


Figure 5.29: Graphical Presentation of Heavy Metal (Cd) of 24 Wards including Two Dumpsites MCGM Region (Pre-monsoon Season)

Table 5.43

**Heavy Metals Analysis (CO) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Pre-monsoon Season)**

Name of the Wards	CO (mg/kg)
A	2.83
B	2.47
C	0.35
D	1.01
E	2
F/S	0.64
F/N	1.11
G/S	0.88
G/N	1.21
H/E	1.92
H/W	1.02
K/E	1.66
K/W	1.19
P/S	1.32
P/N	1.09
R/S	1.63
R/C	0.91
R/T	0.75
L	1.43
M/E	1.71
M/W	1.06
N	1.58
S	0.82
T	1.15
Deonar (Old dumped waste)	3.43
Deonar(Freshly dumped waste)	1.47
Mulund (Old dumped waste)	2.78
Mulund (Freshly dumped waste)	1.61

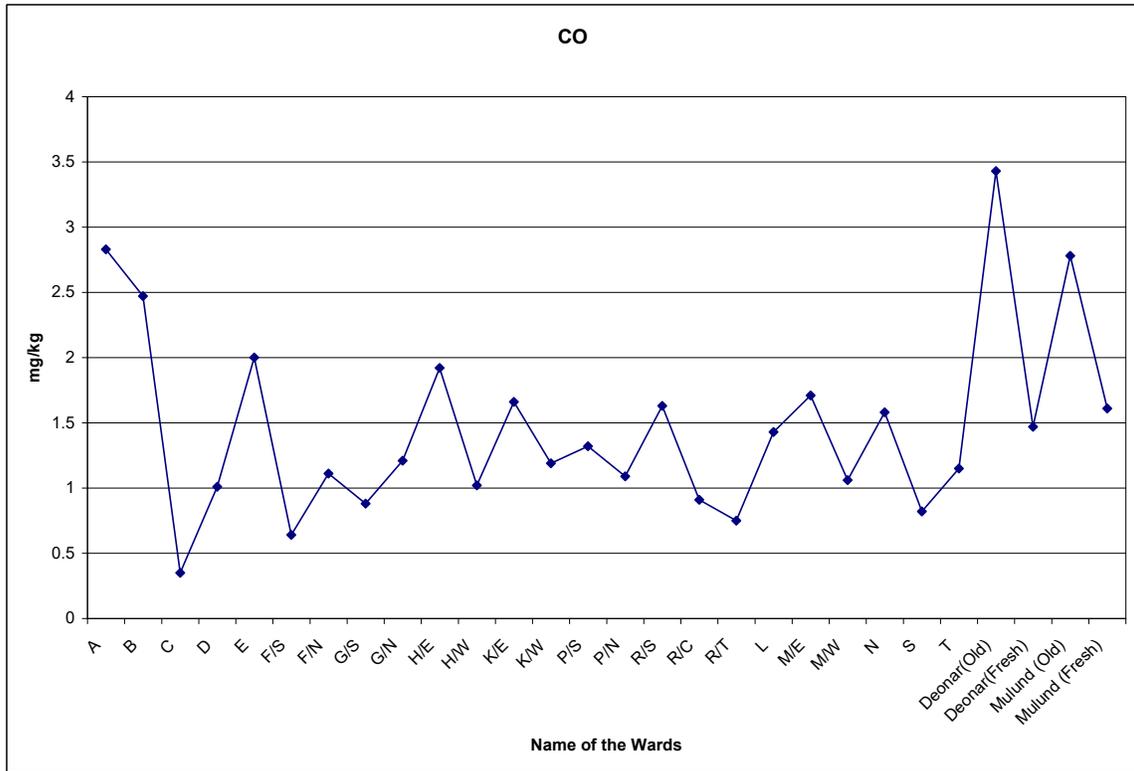


Figure 5.30: Graphical Presentation of Heavy Metal (Co) of 24 Wards including Two Dump sites MCGM Region (Pre-monsoon Season)

Table 5.44

**Heavy Metals Analysis (Pb) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Pre-monsoon Season)**

Name of the Wards	Pb (mg/kg)
A	1.75
B	2.77
C	0.66
D	1.92
E	1.39
F/S	0.37
F/N	2.26
G/S	1.84
G/N	0.89
H/E	3.56
H/W	1.07
K/E	1.44
K/W	0.53
P/S	0.87
P/N	1.21
R/S	1.1
R/C	1.27
R/T	0.77
L	0.91
M/E	1.23
M/W	1.37
N	1.02
S	1.15
T	0.62
Deonar (Old dumped waste)	2.46
Deonar (Freshly dumped waste)	1.23
Mulund (Old dumped waste)	2.72
Mulund (Freshly dumped waste)	0.82

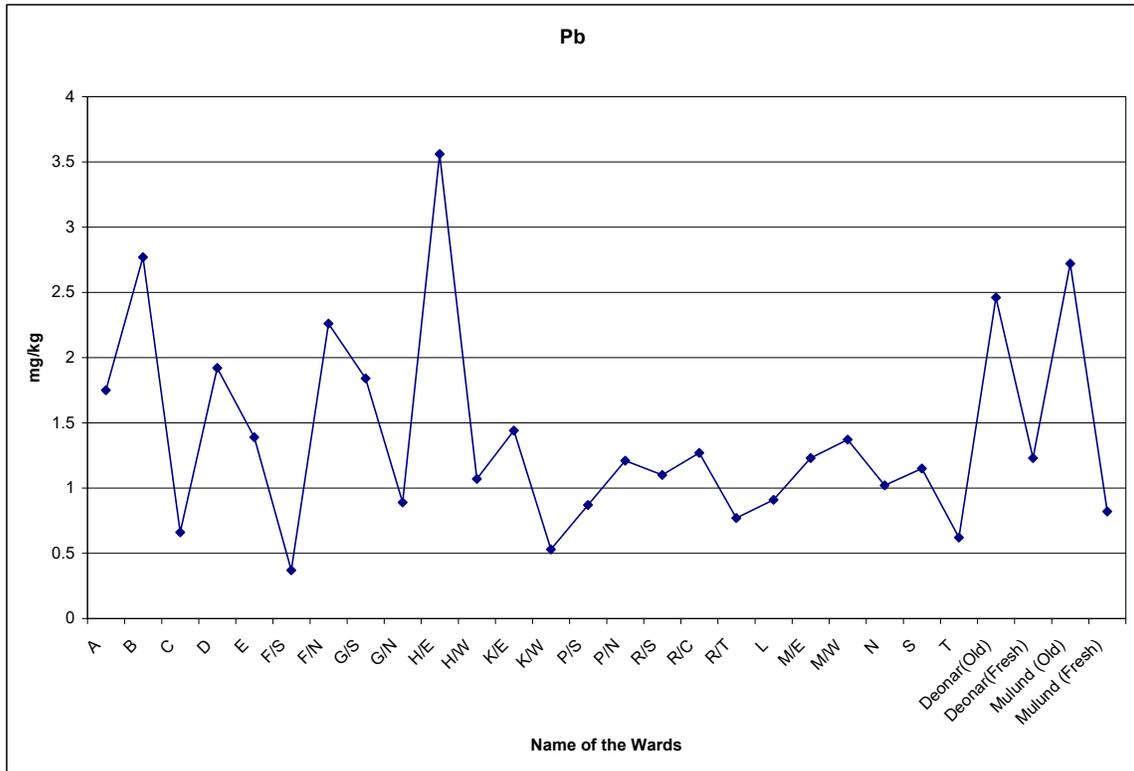


Figure 5.31: Graphical Presentation of Heavy Metal (Pb) of 24 Wards including Two Dump sites MCGM Region (Pre-monsoon Season)

Table 5.45

**Heavy Metals Analysis (Ni) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Pre-monsoon Season)**

Name of the Wards	Ni (mg/kg)
A	1.53
B	0.902
C	BDL
D	1.8
E	BDL
F/S	2.278
F/N	BDL
G/S	BDL
G/N	BDL
H/E	3.932
H/W	BDL
K/E	BDL
K/W	BDL
P/S	BDL
P/N	BDL
R/S	0.921
R/C	0.007
R/T	BDL
L	BDL
M/E	0.001
M/W	BDL
N	0.002
S	BDL
T	BDL
Deonar (Old dumped waste)	0.871
Deonar (Freshly dumped waste)	BDL
Mulund (Old dumped waste)	0.41
Mulund (Freshly dumped waste)	0.048

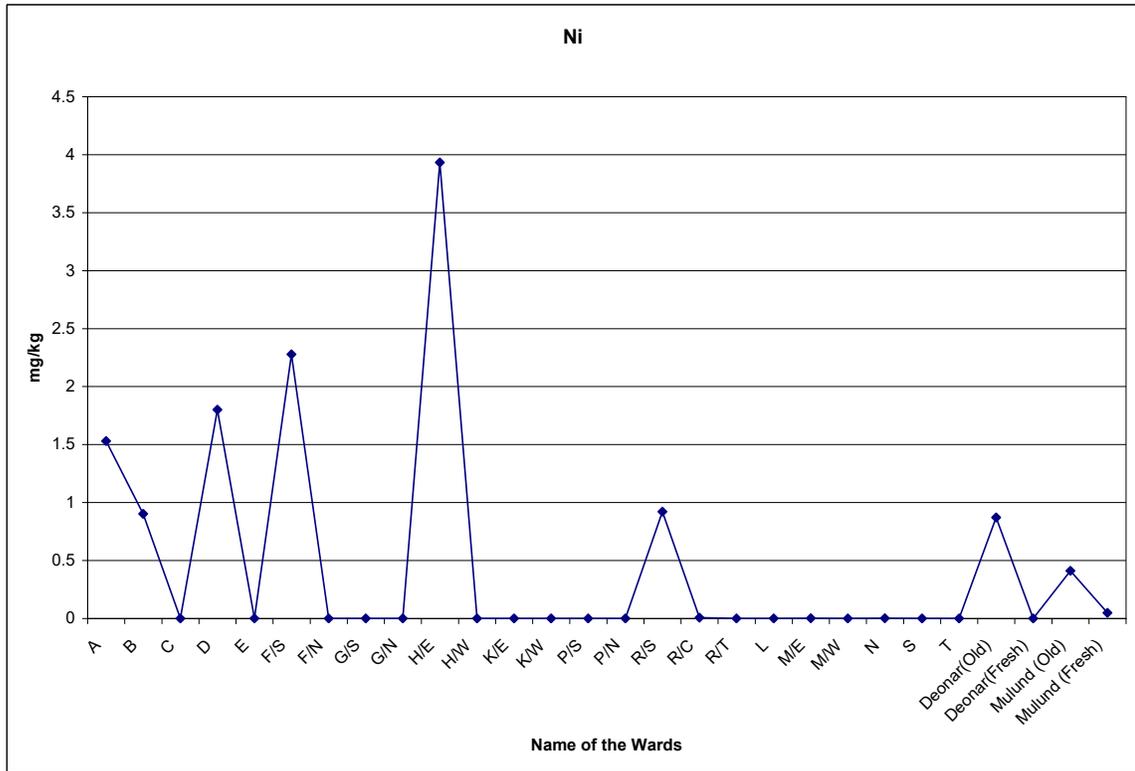


Figure 5.32: Graphical Presentation of Heavy Metal (Ni) of 24 Wards including Two Dumpsites MCGM Region (Pre-monsoon Season)

Table 5.46

**Heavy Metals Analysis (Mn) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Pre-monsoon Season)**

Name of the Wards	Mn (mg/kg)
A	46.47
B	41.79
C	39.02
D	25.86
E	17.53
F/S	23.48
F/N	32.82
G/S	52.3
G/N	32.66
H/E	87.94
H/W	46.16
K/E	34.16
K/W	48.16
P/S	61.11
P/N	70.17
R/S	34.16
R/C	47.94
R/T	24.15
L	51.78
M/E	43.72
M/W	71.43
N	48.13
S	40.75
T	37.48
Deonar (Old dumped waste)	149.54
Deonar (Freshly dumped waste)	42.84
Mulund (Old dumped waste)	121.43
Mulund (Freshly dumped waste)	51.21

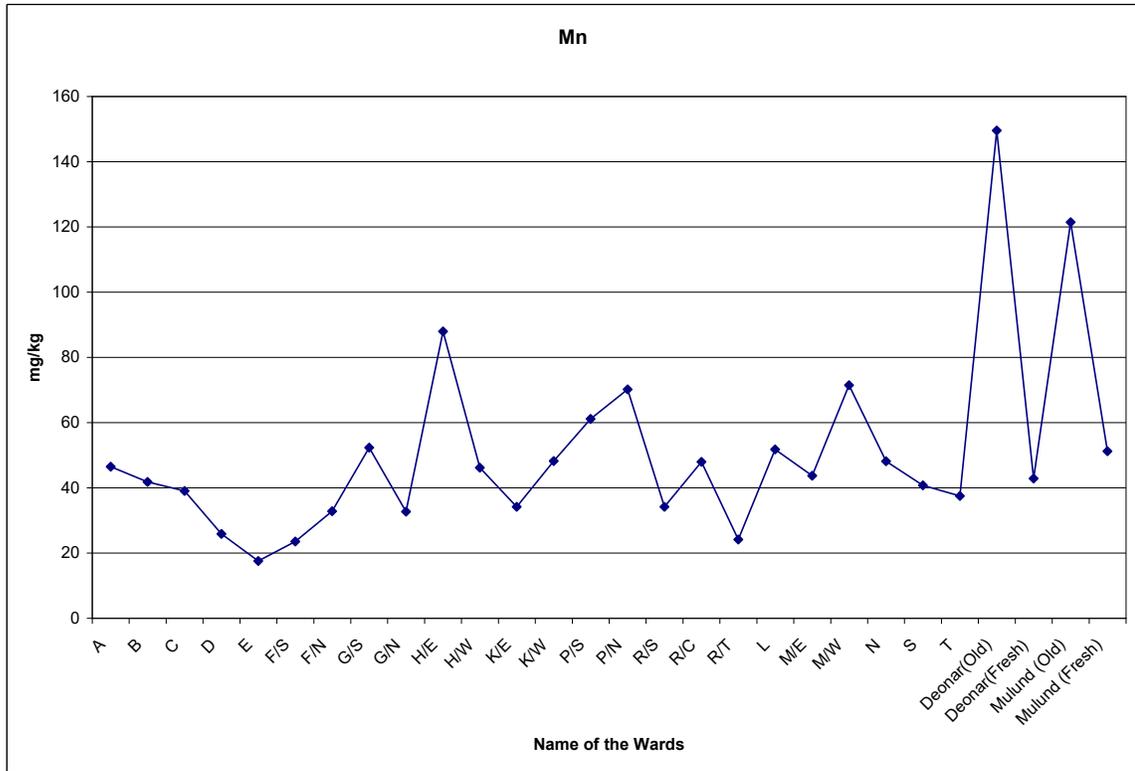


Figure 5.33: Graphical Presentation of Heavy Metal (Mn) of 24 Wards including Two Dump sites MCGM Region (Pre-monsoon Season)

Table 5.47

**Heavy Metals Analysis (Cr) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Pre-monsoon Season)**

Name of the Wards	Cr (mg/kg)
A	7.27
B	5.93
C	6.39
D	9.2
E	11.46
F/S	9.91
F/N	14.29
G/S	9.98
G/N	11.55
H/E	10.12
H/W	5.14
K/E	7.11
K/W	9.1
P/S	10.24
P/N	8.46
R/S	7.05
R/C	9.29
R/T	12.31
L	11.91
M/E	8.27
M/W	8.33
N	12.34
S	6.53
T	8.22
Deonar (Old dumped waste)	31.41
Deonar (Freshly dumped waste)	16.42
Mulund (Old dumped waste)	24.75
Mulund (Freshly dumped waste)	13.42

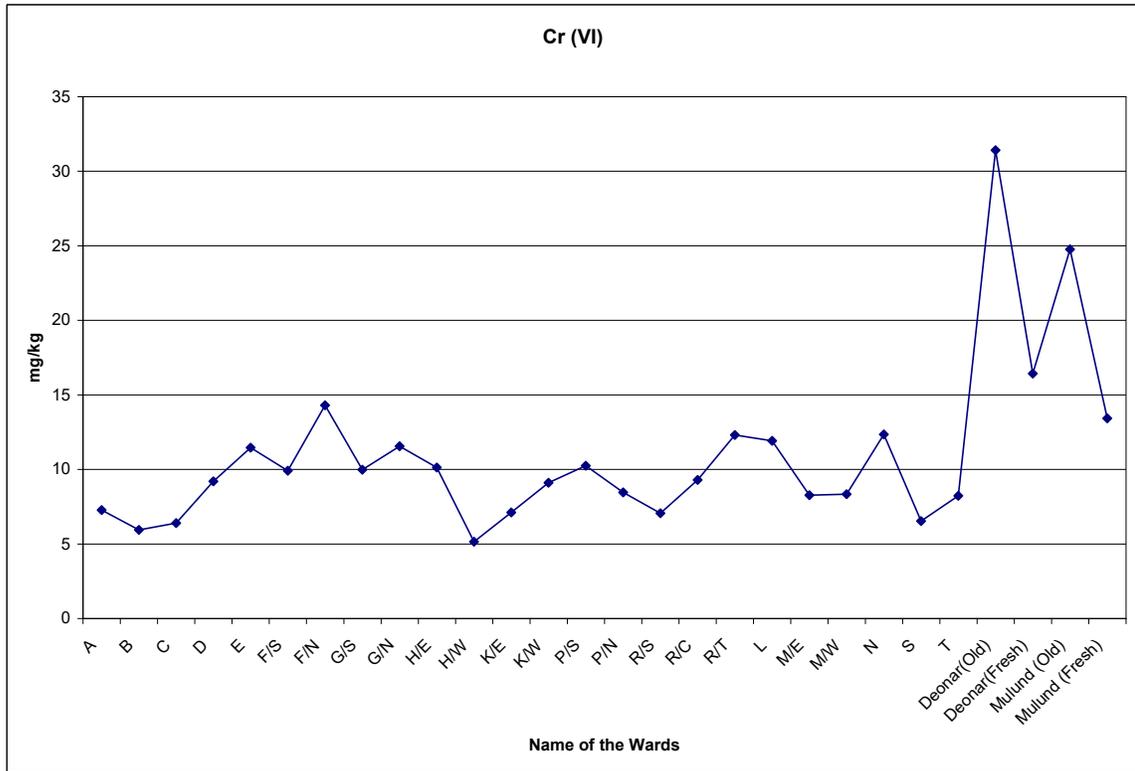


Figure 5.34: Graphical Presentation of Heavy Metal (Cr [VI]) of 24 Wards including Two Dumpsites MCGM Region (Pre-monsoon Season)

Table 5.48

**Heavy Metals Analysis (Cu) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Pre-monsoon Season)**

Name of the Wards	Cu (mg/kg)
A	16.4
B	12.92
C	11.52
D	28.06
E	16.7
F/S	16.57
F/N	24.04
G/S	18.35
G/N	10.26
H/E	22.6
H/W	17.46
K/E	16.48
K/W	18.79
P/S	15.41
P/N	16.78
R/S	14.74
R/C	11.79
R/T	10.48
L	11.73
M/E	10.57
M/W	13.49
N	14.76
S	10.77
T	12.61
Deonar (Old dumped waste)	31.41
Deonar (Freshly dumped waste)	12.47
Mulund (Old dumped waste)	41.03
Mulund (Freshly dumped waste)	11.4

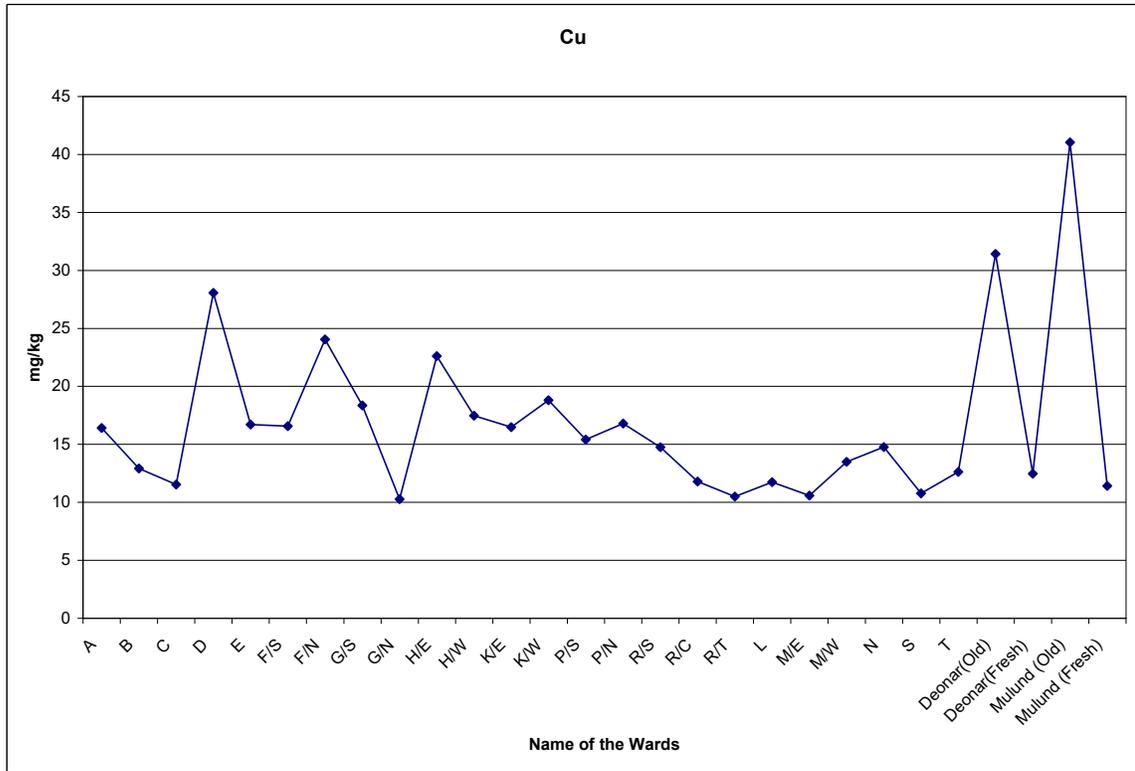


Figure 5.35: Graphical Presentation of Heavy Metal (Cr [VI]) of 24 Wards including Two dumpsites MCGM Region (Pre-monsoon Season)

Table 5.49

**Heavy Metals Analysis (Fe) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Pre-monsoon Season)**

Name of the Wards	Fe (mg/kg)
A	12870
B	13250
C	6300
D	12350
E	7911
F/S	7204
F/N	10606
G/S	10314
G/N	13062
H/E	12486
H/W	8720
K/E	10341
K/W	9271
P/S	6620
P/N	8813
R/S	10039
R/C	12036
R/T	13022
L	10194
M/E	7314
M/W	6014
N	10230
S	7961
T	9301
Deonar (Old dumped waste)	19435
Deonar (Freshly dumped waste)	9784
Mulund (Old dumped waste)	16483
Mulund (Freshly dumped waste)	6482

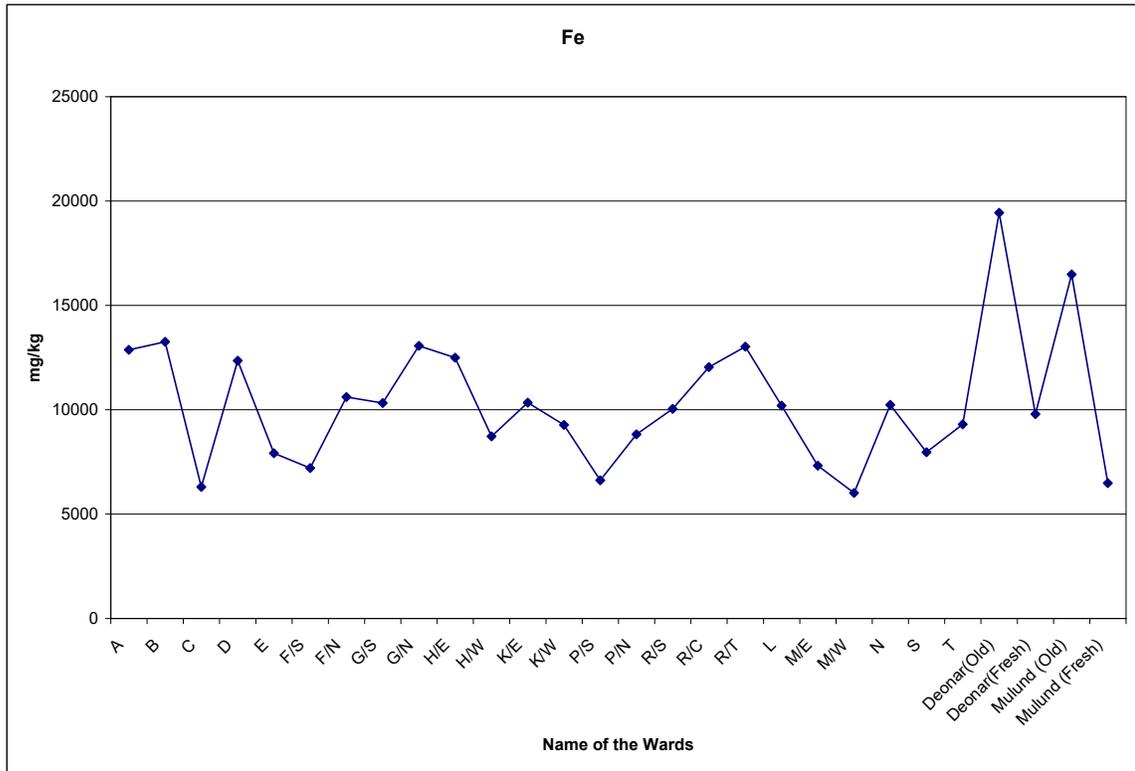


Figure 5.36: Graphical Presentation of Heavy Metal (Fe) of 24 Wards including Two Dumpsites MCGM Region (Pre-monsoon Season)

Table 5.50

**Heavy Metals Analysis (Zn) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Pre-monsoon Season)**

Name of the Wards	Zn (mg/kg)
A	44.29
B	36.41
C	30.08
D	59.84
E	49.9
F/S	31.32
F/N	32.32
G/S	32.7
G/N	40.78
H/E	45.36
H/W	44.7
K/E	43.01
K/W	30.22
P/S	39.56
P/N	41.49
R/S	35.77
R/C	38.55
R/T	33.65
L	38.01
M/E	40.44
M/W	42.98
N	37.69
S	38.31
T	32.08
Deonar (Old dumped waste)	84.16
Deonar (Freshly dumped waste)	39.42
Mulund (Old dumped waste)	76.41
Mulund (Freshly dumped waste)	41.47

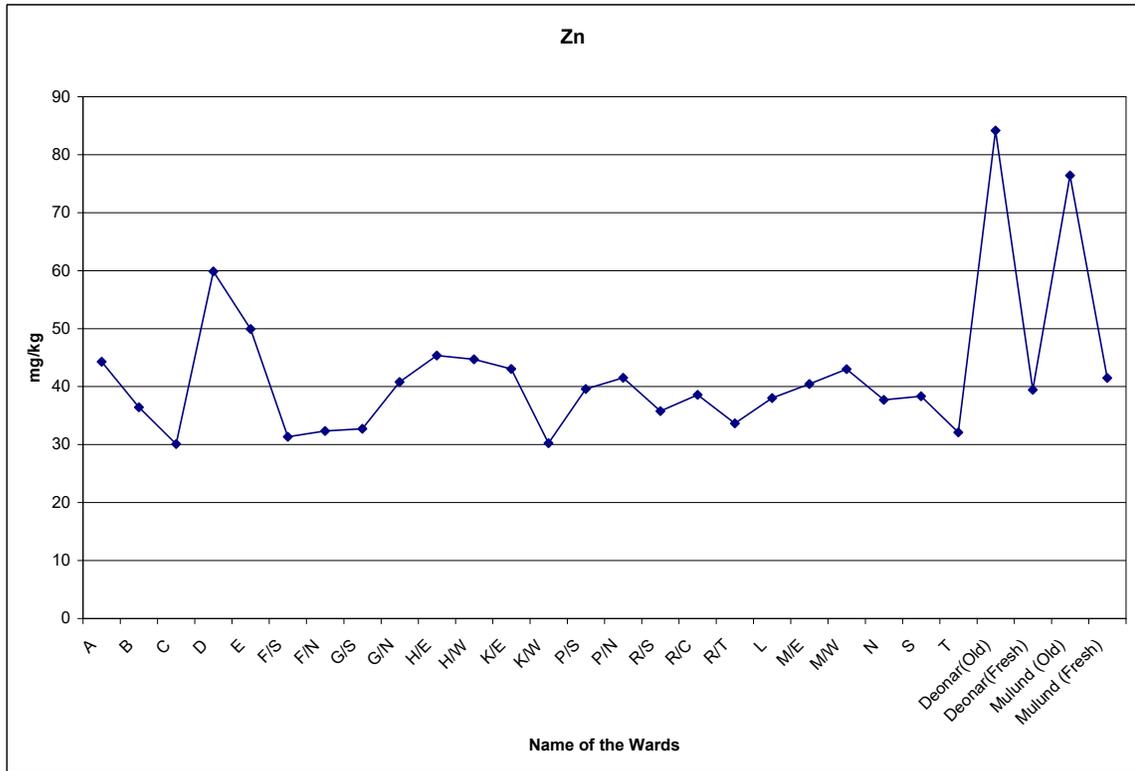


Figure 5.37: Graphical Presentation of Heavy Metal (Zn) of 24 Wards including Two Dumpsites MCGM Region (Pre-monsoon Season)

5.2 Monsoon Season

In Monsoon season, physical characteristics were not performed due to heavy rain. Only single set of sample was taken at different locations from each ward for chemical analysis in MCGM Mumbai.

5.2.1 Physico-chemical Characterization of MSW (Monsoon Season)

Chemical characteristics of MSW for the Pre-monsoon Season of 24 wards including two dump sites are presented in Tables 5.51 through 5.63.

Table 5.51

Physico-chemical Analysis (Moisture Content) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Monsoon Season)

Name of the Wards	Moisture Content Avg. (%)
A	87.06
B	84.09
C	83.11
D	88.47
E	84.67
F/S	85.06
F/N	86.27
G/S	83.1
G/N	87.31
H/E	85.27
H/W	86.23
K/E	85.12
K/W	87.065
L	88
M/E	88.7
M/W	87.23
N	85.61
P/S	85.12
P/N	88.76
R/S	87.23
R/C	85.33
R/N	86.22
S	86.16
T	85.37
Deonar (Old Dumped Waste)	85.92
Deonar New (Freshly Dumped Waste)	87.32
Mulund (Old Dumped Waste)	84.62
Mulund New (Freshly Dumped Waste)	87.82

Table 5.52

Physico-chemical Analysis (Total Solid) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Monsoon Season)

Name of the Wards	Total Solids (Avg. %)
A	16.89
B	11.53
C	15.33
D	14.94
E	13.73
F/S	16.9
F/N	12.69
G/S	14.73
G/N	13.77
H/E	14.88
H/W	12.935
K/E	12
K/W	11.3
L	12.77
M/E	14.39
M/W	14.88
N	11.24
P/S	12.77
P/N	14.67
R/S	13.78
R/C	13.84
R/N	14.63
S	14.08
T	12.68
Deonar (Old Dumped Waste)	15.38
Deonar New (Freshly Dumped Waste)	12.18
Mulund (Old Dumped Waste)	15.38
Mulund New (Freshly Dumped Waste)	12.18

Table 5.53

Physico-chemical Analysis (Loss on Ignition) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Monsoon Season)

Name of the Wards	Loss on Ignition Avg. (%)
A	89.07
B	87.2
C	89.2
D	89.2
E	83.31
F/S	82.34
F/N	76.62
G/S	88.21
G/N	77.28
H/E	90.13
H/W	89.69
K/E	74.71
K/W	90.11
L	81.9
M/E	85.04
M/W	82.51
N	91.26
P/S	78.28
P/N	83.97
R/S	63.31
R/C	75.73
R/N	67.78
S	86.71
T	90.11
Deonar (Old Dumped Waste)	70.955
Deonar New (Freshly Dumped Waste)	76.59
Mulund (Old Dumped Waste)	73.69
Mulund New (Freshly Dumped Waste)	78.82

Table 5.54

Physico-chemical Analysis (Moisture Content) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Monsoon Season)

Name of the Wards	Ash Content Avg. (%)
A	10.925
B	12.795
C	10.795
D	10.795
E	16.685
F/S	17.655
F/N	23.375
G/S	11.785
G/N	22.715
H/E	9.865
H/W	10.305
K/E	25.285
K/W	9.885
L	18.095
M/E	14.955
M/W	17.485
N	8.735
P/S	21.715
P/N	16.025
R/S	36.685
R/C	24.265
R/N	32.215
S	13.285
T	9.885
Deonar (Old Dumped Waste)	29.045
Deonar New (Freshly Dumped Waste)	23.41
Mulund (Old Dumped Waste)	26.31
Mulund New (Freshly Dumped Waste)	21.18

Table 5.55

Physico-chemical Analysis (Carbon) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Monsoon Season)

Name of the Wards	Carbon Avg. (%)
A	51.4
B	50.73
C	51.06
D	54.15
E	49.76
F/S	47.3
F/N	43.235
G/S	49.66
G/N	44.73
H/E	51.43
H/W	50.81
K/E	47.31
K/W	51.28
L	48.03
M/E	51.5
M/W	46.77
N	51.23
P/S	46.33
P/N	45.09
R/S	34.92
R/C	43.67
R/N	38.72
S	50.815
T	50.6
Deonar (Old Dumped Waste)	37.55
Deonar New (Freshly Dumped Waste)	40.62
Mulund (Old Dumped Waste)	33.4
Mulund New (Freshly Dumped Waste)	42.43

Table 5.56

Physico-chemical Analysis (Nitrogen) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Monsoon Season)

Name of the Wards	Nitrogen Avg. (%)
A	1.8
B	1.44
C	1.59
D	1.56
E	0.92
F/S	1.12
F/N	1.07
G/S	1.38
G/N	1.525
H/E	1.69
H/W	0.98
K/E	1.76
K/W	1.81
L	3.05
M/E	3.35
M/W	1.42
N	2.11
P/S	1.34
P/N	1.05
R/S	1.53
R/C	0.69
R/N	1.52
S	1.42
T	0.455
Deonar (Old Dumped Waste)	1.59
Deonar New (Freshly Dumped Waste)	1.02
Mulund (Old Dumped Waste)	1.95
Mulund New (Freshly Dumped Waste)	2.25

Table 5.57**Physico-chemical Analysis (Calorific Value) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Monsoon Season)**

Name of the Wards	Calorific Value Avg. (kcal/kg)
ward A	4323.125
ward B	1458.175
Ward C	2198.28
ward D	4222.57
ward E	3637.55
ward F/S	3959.49
ward F/N	4270.06
ward G/S	3938.275
ward G/N	3574.525
ward H/E	2291.38
ward H/W	4117.025
ward K/E	3699.445
ward K/W	3529.91
ward P/S	3383.54
ward P/N	3583.225
ward R/S	4582.9
ward R/C	3756.43
ward R/N	1526.22
ward L	4044.97
ward M/E	1976.225
ward M/W	3324.455
ward N	4138.795
ward S	4172.48
ward T	2427.92
Deonar (Old Dumped Waste)	3873.68
Deonar New (Freshly Dumped Waste)	3514.3
Mulund (Old Dumped Waste)	3927.675
Mulund New (Freshly Dumped Waste)	4097.97

** Calorific value of MSW was higher in most of the wards due to presence of enormous amount of rice straw, baggasses, coconut husk and good quality of plastics and paper.

Table 5.58

Physico-chemical Analysis (Sulphur) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Monsoon Season)

Name of the Wards	Sulphur Avg. (%)
A	8.02
B	8.13
C	9.32
D	7.06
E	9.14
F/S	10.05
F/N	7.97
G/S	9.66
G/N	8.34
H/E	8.83
H/W	9.95
K/E	7.95
K/W	7.99
L	8.22
M/E	8.66
M/W	9.95
N	8.04
P/S	8.35
P/N	9.77
R/S	7.98
R/C	8.12
R/N	9.27
S	10.28
T	11
Deonar (Old Dumped Waste)	7.72
Deonar New (Freshly Dumped Waste)	8.54
Mulund (Old Dumped Waste)	8.87
Mulund New (Freshly Dumped Waste)	10.02

Table 5.59

Physico-chemical Analysis (Phosphorous) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Monsoon Season)

Name of the Wards	Phosphorus Avg. (%)
A	1.31
B	0.65
C	0.65
D	1.12
E	0.93
F/S	1.52
F/N	1.21
G/S	1.55
G/N	1.1
H/E	0.86
H/W	1.58
K/E	1.44
K/W	1.02
L	2.2
M/E	1.64
M/W	1.89
N	1.17
P/S	0.55
P/N	1.53
R/S	0.97
R/C	1.53
R/N	1.22
S	0.33
T	0.97
Deonar (Old Dumped Waste)	0.4
Deonar New (Freshly Dumped Waste)	0.9
Mulund (Old Dumped Waste)	0.38
Mulund New (Freshly Dumped Waste)	1.28

Table 5.60
Physico-chemical Analysis (Sodium) of MSW of 24 Wards including Two Dumpsites of
MCGM, Mumbai Region (Monsoon Season)

Name of the Wards	Sodium Avg. (%)
A	24.4
B	22.9
C	16.17
D	12.35
E	1.18
F/S	7.5
F/N	1.48
G/S	1.54
G/N	3.7
H/E	13.9
H/W	19.5
K/E	4.7
K/W	6.95
L	15.75
M/E	47.5
M/W	15.5
N	5
P/S	19
P/N	9.95
R/S	1.31
R/C	8.5
R/N	6.75
S	1.34
T	2.05
Deonar (Old Dumped Waste)	6.1
Deonar New (Freshly Dumped Waste)	7.45
Mulund (Old Dumped Waste)	5.45
Mulund New (Freshly Dumped Waste)	6.5

Table 5.61

Physico-chemical Analysis (Potassium) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Monsoon Season)

Name of the Wards	Potassium Avg. (%)
A	0.8
B	0.6
C	0.31
D	1.9
E	3.015
F/S	1.36
F/N	2.75
G/S	3.37
G/N	1.22
H/E	2.33
H/W	2.01
K/E	0.77
K/W	3.25
L	0.55
M/E	1.22
M/W	2.2
N	1.62
P/S	0.61
P/N	2.6
R/S	1.33
R/C	1.31
R/N	1.66
S	1.41
T	1.45
Deonar (Old Dumped Waste)	1.71
Deonar New (Freshly Dumped Waste)	0.71
Mulund (Old Dumped Waste)	1.36
Mulund New (Freshly Dumped Waste)	0.83

Table 5.62

Physico-chemical Analysis (pH Value) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Monsoon Season)

Name of the Wards	pH Value Avg. (%)
A	6.21
B	5.35
C	5.51
D	5.57
E	7.02
F/S	7.09
F/N	6.75
G/S	7.37
G/N	7.55
H/E	9.01
H/W	6.53
K/E	8.33
K/W	7.19
L	6.63
M/E	5.95
M/W	7.72
N	6.36
P/S	8.15
P/N	7.22
R/S	6.68
R/C	6.51
R/N	7.18
S	7.38
T	7.3
Deonar (Old Dumped Waste)	9.76
Deonar New (Freshly Dumped Waste)	8.34
Mulund (Old Dumped Waste)	9.59
Mulund New (Freshly Dumped Waste)	9.68

Table 5.63

Physico-chemical Analysis (C/N) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Monsoon Season)

Name of the Wards	C/N Value Avg. (%)
A	26.6
B	26.085
C	26.325
D	27.855
E	25.34
F/S	24.21
F/N	22.1525
G/S	25.52
G/N	23.1275
H/E	26.56
H/W	25.895
K/E	24.535
K/W	26.545
L	25.54
M/E	27.425
M/W	24.095
N	26.67
P/S	23.835
P/N	23.07
R/S	18.225
R/C	22.18
R/N	20.12
S	26.1175
T	25.5275
Deonar (Old Dumped Waste)	19.57
Deonar New (Freshly Dumped Waste)	20.82
Mulund (Old Dumped Waste)	17.675
Mulund New (Freshly Dumped Waste)	22.34

Table 5.64 presents overall monsoon chemical characteristics value of MSW in 24 wards of MCGM including two dump sites.

Table 5.64
Overall Average of Physico-chemical Characteristics of 24 Wards including Two Dump Sites of MCGM Region (Monsoon Season)

Parameters	Max.	Min.	Avg.
Loss on ignition (%)	84.06	79.78	81.91
Ash Content (%)	20.22	15.94	18.07
TOC (%)	47.82	45.35	46.59
Moisture content (%)	86.69	85.61	86.15
Total Solids (%)	14.39	13.21	13.8
pH value	7.53	7	7.26
Nitrogen (%)	1.71	1.38	1.55
Phosphate (%)	1.19	1.09	1.14
Sulphate (%)	1.88	0.98	1.43
Sodium (%)	10.23	0.47	10.52
Potassium (%)	1.59	1.56	1.58
C/N	24.76	23.37	24.07
Calorific value (kcal/kg)	3614.5	3553.4	3484

5.2.2 Heavy Metals of Monsoon Season

The MSW samples were analyzed in the NEERI laboratory for various heavy metals, such as cadmium, copper, iron, lead, nickel, zinc etc. Heavy metal of MSW for the - Monsoon Season of 24 wards including two dumpsites are presented in Tables 5.65 through 5.73 And Graphical Representation for Heavy metal of MSW for the Monsoon Season is Shown in Figure 5.38 through 5.46.

Table 5.65

Heavy Metals Analysis (Cd) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Monsoon Season)

Name of the Wards	Cd (mg/kg)
A	0.02
B	0.30
C	0.07
D	0.04
E	0.50
F/S	0.13
F/N	0.19
G/N	0.05
G/S	0.25
H/E	0.06
H/W	0.12
K/E	0.17
K/W	0.27
L	0.50
M/E	1.32
M/W	0.11
N	0.17
P/S	0.10
P/N	0.23
R/S	0.19
R/C	0.11
R/N	0.88
S	0.32
T	0.24
Mulund (Old dumped waste)	0.834
Mulund (Freshly dumped waste)	0.34
Deonar OLD(Old dumped waste)	0.93
Deonar (Freshly dumped waste)	0.44

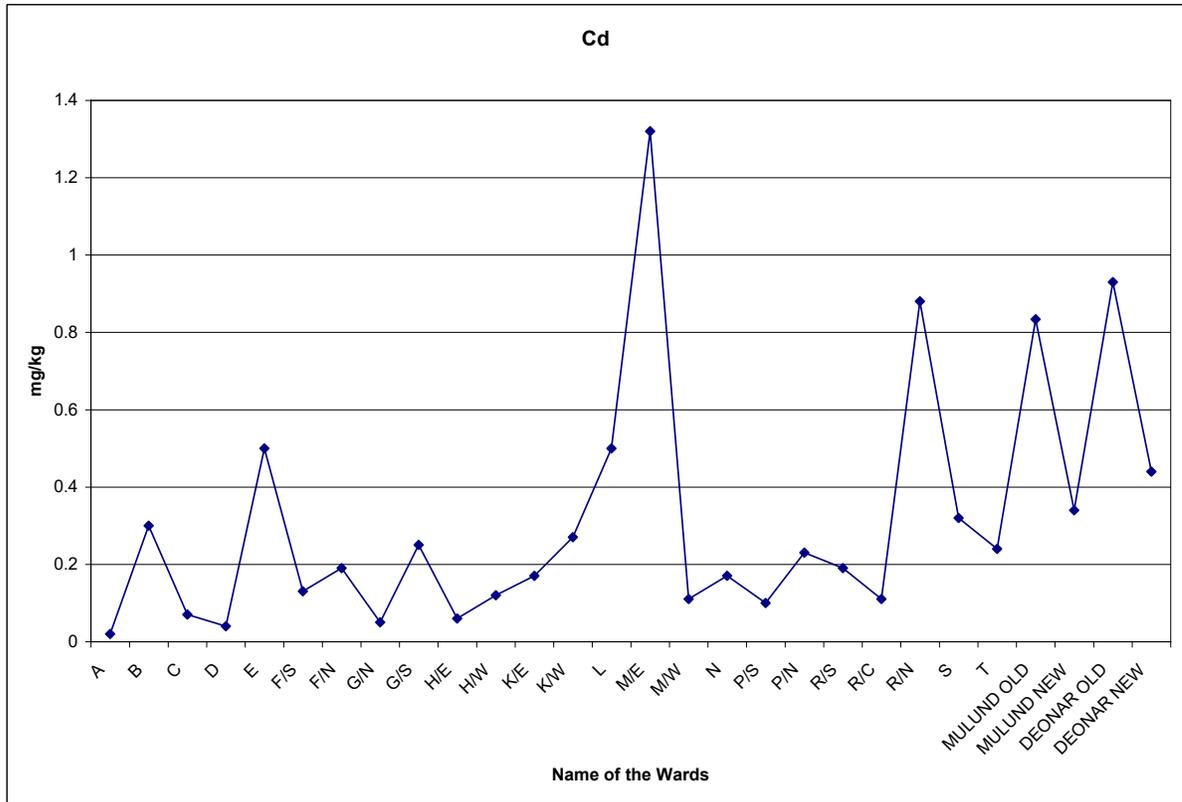


Figure 5.38: Graphical Presentation of Heavy Metal (Cd) of 24 Wards including Two Dumpsites MCGM Region (Monsoon season)

Table 5.66

**Heavy Metals Analysis (Co) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Monsoon Season)**

Ward name	Co (mg/kg)
A	0.39
B	5.40
C	1.53
D	0.68
E	16.45
F/S	1.90
F/N	4.50
G/N	4.73
G/S	0.60
H/E	0.94
H/W	1.03
K/W	1.55
K/E	3.53
L	12.77
M/W	1.63
M/E	0.55
N	3.55
P/S	0.72
P/N	1.57
R/S	3.69
R/C	0.88
R/N	10.33
S	22.77
T	7.03
Mulund (Old dumped waste)	2.82
Mulund (Freshly dumped waste)	1.84
Deonar OLD(Old dumped waste)	3.41
Deonar (Freshly dumped waste)	2.60

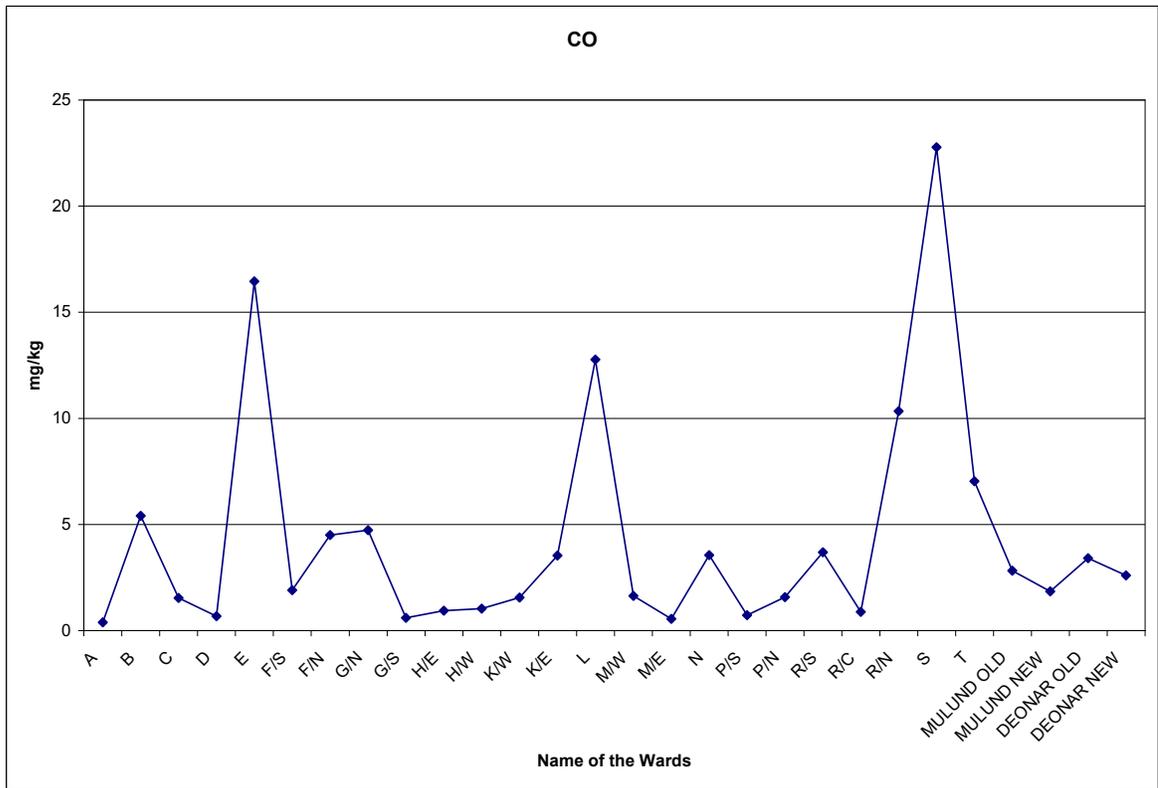


Figure 5.39: Graphical Presentation of Heavy Metal (Co) of 24 Wards including Two Dumpsites MCGM Region (Monsoon season)

Table 5.67

**Heavy Metals Analysis (Cr) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Monsoon Season)**

Ward name	Cr (mg/kg)
A	13.36
B	31.38
C	62.19
D	2.40
E	60.04
F/S	18.49
F/N	63.78
G/N	67.19
G/S	7.02
H/E	10.21
H/W	11.46
K/W	9.44
K/E	11.13
L	52.24
M/W	10.77
M/E	10.12
N	25.05
P/S	16.26
P/N	9.34
R/S	48.89
R/C	9.83
R/N	39.28
S	26.32
T	41.93
Mulund (Old dumped waste)	20.56
Mulund (Freshly dumped waste)	38.59
Deonar OLD(Old dumped waste)	29.44
Deonar (Freshly dumped waste)	21.05

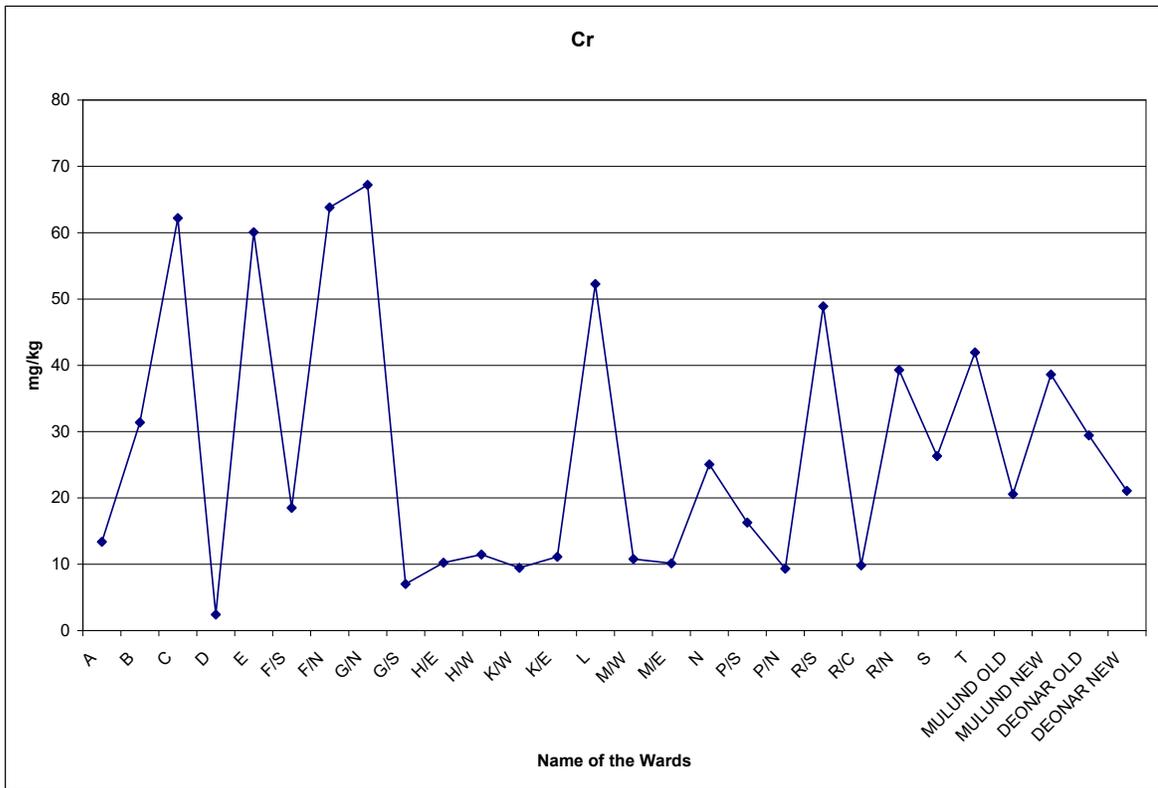


Figure 5.40: Graphical Presentation of Heavy Metal (Cr) of 24 Wards including Two Dumpsites MCGM Region (Monsoon season)

Table 5.68

**Heavy Metals Analysis (Cu) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Monsoon Season)**

Ward name	Cu (mg/kg)
A	23.22
B	18.83
C	14.32
D	13.87
E	59.79
F/S	12.22
F/N	43.62
G/N	41.55
G/S	5.53
H/E	27.61
H/W	16.32
K/W	16.05
K/E	24.42
L	50.40
M/W	27.08
M/E	23.48
N	42.12
P/S	11.16
P/N	16.06
R/S	14.02
R/C	22.98
R/N	41.41
S	40.23
T	20.11
Mulund (Old dumped waste)	25.18
Mulund (Freshly dumped waste)	16.43
Deonar OLD(Old dumped waste)	37.45
Deonar (Freshly dumped waste)	28.09

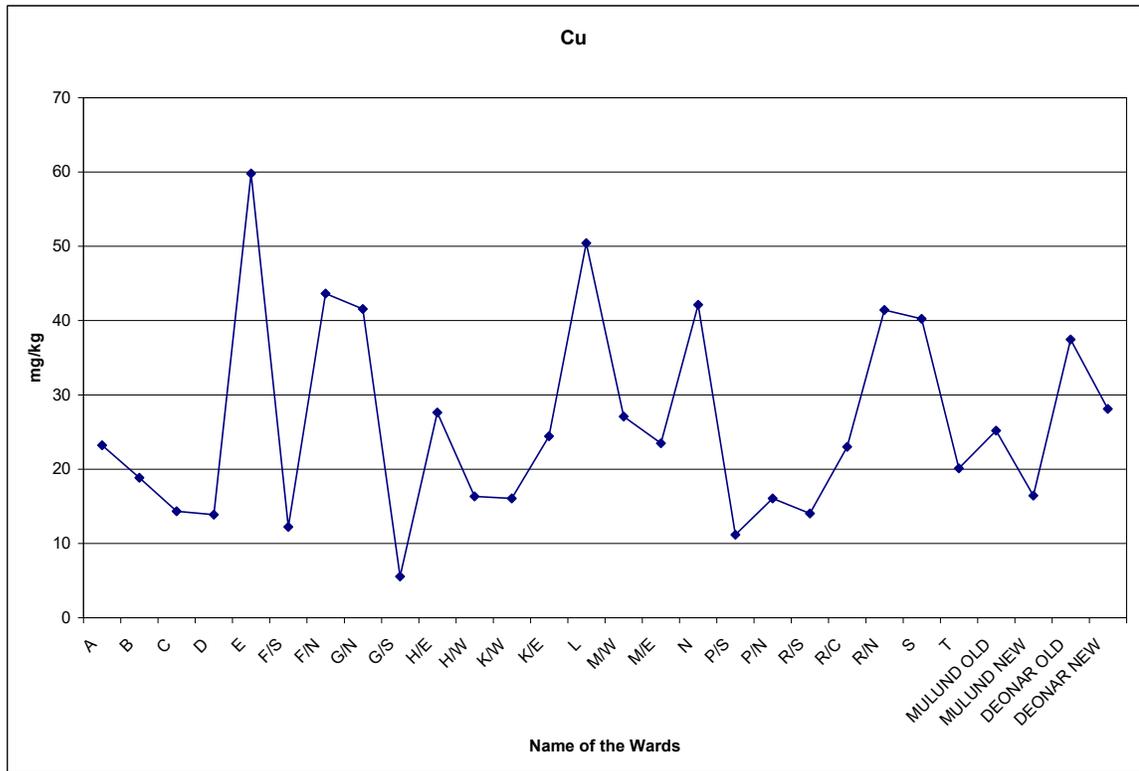


Figure 5.41: Graphical Presentation of Heavy Metal (Cu) of 24 Wards including Two Dumpsites MCGM Region (Monsoon season)

Table 5.69

**Heavy Metals Analysis (Fe) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Monsoon Season)**

Ward name	Fe (mg/kg)
A	379.82
B	4578.61
C	2860.38
D	299.51
E	12410.80
F/S	2177.02
F/N	3621.38
G/S	2870.38
G/N	4594.61
H/E	958.15
H/W	1117.89
K/E	2855.74
K/W	3347.06
L	11109.49
M/W	1710.55
M/E	1202.29
N	2989.37
P/S	796.95
P/N	3127.06
R/S	3253.75
R/C	883.07
R/N	10041.06
S	6905.31
T	4838.26
Mulund (Old dumped waste)	4390.54
Mulund (Freshly dumped waste)	3284.16
Deonar OLD(Old dumped waste)	3984.80
Deonar (Freshly dumped waste)	2305.56

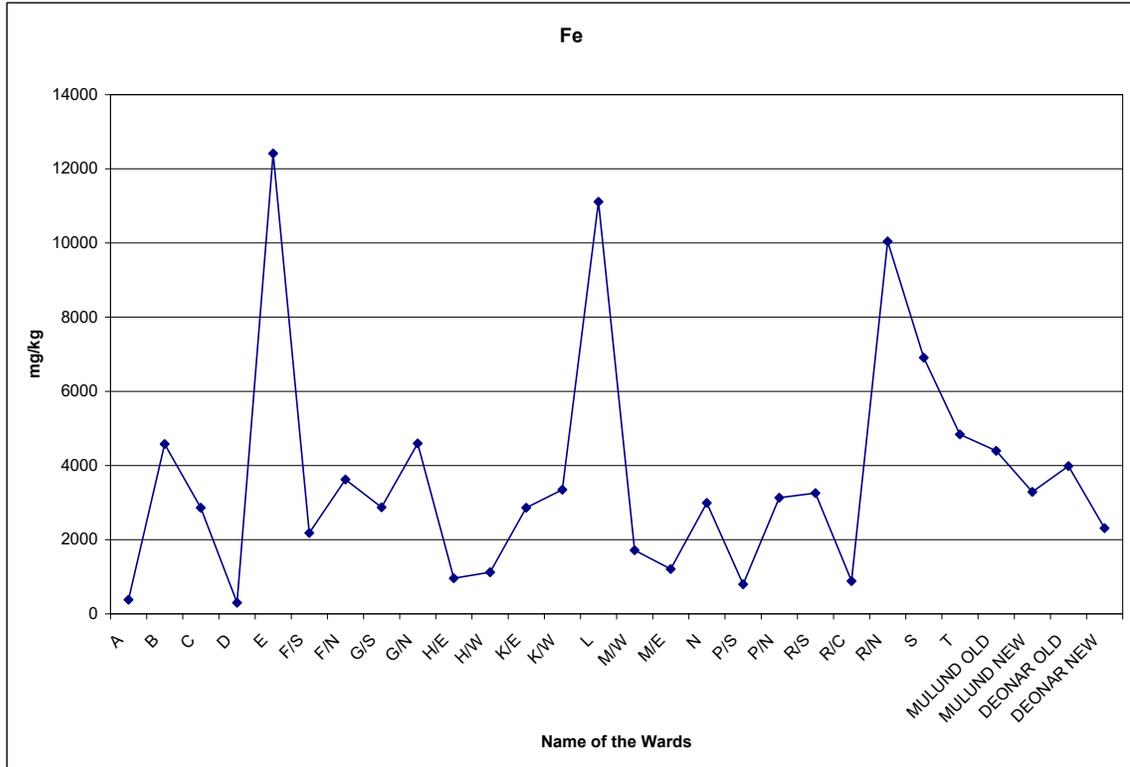


Figure 5.42: Graphical Presentation of Heavy Metal (Fe) of 24 Wards including Two Dumpsites MCGM Region (Monsoon season)

Table 5.70

**Heavy Metals Analysis (Mn) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Monsoon Season)**

Ward name	Mn (mg/kg)
A	122.71
B	197.47
C	101.85
D	41.10
E	346.77
F/S	112.12
F/N	88.48
G/N	111.85
G/S	31.07
H/E	61.81
H/W	48.10
K/W	114.54
K/E	123.87
L	287.39
M/W	84.15
M/E	50.30
N	150.30
P/S	25
P/N	124.54
R/S	120.89
R/C	120.02
R/N	262.94
S	1217.81
T	687.27
Mulund (Old dumped waste)	137.59
Mulund (Freshly dumped waste)	1348.20
Deonar OLD(Old dumped waste)	1738.42
Deonar (Freshly dumped waste)	150.32

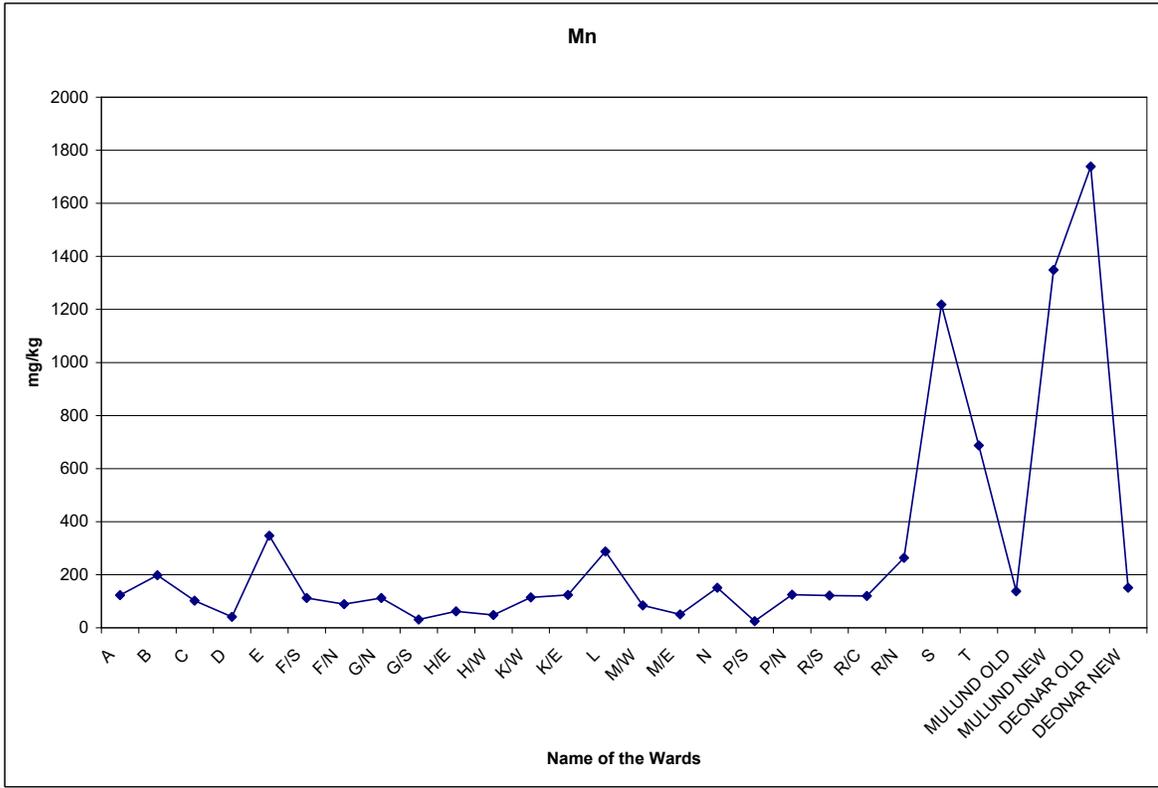


Figure 5.43: Graphical Presentation of Heavy Metal (Mn) of 24 Wards including Two Dump sites MCGM Region (Monsoon season)

Table 5.71

**Heavy Metals Analysis (Ni) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Monsoon Season)**

Ward name	Ni (mg/kg)
A	3.81
B	16.30
C	5.23
D	3.04
E	31.97
F/S	7.56
F/N	20.70
G/N	21.25
G/S	3.53
H/E	3.82
H/W	4.91
K/W	6.33
K/E	5.34
L	26.44
M/W	5.52
M/E	5.53
N	12.63
P/S	4.65
P/N	9.33
R/S	22.23
R/C	5.10
R/N	22.13
S	13.96
T	18.16
Mulund (Old dumped waste)	21.45
Mulund (Freshly dumped waste)	15.40
Deonar OLD(Old dumped waste)	23.28
Deonar (Freshly dumped waste)	18.57

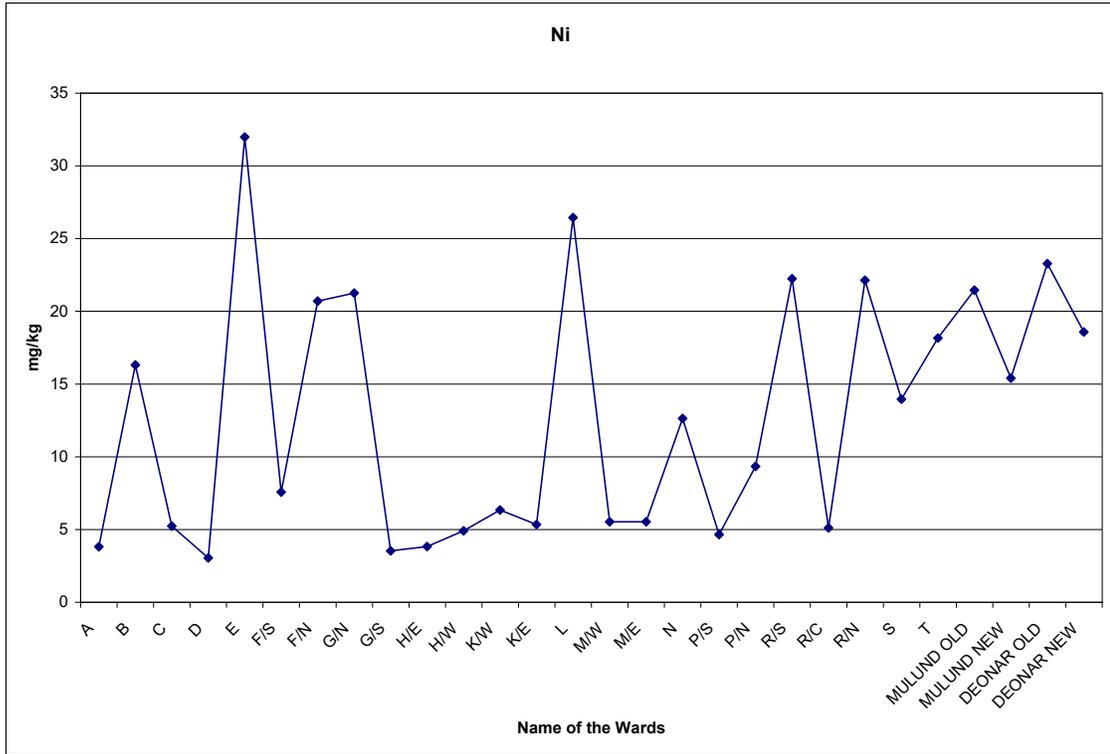


Figure 5.44: Graphical Presentation of Heavy Metal (Ni) of 24 Wards including Two Dumpsites MCGM Region (Monsoon season)

Table 5.72

**Heavy Metals Analysis (Pb) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Monsoon Season)**

Ward name	Pb (mg/kg)
A	0.51
B	86.96
C	38.94
D	10.01
E	1.17
F/S	3.25
F/N	13.23
G/N	8.92
G/S	0.36
H/E	1.05
H/W	1.34
K/W	2.11
K/E	1.57
L	BDL
M/W	1.79
M/E	44.94
N	41.51
P/S	0.80
P/N	1.11
R/S	11.20
R/C	1.33
R/N	2.93
S	1.03
T	2.56
Mulund (Old dumped waste)	0.67
Mulund (Freshly dumped waste)	1.24
Deonar (Old dumped waste)	1.64
Deonar (Freshly dumped waste)	0.93

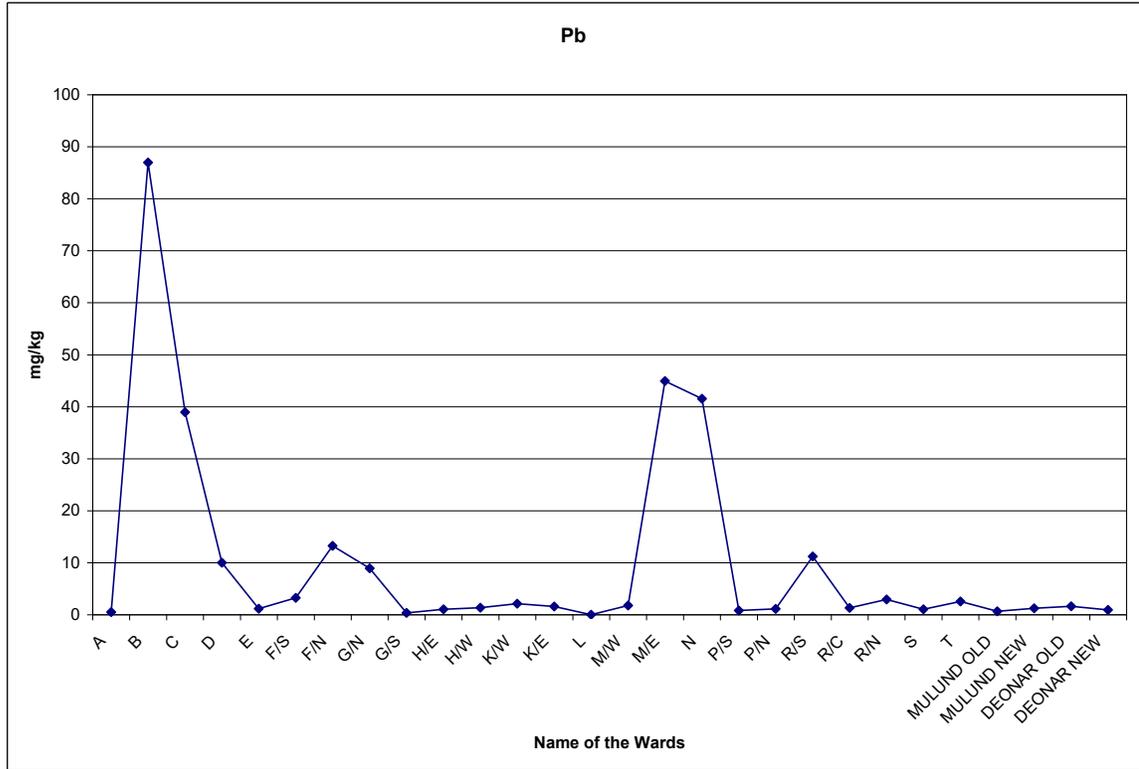


Figure 5.45: Graphical Presentation of Heavy Metal (Pb) of 24 Wards including Two Dumpsites MCGM Region (Monsoon season)

Table 5.73

**Heavy Metals Analysis (Zn) of MSW of 24 Wards including Two Dumpsites of MCGM,
Mumbai Region (Monsoon Season)**

Ward name	Zn (mg/kg)
A	31.11
B	74.38
C	64.80
D	44.21
E	70.08
F/S	42.05
F/N	88.80
G/N	102.95
G/S	22.13
H/E	38.69
H/W	45.26
K/W	48.95
K/E	55.81
L	93.93
M/W	42.06
M/E	104.21
N	54.80
P/S	27.55
P/N	38.95
R/S	48.48
R/C	43.36
R/N	101.56
S	60.29
T	61.16
Mulund (Old dumped waste)	56.34
Mulund (Freshly dumped waste)	32.63
Deonar (Old dumped waste)	78.59
Deonar (Freshly dumped waste)	49.51

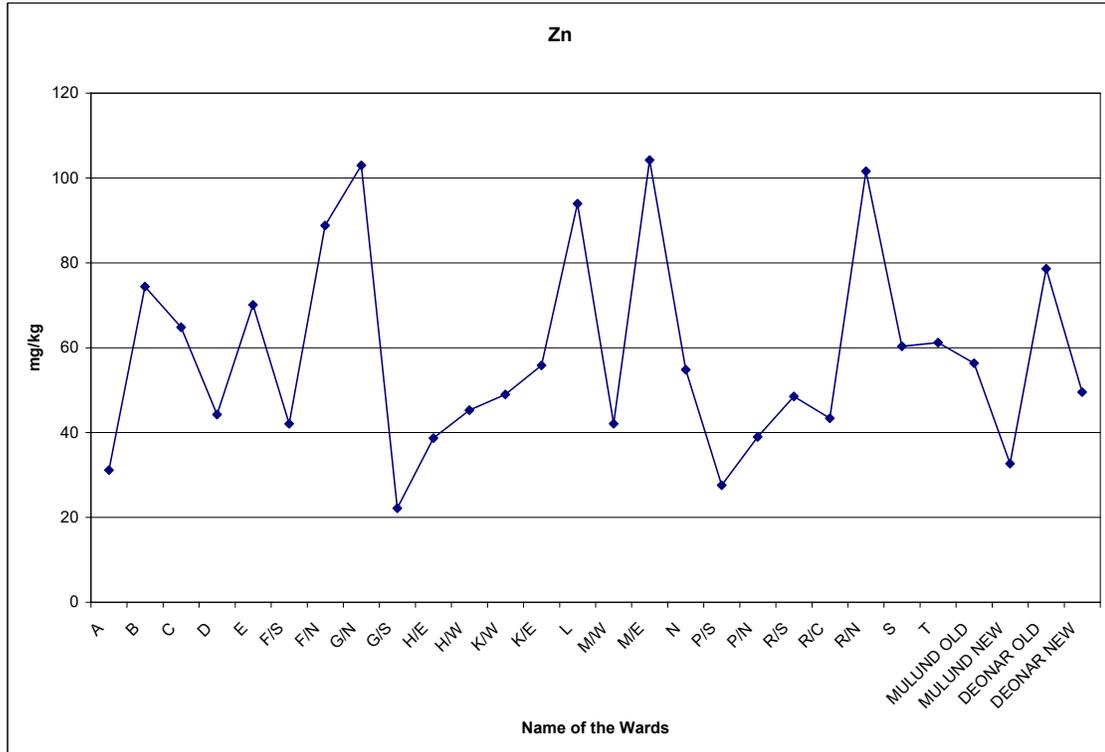


Figure 5.46: Graphical Presentation of Heavy Metal (Zn) of 24 Wards including Two Dumpsites MCGM Region (Monsoon Season)

5.3 Post Monsoon

A total of 24 MSW samples were collected from the identified HIG, MIG, LIGs, CAs, as well as both landfill site (Mulund & Deonar). Physical characteristics of MSW were carried out at all the sampling points. Physical characteristics of MSW comprised of food waste, papers, plastics, metals & glasses and inerts.

5.3.1 Physical Characterization of MSW

Physical Characteristics of MSW for the Pre- Monsoon Season of 24 wards including two dumpsites are presented in Tables 5.74 through 5.101. And Graphical Representation for Physical Characterization of MSW for the Pre-Monsoon Season is shown in Figure 5.47 through 5.27.

Table 5.74

Physical Characteristics of MSW of Ward A (Post-monsoon season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	84.2	70	77.1
Paper	10	6.4	8.2
Plastics	11.1	4	7.55
Metals and glasses	5	.8	2.9
Inerts	6	2.6	4.3

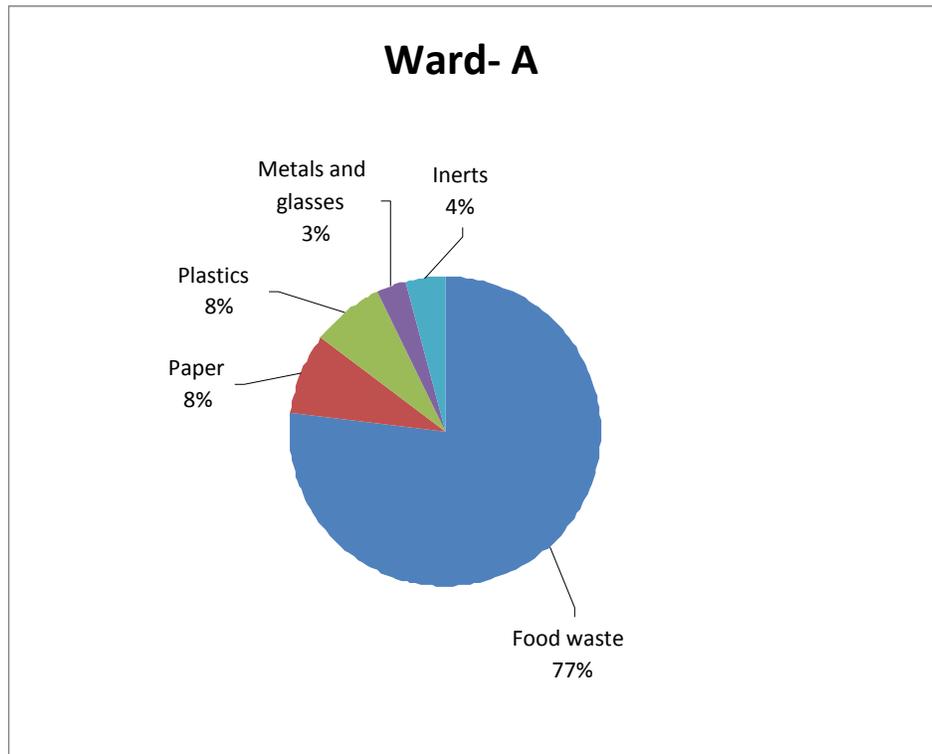


Figure 5.47 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward A

Table 5.75

Physical Characteristics of MSW of Ward B (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	73	70	71.85
Paper	7.8	5.2	6.5
Plastics	6	3.5	4.75
Metals and glasses	9	7.2	8.1
Inerts	10	8.6	9.3

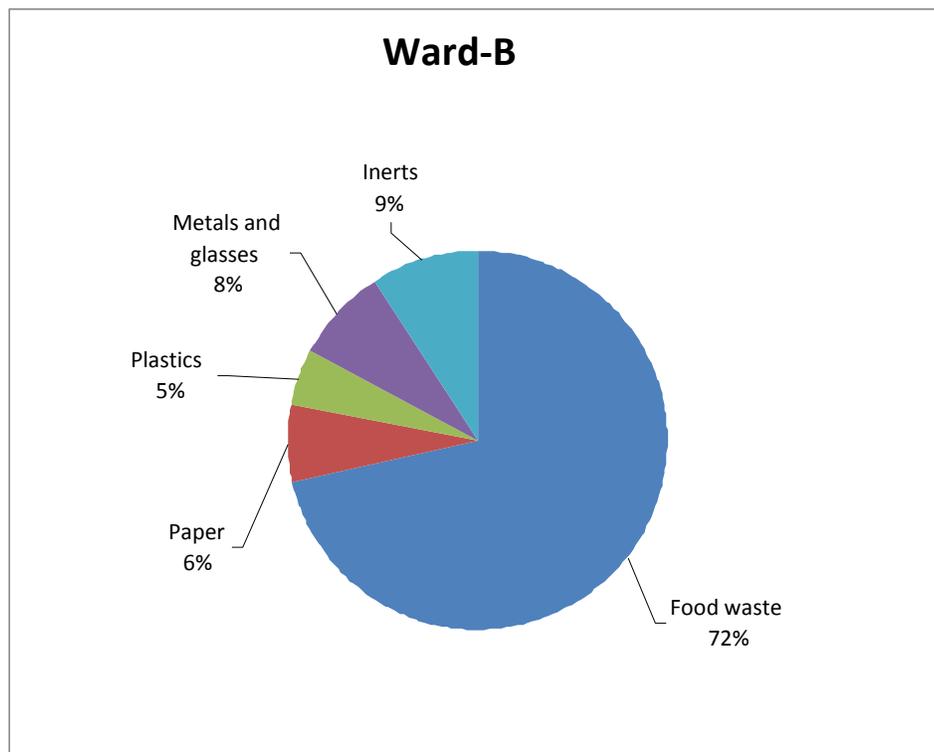


Figure 5.48 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward B

Table 5.76

Physical Characteristics of MSW of Ward C (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	81	75	78
Paper	6.9	4.7	5.8
Plastics	8.5	7.1	7.8
Metals and glasses	5.3	3.2	4.25
Inerts	6.5	4.3	5.4

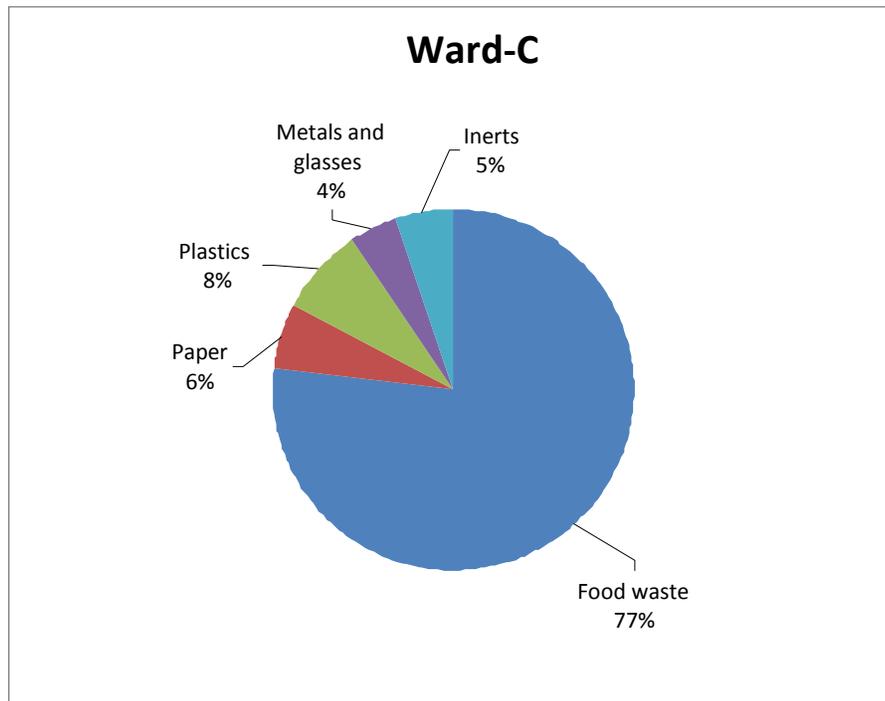


Figure 5.49: Graphical Presentation of (Post-monsoon Season) Physical Characteristics of MSW of Ward C

Table 5.77

Physical Characteristics of MSW of Ward D (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	86	79.3	82.65
Paper	7.5	5.9	6.7
Plastics	4	3.2	3.6
Metals and glasses	5.6	4.6	5.1
Inerts	2.6	1.5	2.05

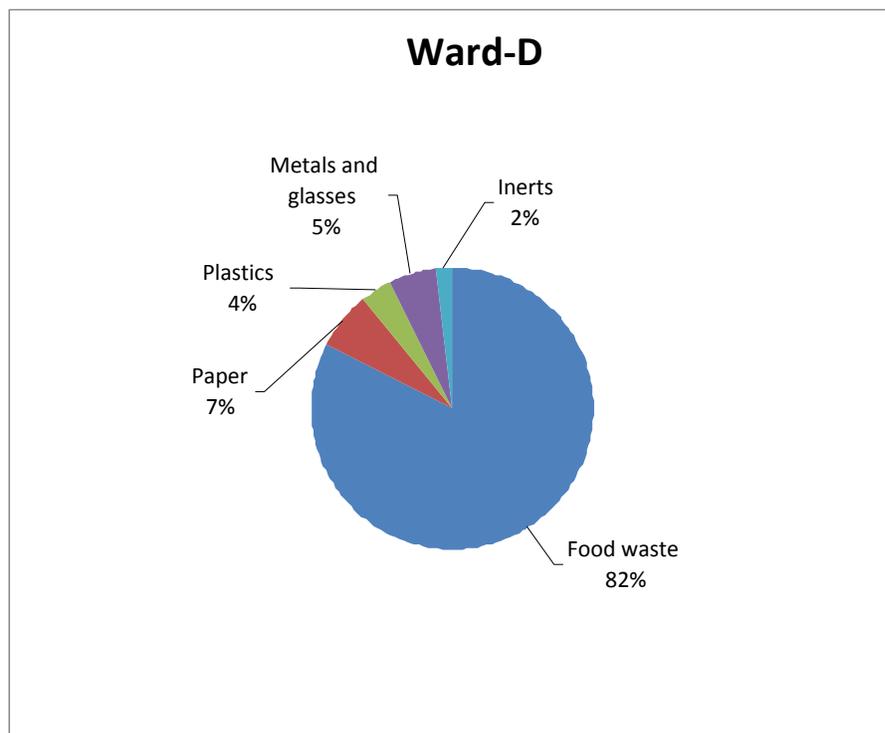


Figure 5.50 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward D

Table 5.78

Physical Characteristics of MSW of Ward E (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	79	70.2	74.6
Paper	8.3	7.5	7.9
Plastics	6.6	5.4	6
Metals and glasses	4.5	3.2	3.85
Inerts	8	7.3	7.65

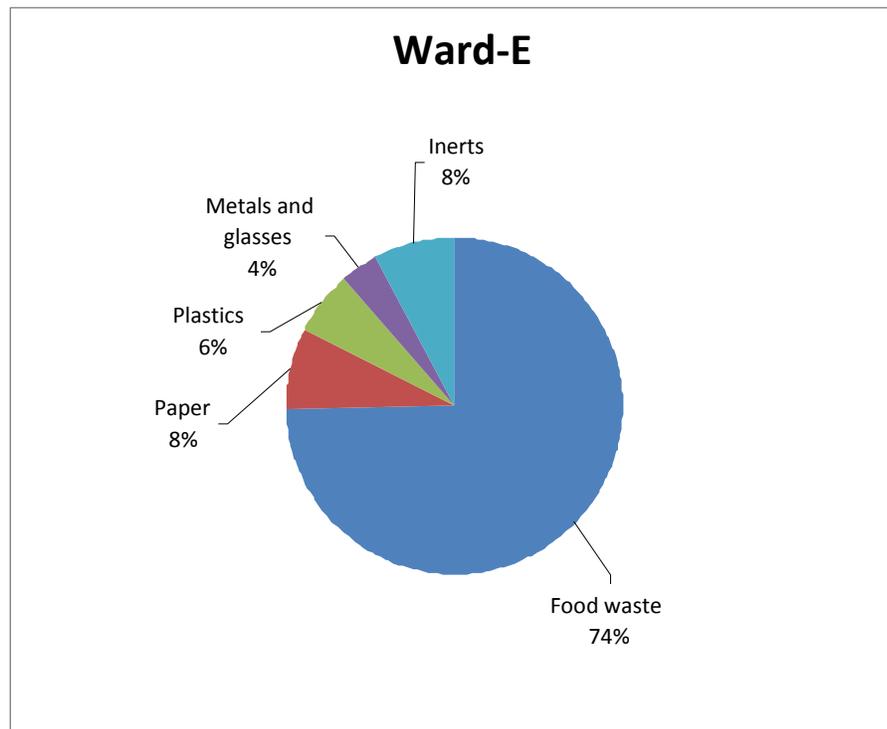


Figure 5.51 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward E

Table 5.79

Physical Characteristics of MSW of Ward F/S (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	82	76	79
Paper	8.7	6.3	7.5
Plastics	5	4.2	4.6
Metals and glasses	3.5	1.5	2.5
Inerts	8	5.6	6.8

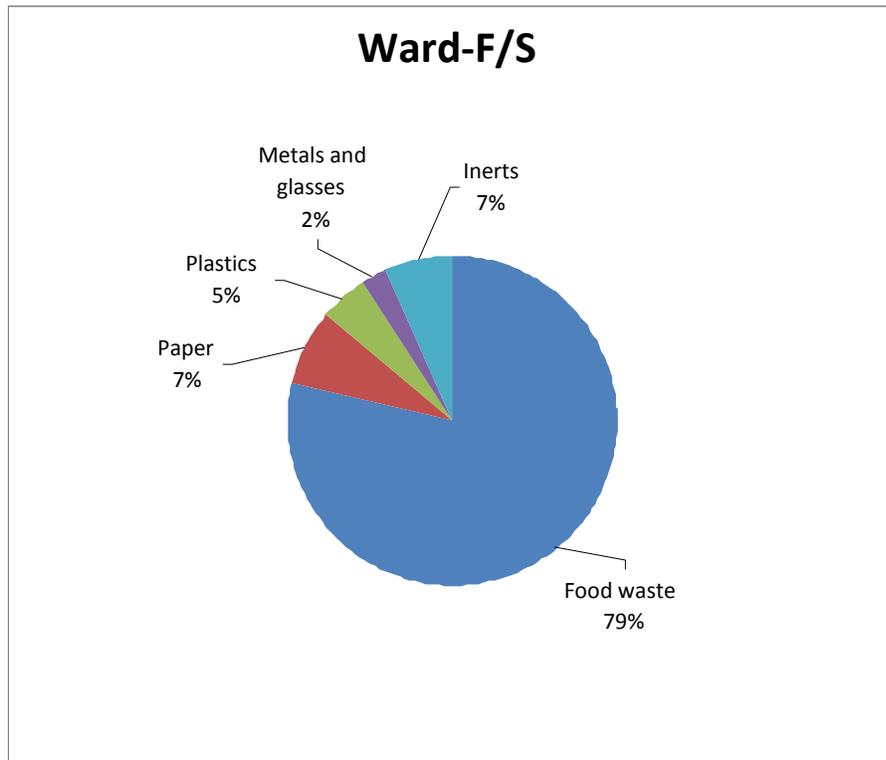


Figure 5.52 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward F/S

Table 5.80

Physical Characteristics of MSW of Ward F/N (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	89	77.5	83.25
Paper	4.8	4.3	4.55
Plastics	4.6	3.2	3.9
Metals and glasses	2.9	1.5	2.2
Inerts	7.5	6.9	7.2

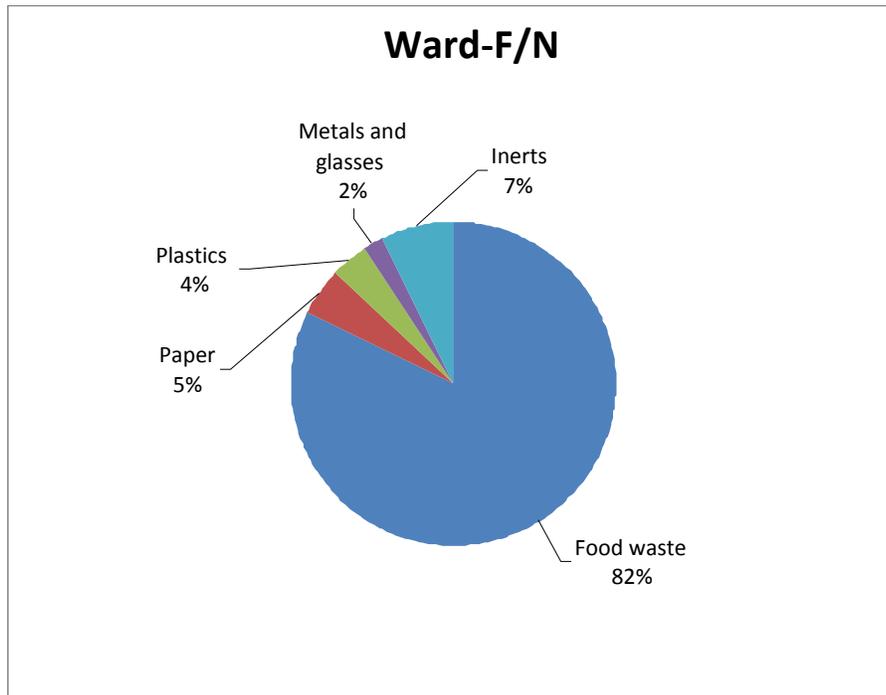


Figure 5.53 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward F/N

Table 5.81

Physical Characteristics of MSW of Ward G/S (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	83.34	73.36	78.85
Paper	4.47	4.16	4.31
Plastics	4.49	3.51	4
Metals and glasses	3.60	2.10	2.85
Inerts	11.72	9.24	10.48

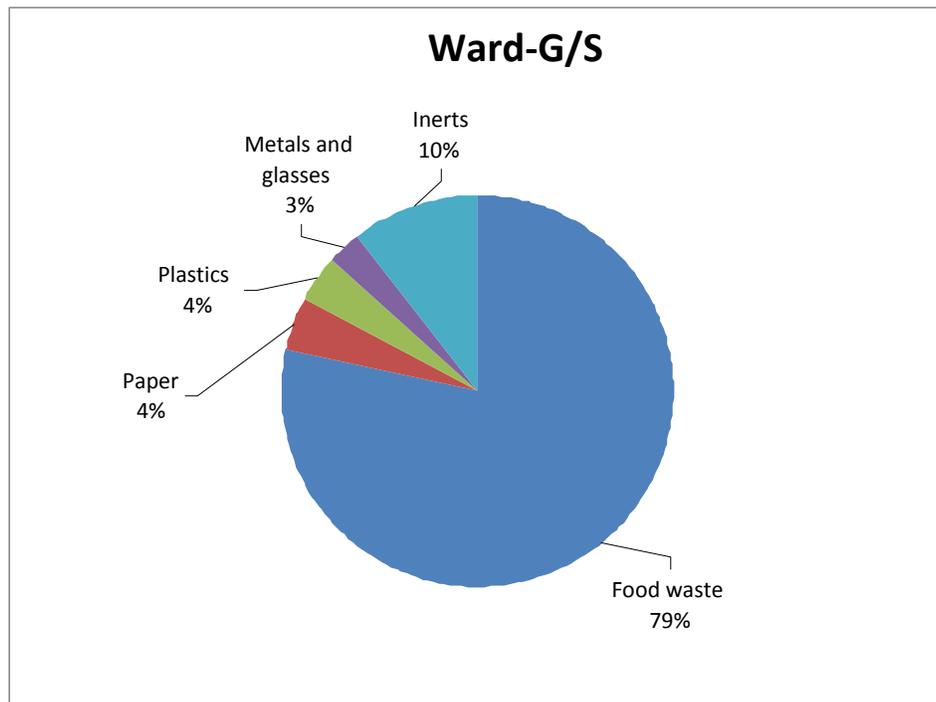


Figure 5.54 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward G/S

Table 5.82

Physical Characteristics of MSW of Ward G/N (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	79.1	74.7	76.9
Paper	6.62	5.67	6.14
Plastics	3.03	3.13	3.08
Metals and glasses	5.15	4.5	4.82
Inerts	10.78	8.76	9.77

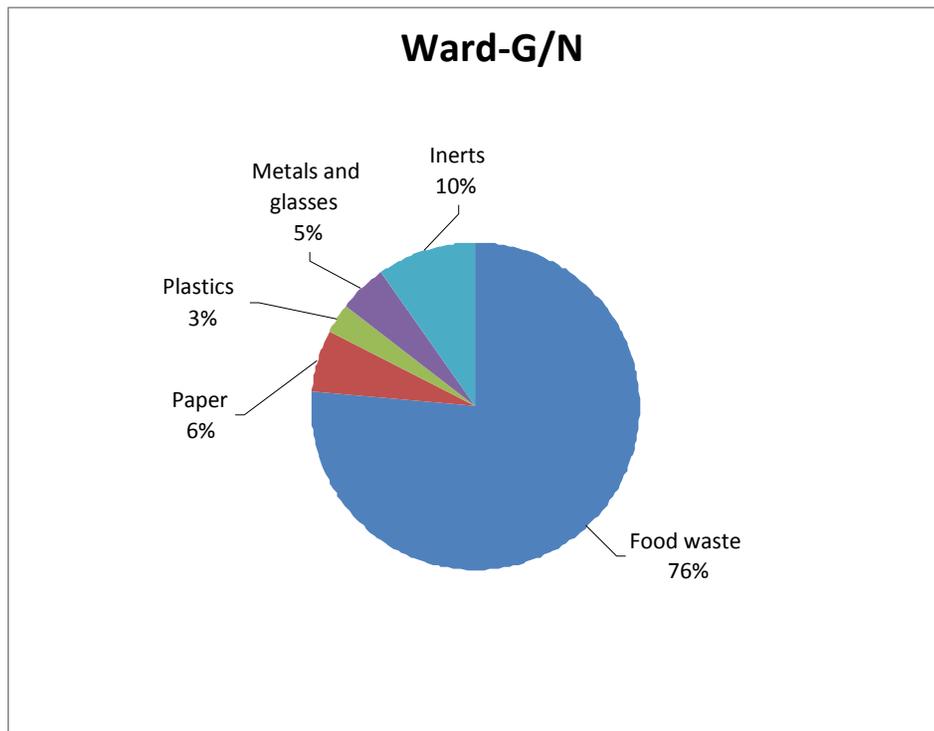


Figure 5.55 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward G/N

Table 5.83

Physical Characteristics of MSW of Ward H/E (Post-monsoon)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	83.2	70.3	76.75
Paper	5.2	4.1	4.65
Plastics	6	4.2	5.1
Metals and glasses	2.5	1.64	2.07
Inerts	12.13	10.82	11.47

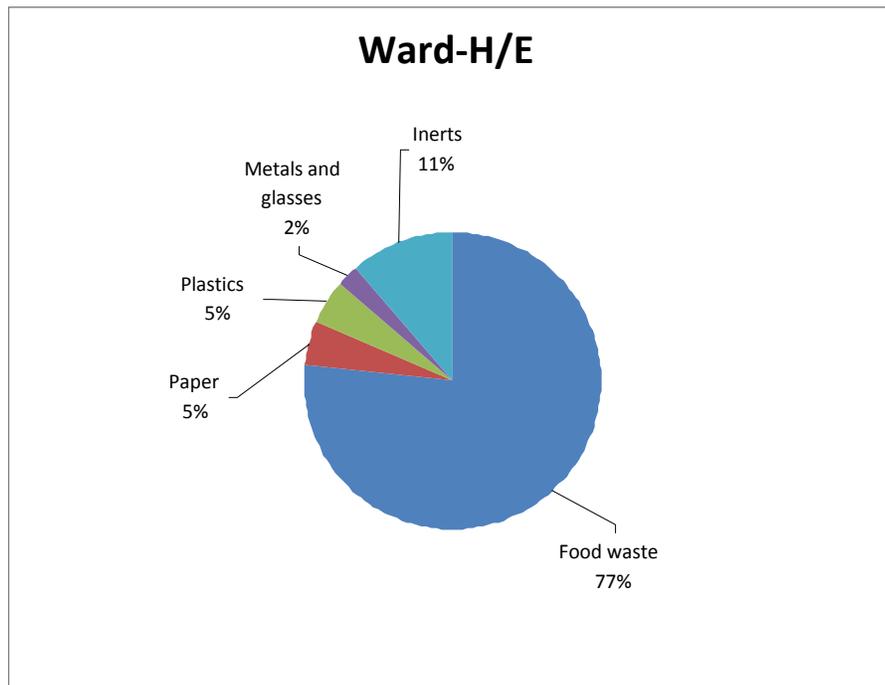


Figure 5.56 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward H/E

Table 5.84

Physical Characteristics of MSW of Ward H/W (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	84.64	63.61	74.12
Paper	6.13	5.61	5.87
Plastics	3.05	2.67	2.86
Metals and glasses	4.10	3.07	3.58
Inerts	15.05	12.18	13.61

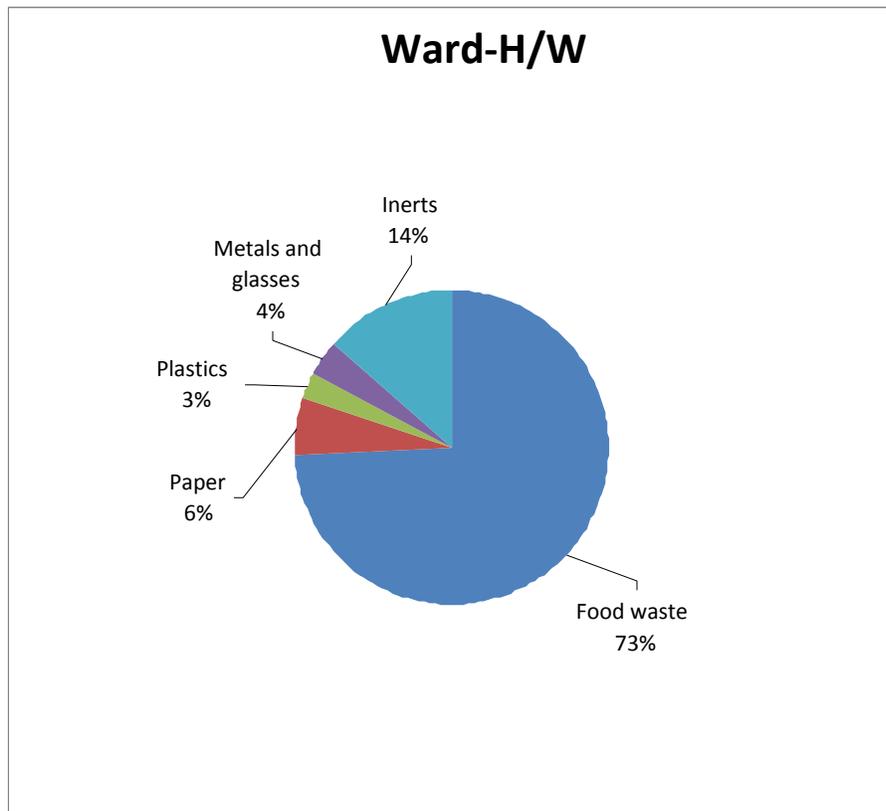


Figure 5.57 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward H/W

Table 5.85

Physical Characteristics of MSW of Ward K/W (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	90.04	73.01	81.52
Paper	3.16	2.71	2.93
Plastics	2.36	1.30	1.83
Metals and glasses	1.91	.05	.98
Inerts	15.1	12.15	13.62

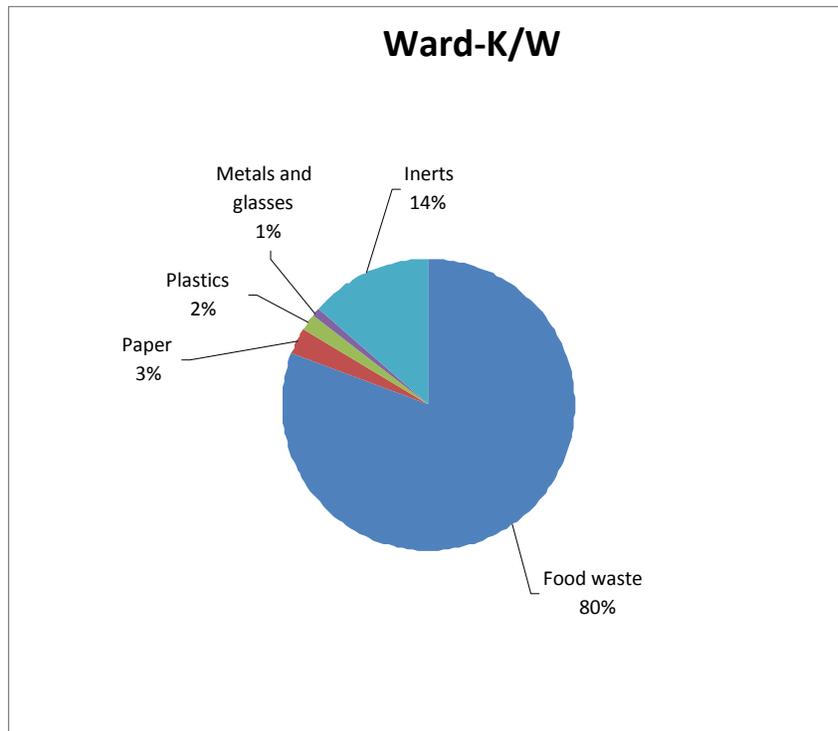


Figure 5.58 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward K/W

Table 5.86

Physical Characteristics of MSW of Ward P/S (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	87.9	74.00	80.95
Paper	5.03	4.10	4.56
Plastics	2.17	1.06	1.61
Metals and glasses	3.06	2.17	2.61
Inerts	13.16	9.07	11.11

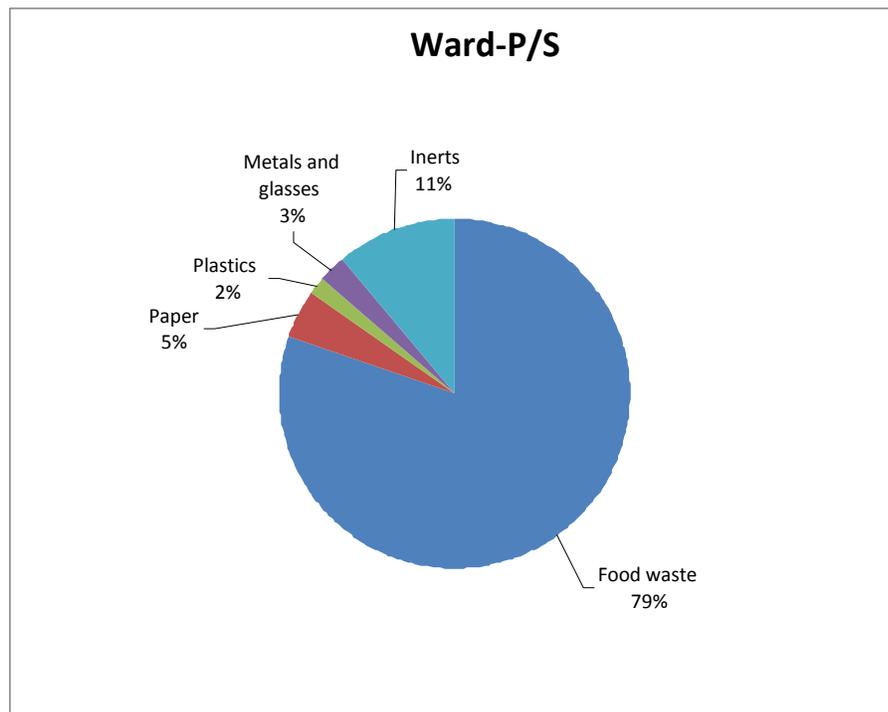


Figure 5.59 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward P/S

Table 5.87
Physical Characteristics of MSW of Ward P/N (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	85.12	72.01	78.56
Paper	1.66	1.04	1.35
Plastics	3.87	2.10	2.98
Metals and glasses	2.12	0.62	1.37
Inerts	15.86	16.95	16.40

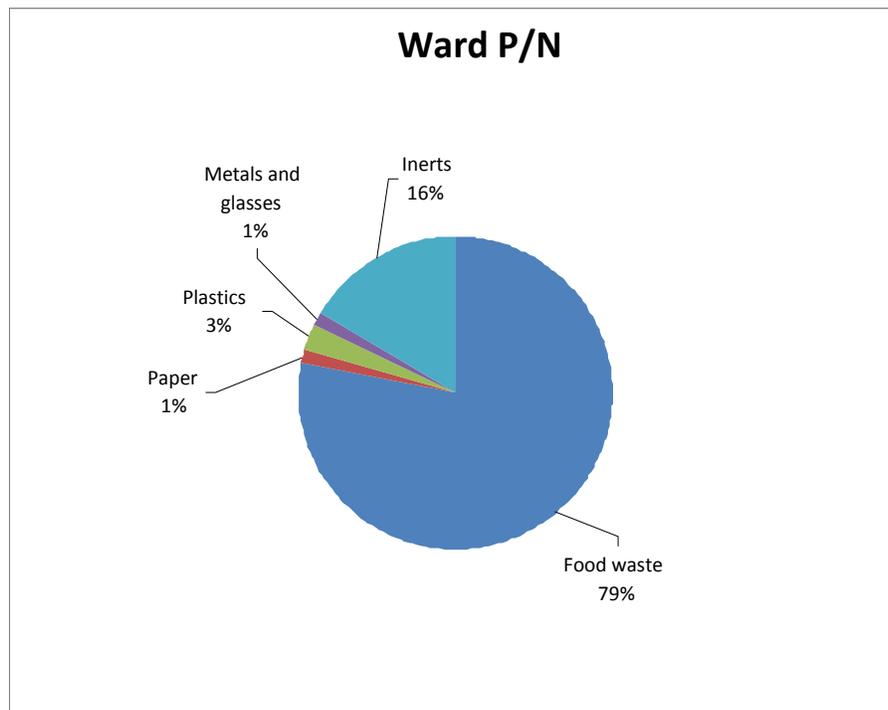


Figure 5.60 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward P/N

Table 5.88
Physical Characteristics of MSW of Ward R/S (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	87.61	73.07	80.34
Paper	4.01	2.06	3.03
Plastics	1.85	.86	1.35
Metals and glasses	3.01	.96	1.98
Inerts	15.12	13.05	14.08

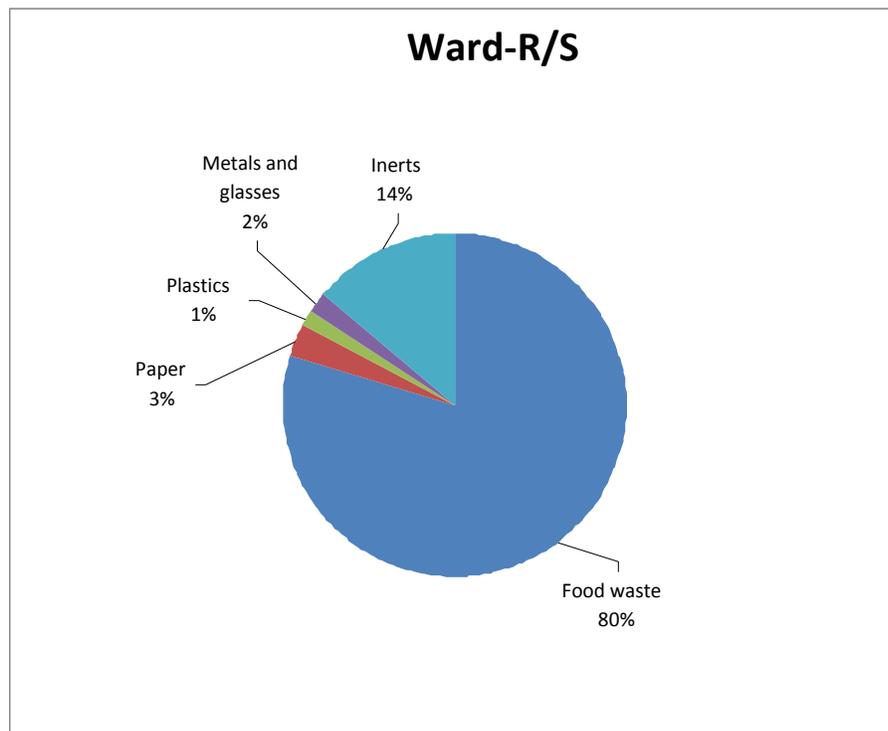


Figure 5.61 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward R/S

Table 5.89
Physical Characteristics of MSW of Ward R/C (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg.(%)
Food waste	87.13	72.07	79.6
Paper	3.08	2.51	2.79
Plastics	2.68	1.05	1.86
Metals and glasses	7.07	3.16	5.11
Inerts	14.05	10.65	12.35

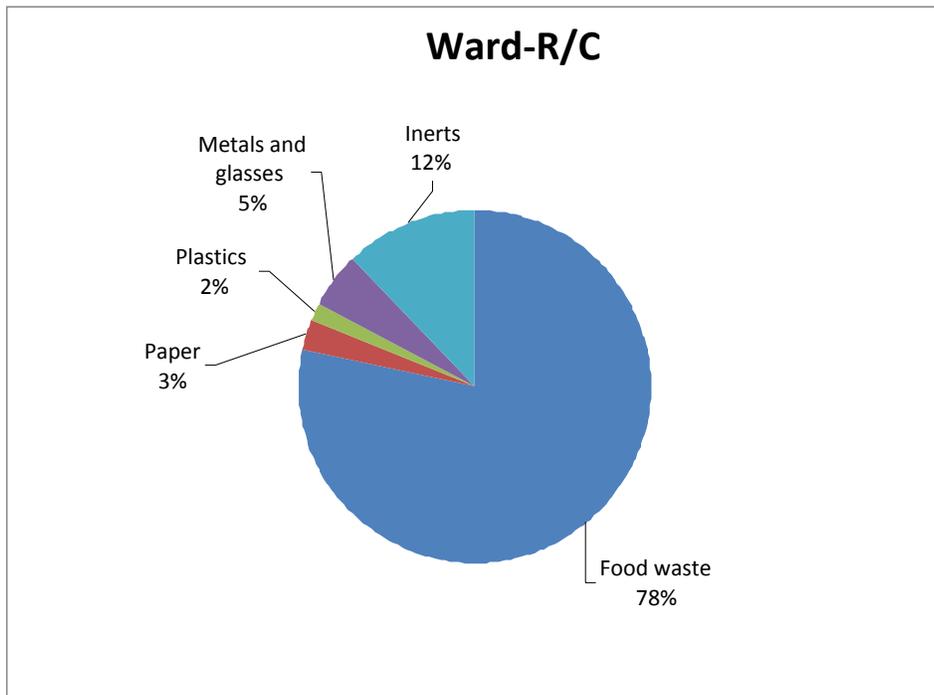


Figure 5.62 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward R/C

Table 5.90
Physical Characteristics of MSW of Ward R/N (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	81.3	72.54	76.92
Paper	4.16	3.98	4.07
Plastics	2.02	1.95	1.98
Metals and glasses	4.72	2.17	3.44
Inerts	15.13	12.09	13.61

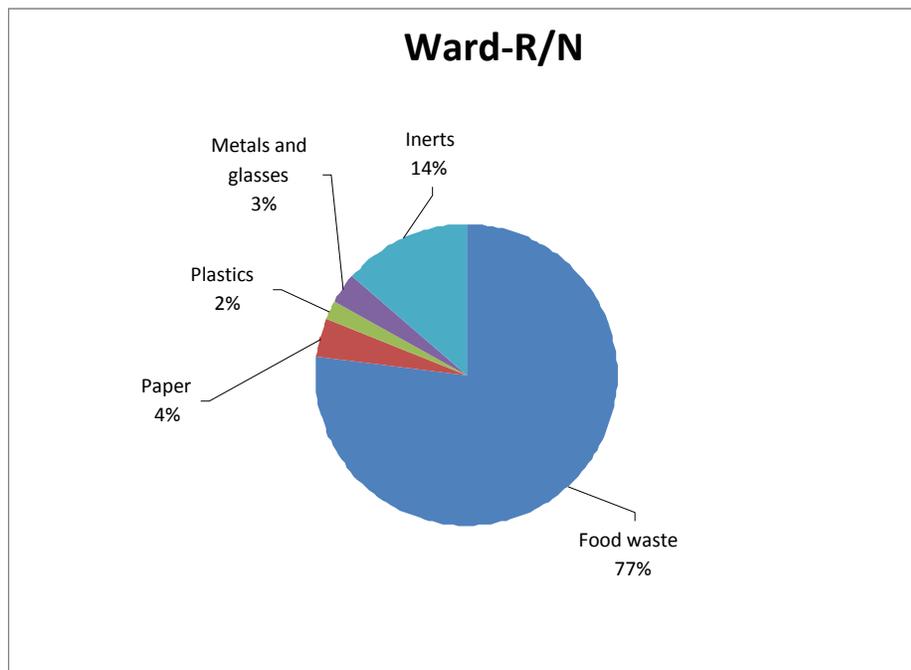


Figure 5.63 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward R/N

Table 5.91

Physical Characteristics of MSW of Ward L (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	80.54	68.04	74.29
Paper	5.16	3.29	4.22
Plastics	4.09	2.17	3.13
Metals and glasses	2.34	1.95	2.14
Inerts	18.16	14.08	16.64

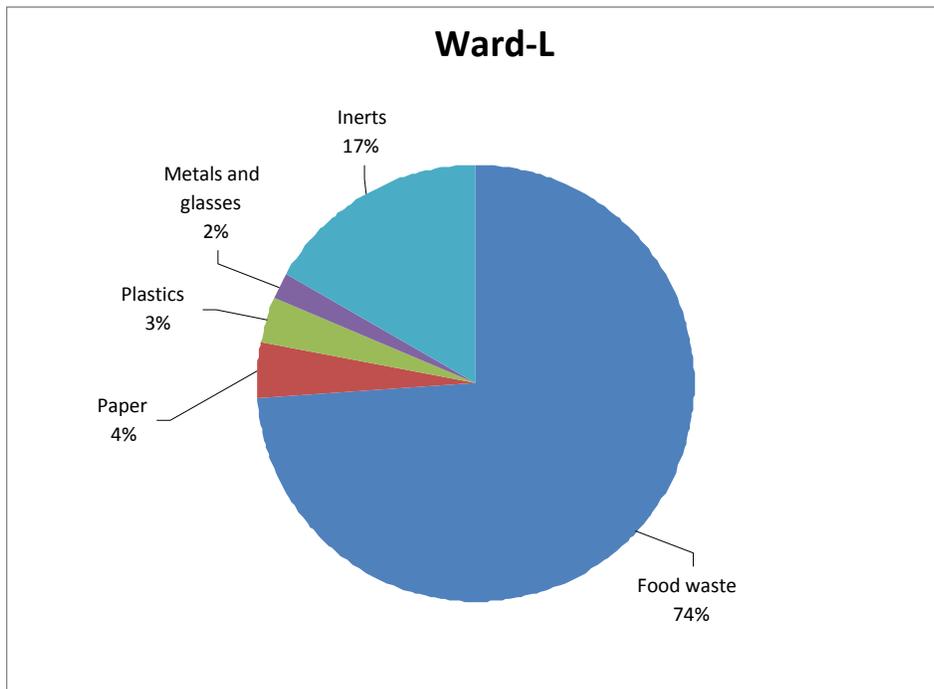


Figure 5.64 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward L

Table 5.92
Physical Characteristics of MSW of Ward M/E (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	89.04	75.17	82.10
Paper	3.06	1.05	2.05
Plastics	1.65	1.34	1.49
Metals and glasses	2.12	.58	1.35
Inerts	14.06	12.03	13.04

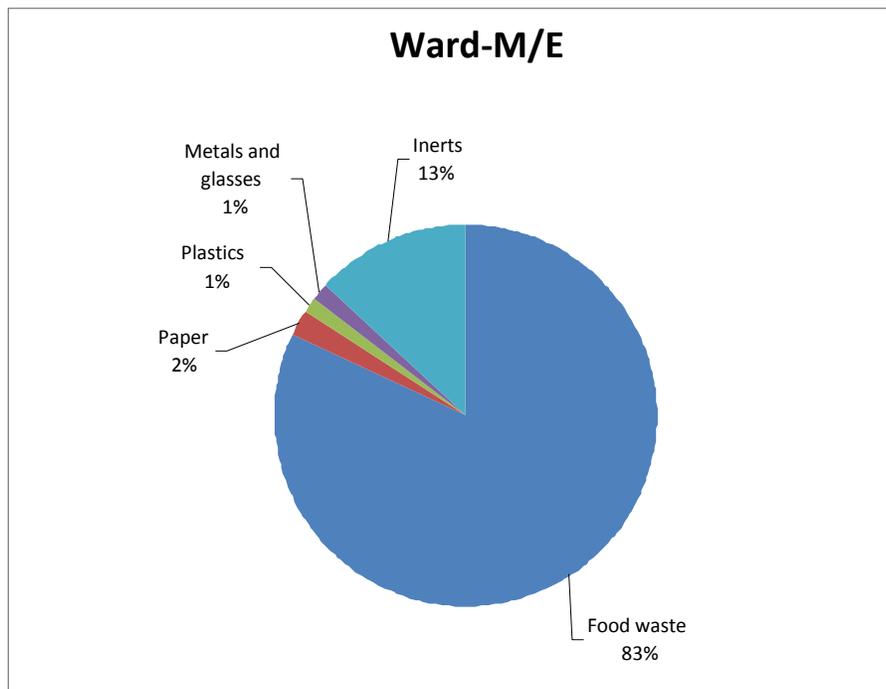


Figure 5.65 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward M/E

Table 5.93

Physical Characteristics of MSW of Ward M/W (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	81.92	68.14	75.03
Paper	3.86	2.12	2.99
Plastics	2.46	.95	1.70
Metals and glasses	3.78	2.57	3.17
Inerts	19.67	15.23	17.45

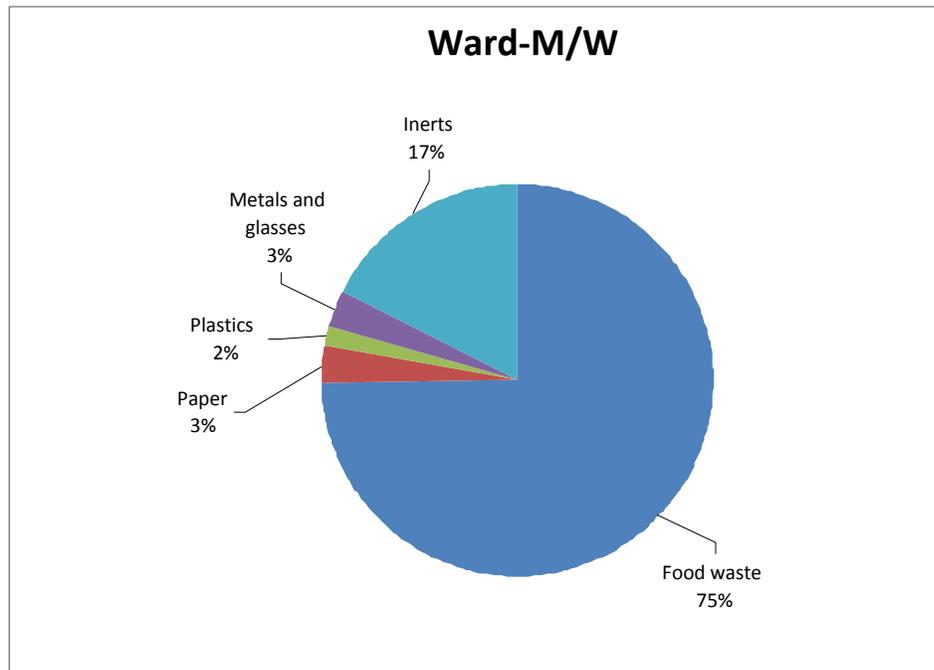


Figure 5.66 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward M/W

Table 5.94

Physical Characteristics of MSW of Ward N (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	89.03	67.02	78.02
Paper	5.28	2.34	3.81
Plastics	4.15	1.36	2.75
Metals and glasses	2.37	1.16	1.76
Inerts	16.25	11.08	13.66

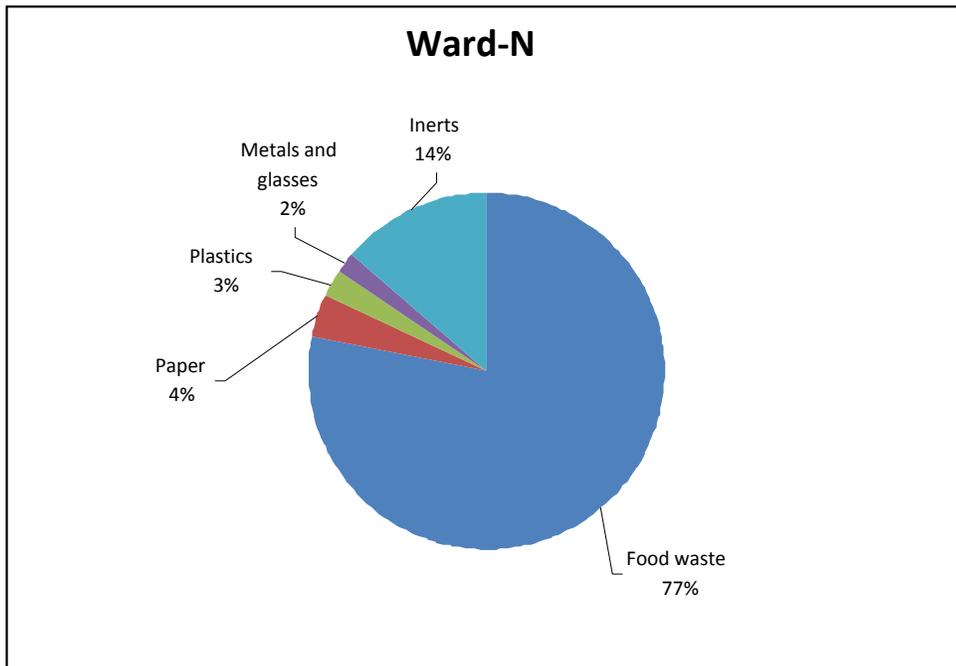


Figure 5.67 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward N

Table 5.95

Physical Characteristics of MSW of Ward S (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	84.05	69.26	76.65
Paper	6.32	3.67	4.99
Plastics	5.08	2.10	3.59
Metals and glasses	3.10	2.13	2.61
Inerts	15.35	10.23	12.79

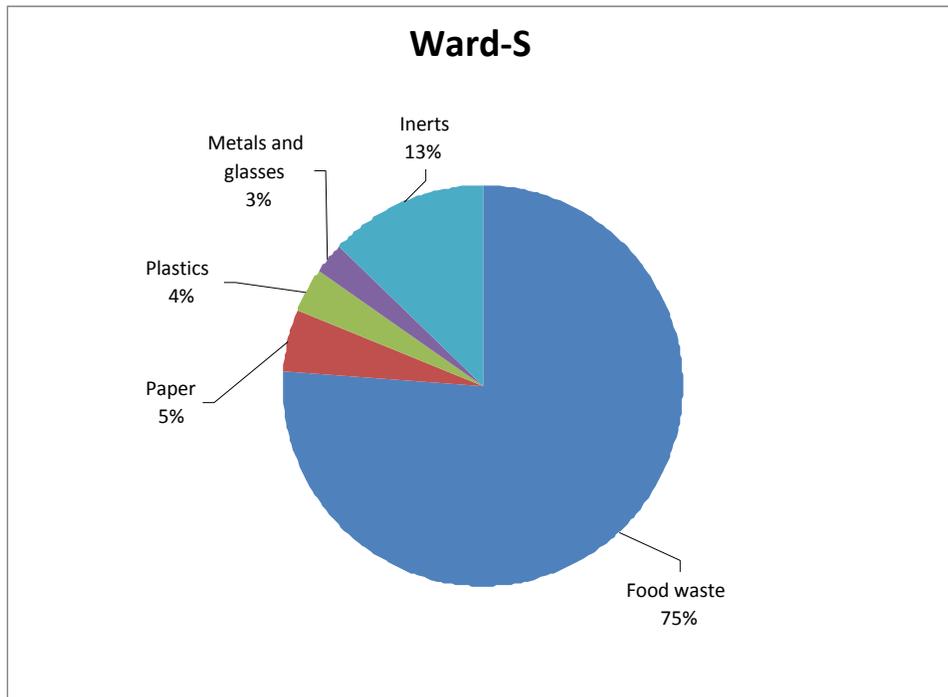


Figure 5.68 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward S

Table 5.96

Physical Characteristics of MSW of Ward T (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	79.6	69.42	74.51
Paper	6.61	5.33	5.97
Plastics	3.64	1.45	2.54
Metals and glasses	3.90	2.78	3.34
Inerts	14.98	13.87	14.42

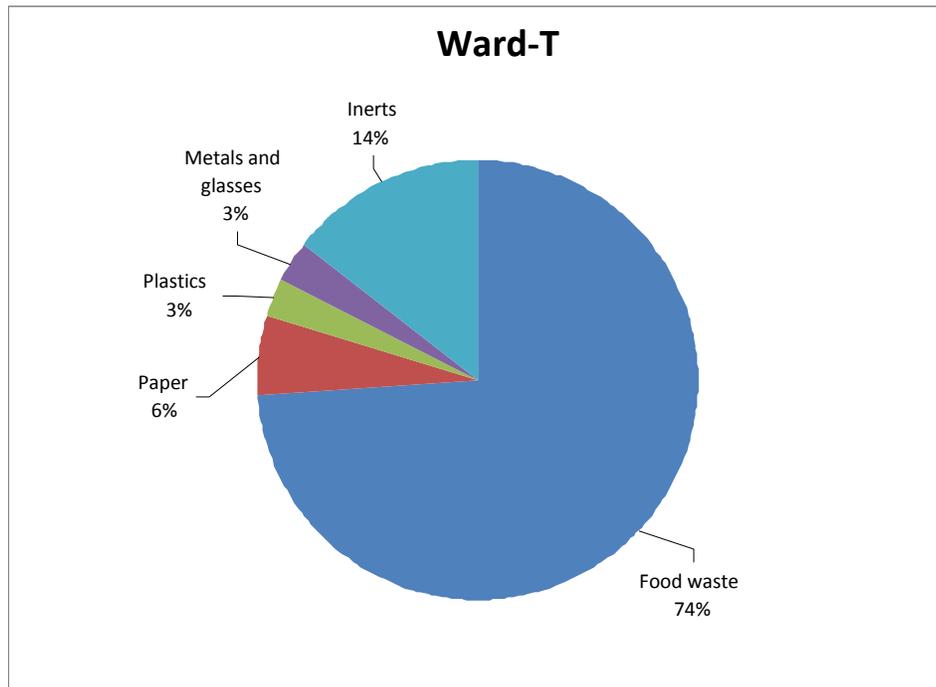


Figure 5.69 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Ward T

Table 5.97

Physical Characteristics of MSW of Deonar Old Dumped Waste (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	88.01	74.08	81.04
Paper	4.89	3.94	4.41
Plastics	6	2.03	4.01
Metals and glasses	1.27	1.16	1.21
Inerts	10.25	9.08	9.66

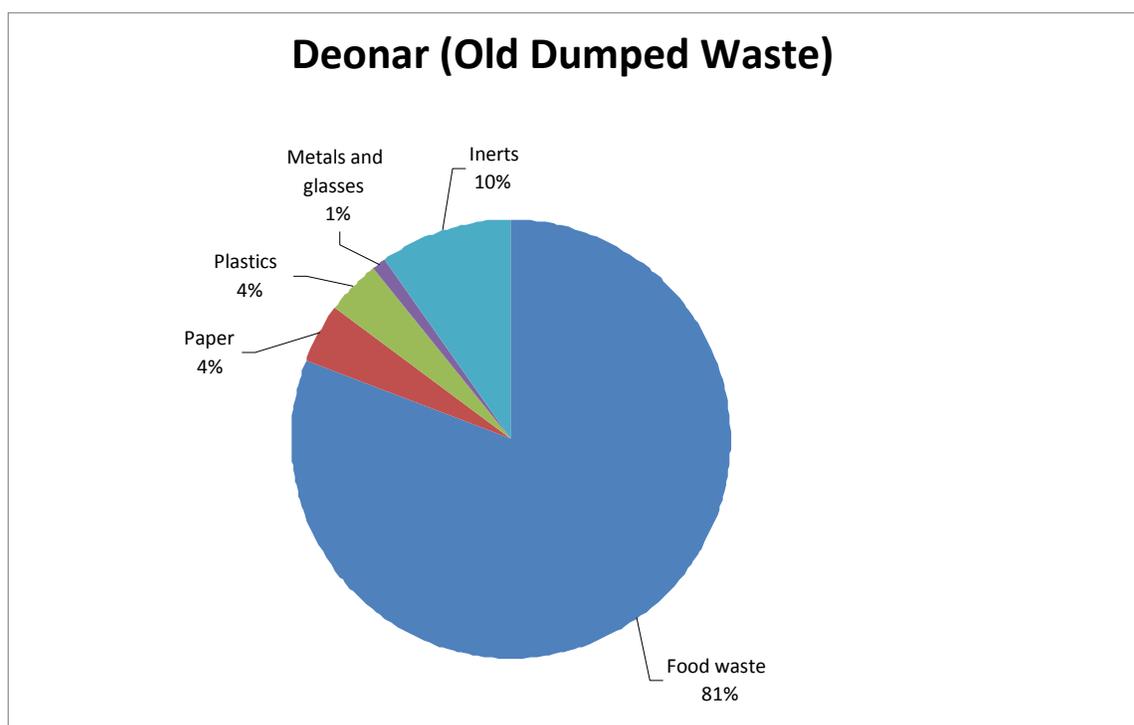


Figure 5.70 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Deonar (Old Dumped Waste)

Table 5.98

Physical Characteristics of MSW of Deonar (New) freshly Dumped Waste (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	84.18	74.81	79.49
Paper	5.68	3.04	4.36
Plastics	3.45	3.36	3.40
Metals and glasses	1.97	1.36	1.66
Inerts	13.05	10.08	11.56

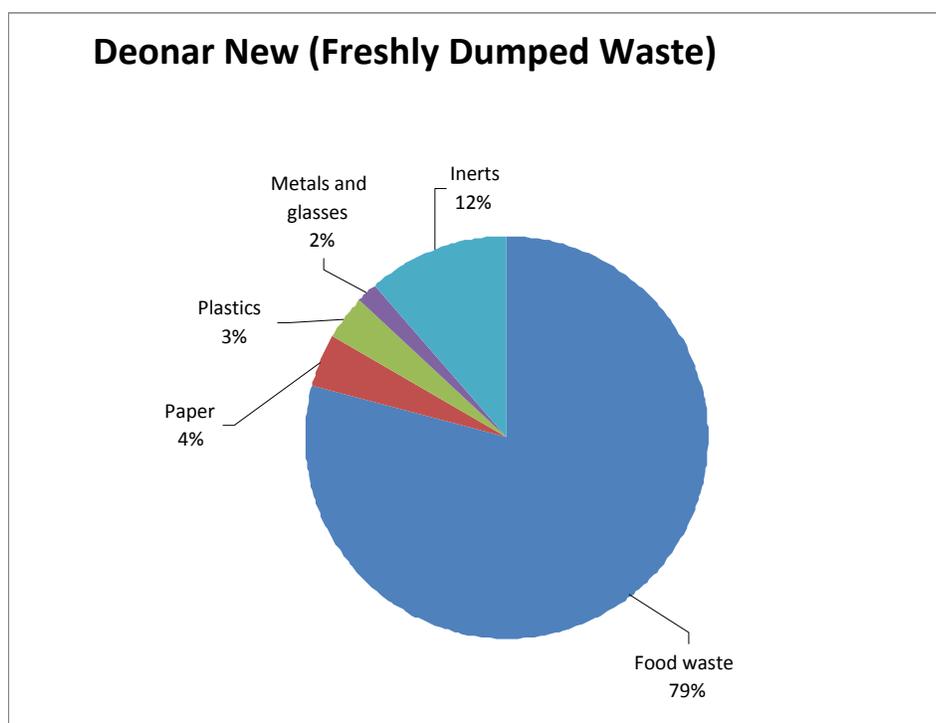


Figure 5.71 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Deonar New (Freshly Dumped Waste)

Table 5.99

Physical Characteristics of MSW of Mulund Old Dumped Waste (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	77.53	70.64	74.08
Paper	4.81	3.62	4.21
Plastics	4.05	3.43	3.74
Metals and glasses	3.51	2.06	2.78
Inerts	16.01	14.71	15.36

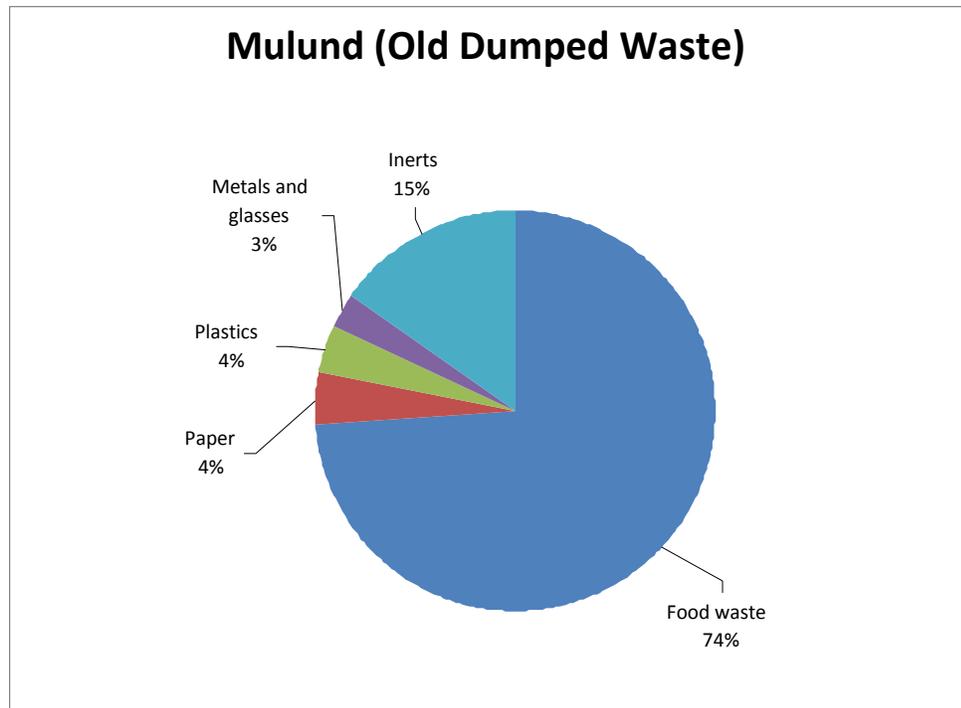


Figure 5.72 Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Mulund Old Dumped Waste

Table 5.100

Physical Characteristics of MSW of Mulund (New) Freshly Dumped Waste (Post-monsoon Season)

Components	Max. (%)	Min. (%)	Avg. (%)
Food waste	86.65	74.81	80.73
Paper	4.26	4.04	4.15
Plastics	3.81	2.06	2.93
Metals and glasses	2.16	1.09	1.62
Inerts	12.05	9.66	10.85

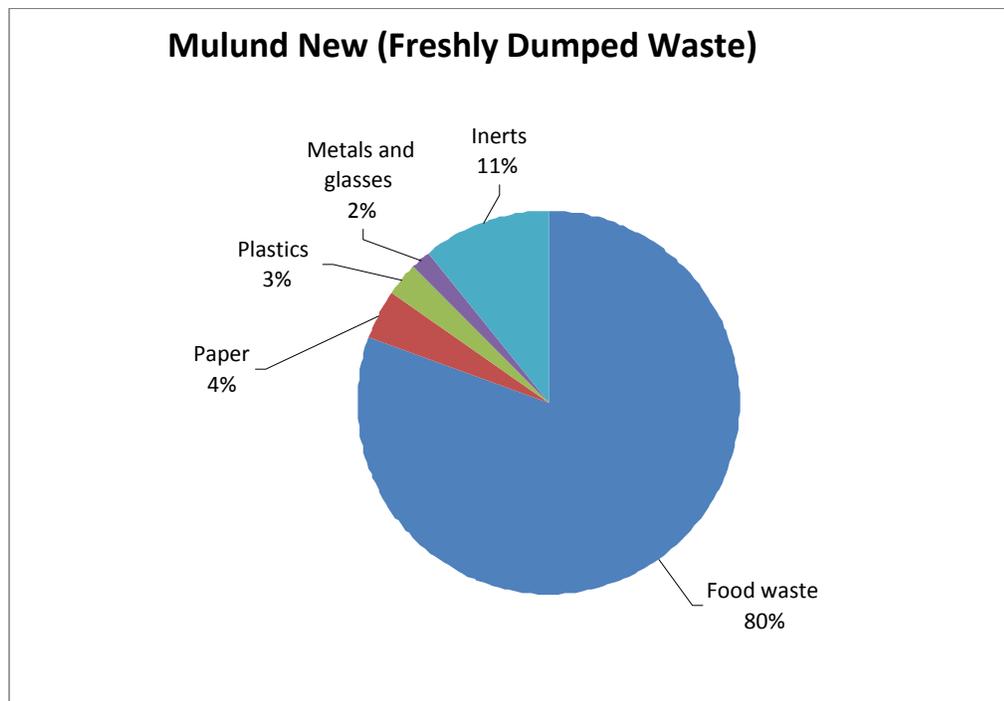


Figure 5.73: Graphical Presentation of (Post-monsoon season) Physical Characteristics of MSW of Mulund New (Freshly Dumped Wastes)

Table 5.101

Overall Physical Characteristics of MSW (Post-monsoon Season) of 24 Wards of MCGM including Two Dumpsites Mumbai region

Component	Max.	Min.	Avg.
food waste	84.4	71.97	78.185
paper	5.47	3.97	4.72
plastics	4.31	2.64	3.475
metals	3.39	1.91	2.65
inerts	12.56	10.23	11.395

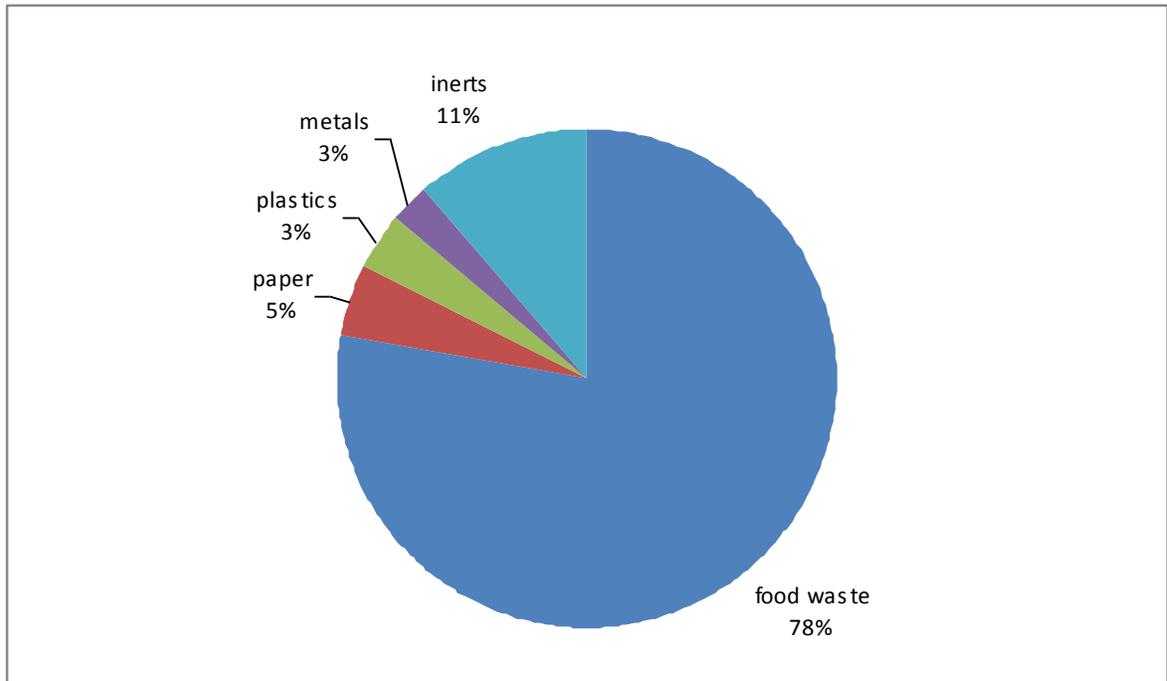


Figure 5.74: Overall Graphical Representation of Physical Characteristics (Post-Monsoon Season) of 24 wards (including Two Dump Sites) of MCGM

5.3.2 Physico-Chemical Characterization of Post Monsoon

Chemical characteristics of MSW for the Post-monsoon Season of 24 wards including two dump sites are presented in Table 5.102 through 5.40.

Table 5.102

Physico-Chemical Analysis (Loss on Ignition) of MSW of 24 Wards including Two Dumpsites of MCGM, Mumbai Region (Post-monsoon Season)

Name of the Wards	Loss on Ignition		
	Max. (%)	Min. (%)	Avg. (%)
A	96	87	91.5
B	96	79	87.5
C	92	73	82.5
D	90	80	85
E	88	78	83
F/S	91	78	84.5
F/N	95	87	91
G/S	92	70	81
G/N	92	83	87.5
H/E	88	74	81
H/W	92	84	88
K/E	88	83	85.5
K/W	87	75	81
L	89	83	86
M/E	90	74	82
M/W	94	88	91
N	106	80	93
P/S	91	75	83
P/N	88	75	81.5
R/S	90	87	88.5
R/C	94	87	90.5
R/N	89	88	88.5
S	92	83	87.5
T	85	73	79
Mulund (Old dumped waste)	86	72	79
Mulund (Freshly dumped waste)	95	77	86
Deonar (Old dumped waste)	87	73	80
Deonar (Freshly dumped waste)	91	79	85

Table 5.103**Physico-Chemical Analysis (Ash Content) of MSW of 24 Wards including Two Dump Sites of MCGM, Mumbai Region (Post-monsoon Season)**

Ash Content			
Name of the Wards	Max. (%)	Min. (%)	Avg. (%)
A	13	4	8.5
B	21	4	12.5
C	27	8	17.5
D	20	10	15
E	22	12	17
F/S	30	9	19.5
F/N	13	5	9
G/S	30	8	19
G/N	17	8	12.5
H/E	26	12	19
H/W	16	8	12
K/E	17	12	14.5
K/W	25	13	19
L	17	11	14
M/E	26	10	18
M/W	12	6	9
N	25	9	17
P/S	25	12	18.5
P/N	13	10	11.5
R/S	13	6	9.5
R/C	12	6	9
R/N	20	14	17
S	17	8	12.5
T	15	7	11
Mulund (Old dumped waste)	14	6	10
Mulund (Freshly dumped waste)	23	9	16
Deonar (Old dumped waste)	27	12	19.5
Deonar (Freshly dumped waste)	9	4	6.5

Table 5.104**Physico-Chemical Analysis (TOC) of MSW of 24 Wards including Two Dump Sites of MCGM, Mumbai Region (Post-monsoon season)**

TOC			
Name of the Wards	Max. (%)	Min. (%)	Avg. (%)
A	55.68	50.46	53.07
B	55.68	45.82	50.75
C	53.36	42.34	47.85
D	52.2	46.4	49.3
E	51.04	45.24	48.14
F/S	52.78	40.6	46.69
F/N	55.31	50.45	52.88
G/S	53.36	40.6	46.98
G/N	53.36	48.14	50.75
H/E	51.04	42.92	46.98
H/W	53.36	48.14	50.75
K/E	51.04	48.14	49.59
K/W	50.46	43.5	46.98
L	51.62	48.14	49.88
M/E	52.2	42.92	47.56
M/W	54.52	51.04	52.78
N	61.48	46.4	53.94
P/S	52.78	43.5	48.14
P/N	51.04	43.5	47.27
R/S	52.2	50.46	51.33
R/C	54.52	50.46	52.49
R/N	64.96	51.04	58
S	53.36	48.14	50.75
T	60.24	49.3	54.77
Mulund (Old dumped waste)	51.46	49.88	50.67
Mulund (Freshly dumped waste)	55.62	44.66	50.14
Deonar (Old dumped waste)	60.54	42.34	51.44
Deonar (Freshly dumped waste)	52.78	40.9	46.84

Table 5.105**Physico-Chemical Analysis (Moisture Content) of MSW of 24 Wards including Two Dump Sites of MCGM, Mumbai Region (Post-monsoon season)**

Moisture Content			
Name of the Wards	Max. (%)	Min. (%)	Avg. (%)
A	80.05	79.21	79.63
B	78.42	77.36	77.89
C	84.31	77.65	80.98
D	85	83.2	84.1
E	77.06	77.02	77.04
F/S	85.9	82.7	84.3
F/N	79.94	77.62	78.78
G/S	79	77.02	78.01
G/N	83.06	82.86	82.96
H/E	85	84	84.5
H/W	84.71	82.45	83.58
K/E	79.54	78.68	79.11
K/W	80.92	77.64	79.28
L	80.76	78.88	79.82
M/E	77.85	77.07	77.46
M/W	81.43	78.57	80
N	84.88	83.42	84.15
P/S	79.06	77.48	78.27
P/N	80.92	79.64	80.28
R/S	83.67	82.99	83.33
R/C	85	83.2	84.1
R/N	79.57	77.87	78.72
S	84	82.6	83.3
T	79.94	78.38	79.16
Mulund (Old dumped waste)	85	83.22	84.11
Mulund (Freshly dumped waste)	82.32	80.88	81.6
Deonar (Old dumped waste)	79.84	78.98	79.41
Deonar (Freshly dumped waste)	80.41	78.63	79.52

Table 5.106**Physico-Chemical Analysis (Total Solid) of MSW of 24 Wards including Two Dump Sites of MCGM, Mumbai Region (Post-monsoon season)**

Total Solid			
Name of the Wards	Max. (%)	Min. (%)	Avg. (%)
A	20.79	19.95	20.37
B	22.64	21.58	22.11
C	22.35	15.69	19.02
D	16.8	15	15.9
E	22.98	22.94	22.96
F/S	17.3	14.1	15.7
F/N	22.38	20.06	21.22
G/S	22.98	21	21.99
G/N	17.14	16.94	17.04
H/E	16	15	15.5
H/W	17.55	15.29	16.42
K/E	21.32	20.46	20.89
K/W	22.36	19.08	20.72
L	21.12	19.24	20.18
M/E	22.93	22.15	22.54
M/W	21.43	18.57	20
N	16.58	15.12	15.85
P/S	22.52	20.94	21.73
P/N	20.36	19.08	19.72
R/S	17.01	16.33	16.67
R/C	16.8	15	15.9
R/N	22.13	20.43	21.28
S	17.4	16	16.7
T	21.62	20.06	20.84
Mulund (Old dumped waste)	16.78	15	15.89
Mulund (Freshly dumped waste)	19.12	17.68	18.4
Deonar (Old dumped waste)	21.02	20.16	20.59
Deonar (Freshly dumped waste)	21.37	19.59	20.48

Table 5.107**Physico-Chemical Analysis (pH Value) of MSW of 24 Wards including Two Dump Sites of MCGM, Mumbai Region (Post-monsoon season)**

pH Value			
Name of the Wards	Max. (%)	Min. (%)	Avg. (%)
A	7.17	6.53	6.85
B	7.37	6.29	6.83
C	6.68	6.02	6.35
D	7.08	6.62	6.85
E	7.99	6.47	7.23
F/S	7.22	6.12	6.67
F/N	8.21	7.49	7.85
G/S	7.54	7.22	7.38
G/N	7.62	6.64	7.13
H/E	7.03	5.61	6.32
H/W	7.63	6.85	7.24
K/E	5.82	3.62	4.72
K/W	7.86	6.12	6.99
L	8.11	7.83	7.97
M/E	7.95	6.37	7.16
M/W	7.55	6.43	6.99
N	8.01	6.47	7.24
P/S	7.33	6.73	7.03
P/N	7.87	6.65	7.26
R/S	7.68	6.4	7.04
R/C	8.05	6.77	7.41
R/N	7.83	5.43	6.63
S	7.35	7.23	7.29
T	8.11	7.47	7.79
Mulund (Old dumped waste)	7.77	6.09	6.93
Mulund (Freshly dumped waste)	7.89	6.71	7.3
Deonar (Old dumped waste)	8.11	7.69	7.9
Deonar (Freshly dumped waste)	8.23	7.41	7.82

Table 5.108**Physico-Chemical Analysis (Nitrogen) of MSW of 24 Wards including Two Dump Sites of MCGM, Mumbai Region (Post-monsoon season)**

Nitrogen			
Name of the Wards	Max. (%)	Min. (%)	Avg. (%)
A	4.31	2.75	3.53
B	3.4	1.94	2.67
C	4.15	2.31	3.23
D	3.67	1.57	2.62
E	3.43	2.35	2.89
F/S	3.02	1.02	2.02
F/N	3.02	2.1	2.56
G/S	4.15	1.81	2.98
G/N	3.16	1.04	2.1
H/E	4.2	1.9	3.05
H/W	3.78	1.86	2.82
K/E	3.69	1.97	2.83
K/W	2.46	2.12	2.29
L	3.47	1.23	2.35
M/E	3.67	1.65	2.66
M/W	4.57	2.43	3.5
N	3.73	1.91	2.82
P/S	3.89	3.23	3.56
P/N	2.14	2.12	2.13
R/S	3	2.46	2.73
R/C	3.37	1.87	2.62
R/N	3.96	1.4	2.68
S	3.31	1.91	2.61
T	3.27	1.85	2.56
Mulund (Old dumped waste)	3.81	1.93	2.87
Mulund (Freshly dumped waste)	4.67	2.85	3.76
Deonar (Old dumped waste)	3.65	1.29	2.47
Deonar (Freshly dumped waste)	3.65	1.43	2.54

Table 5.109**Physico-Chemical Analysis (Phosphorus) of MSW of 24 Wards including Two Dump Sites of MCGM, Mumbai Region (Post-monsoon season)**

Phosphorus			
Name of the Wards	Max. (%)	Min. (%)	Avg (%)
A	7.62	5.34	6.48
B	8	6.42	7.21
C	7.09	6.71	6.9
D	7.57	5.69	6.63
E	7.99	6.73	7.36
F/S	8.01	7.83	7.92
F/N	7.23	5.91	6.57
G/S	7.96	6.44	7.2
G/N	6.72	5.08	5.9
H/E	6.88	5.82	6.35
H/W	7.54	5.26	6.4
K/E	7.03	6.85	6.94
K/W	7.11	5.43	6.27
L	6.54	5.16	5.85
M/E	7.43	5.91	6.67
M/W	8	7.02	7.51
N	7.99	6.87	7.43
P/S	6.76	5.42	6.09
P/N	6.82	5	5.91
R/S	7.72	5.52	6.62
R/C	7.53	5.85	6.69
R/N	8	6.24	7.12
S	7.36	5.8	6.58
T	7.81	6.93	7.37
Mulund (Old dumped waste)	6.66	5.1	5.88
Mulund (Freshly dumped waste)	6.93	5.51	6.22
Deonar OLD(Old dumped waste)	8	7.06	7.53
Deonar (Freshly dumped waste)	8.06	6.84	7.45

Table 5.110**Physico-Chemical Analysis (Sulphur) of MSW of 24 Wards including Two Dump Sites of MCGM, Mumbai Region (Post-monsoon season)**

Sulphur			
Name of the Wards	Max. (%)	Min. (%)	Avg. (%)
A	16.44	8.76	12.6
B	15.66	7.42	11.54
C	46.94	17.22	32.08
D	47.23	13.41	30.32
E	35.93	25.33	30.63
F/S	86.96	9.44	48.2
F/N	31.16	18.66	24.91
G/S	52.92	21.5	37.21
G/N	25.99	7.77	16.88
H/E	28.09	9.25	18.67
H/W	28.08	9.94	19.01
K/E	16.28	16.24	16.26
K/W	41.24	40.66	40.95
L	14.1	9.7	11.9
M/E	75.62	16.94	46.28
M/W	83.73	15.67	49.7
N	59.1	20.3	39.7
P/S	47.92	15.44	31.68
P/N	13.41	17.89	15.65
R/S	25.18	13.64	19.41
R/C	19.48	13.74	16.61
R/N	32.2	16.6	24.4
S	70.94	16.92	43.93
T	63.45	19.67	41.56
Mulund (Old dumped waste)	55.24	10.78	33.01
Mulund (Freshly dumped waste)	48.65	13.37	31.01
Deonar (Old dumped waste)	17.69	9.67	13.68
Deonar (Freshly dumped waste)	32.75	15.71	24.23

Table 5.111**Physico-Chemical Analysis (Sodium) of MSW of 24 Wards including Two Dump Sites of MCGM, Mumbai Region (Post-monsoon Season)**

Sodium			
Name of the Wards	Max. (%)	Min. (%)	Avg. (%)
A	23.46	4.6	14.03
B	50.8	1.4	26.1
C	12.4	8	10.2
D	17.1	5.3	11.2
E	42.1	3.5	22.8
F/S	27.2	16.2	21.7
F/N	15.94	1.36	8.65
G/S	14.4	4.6	9.5
G/N	16.3	2.1	9.2
H/E	6.4	2.2	4.3
H/W	14.03	5.13	9.58
K/E	15.4	4.9	10.15
K/W	12.2	9.7	10.95
L	27.1	7.9	17.5
M/E	12.8	8.64	10.72
M/W	42.3	1.82	22.06
N	3.4	2.4	2.9
P/S	42.1	13.8	27.95
P/N	1.82	1.36	1.59
R/S	6.4	1.55	3.975
R/C	9.2	2.4	5.8
R/N	8.8	1.28	5.04
S	52.6	11.5	32.05
T	9.34	1.82	5.58
Mulund (Old dumped waste)	10.5	3.2	6.85
Mulund (Freshly dumped waste)	9.83	3.75	6.79
Deonar (Old dumped waste)	19.4	7.42	13.41
Deonar (Freshly dumped waste)	11.74	7.8	9.77

Table 5.112**Physico-Chemical Analysis (Potassium) of MSW of 24 Wards including Two Dump Sites of MCGM, Mumbai Region (Post-monsoon Season)**

Potassium			
Name of the Wards	Max. (%)	Min. (%)	Avg. (%)
A	41.1	35	38.05
B	41.8	37	39.4
C	40.7	23.5	32.1
D	50.6	32.1	41.35
E	55.8	37.4	46.6
F/S	76	33.1	54.55
F/N	46.1	30.9	38.5
G/S	38.7	31.9	35.3
G/N	40.9	26	33.45
H/E	40.9	32.8	36.85
H/W	40.4	31.8	36.1
K/E	35.4	32.6	34
K/W	87.6	33.7	60.65
L	82.1	81.2	81.65
M/E	85	28	56.5
M/W	58.3	36.7	47.5
N	31.1	23.7	27.4
P/S	142	114	128
P/N	35.9	32.5	34.2
R/S	37.2	36	36.6
R/C	41	31.8	36.4
R/N	39.1	25.7	32.4
S	37.4	36.9	37.15
T	46	33.1	39.55
MULUND (Old Dumped Waste)	34.7	29.5	32.1
MULUND New (Freshly Dumped Waste)	53.5	31.7	42.6
DEONAR (Old Dumped Waste)	42.8	33.5	38.15
DEONAR New (Freshly Dumped Waste)	33.2	25.8	29.5

Table 5.113**Physico-Chemical Analysis (C/N) of MSW of 24 Wards including Two Dump Sites of MCGM, Mumbai Region (Post-monsoon Season)**

C/N ratio			
Name of the Wards	Max. (%)	Min. (%)	Avg. (%)
A	29.99	26.6	28.295
B	29.54	23.88	26.71
C	28.75	22.32	25.535
D	27.93	23.98	25.955
E	27.23	23.79	25.51
F/S	27.9	20.81	24.355
F/N	29.16	26.27	27.715
G/S	28.75	21.2	24.975
G/N	28.26	24.59	26.425
H/E	27.62	22.41	25.015
H/W	28.57	25	26.785
K/E	27.36	25.05	26.205
K/W	26.46	22.81	24.635
L	27.54	24.68	26.11
M/E	27.93	22.28	25.105
M/W	29.54	26.73	28.135
N	32.6	24.15	28.375
P/S	28.33	23.36	25.845
P/N	26.59	22.81	24.7
R/S	27.6	26.46	27.03
R/C	28.94	26.16	27.55
R/N	34.46	26.22	30.34
S	28.33	25.02	26.675
T	31.75	25.57	28.66
Mulund (Old Dumped Waste)	27.63	25.9	26.765
Mulund New (Freshly Dumped Waste)	11.91	23.75	17.83
Deonar (Old Dumped Waste)	16.58	21.81	19.195
Deonar New (Freshly Dumped Waste)	14.46	21.16	17.81

Table 5.114**Physico-Chemical Analysis (Calorific Value) of MSW of 24 Wards including Two Dump Sites of MCGM, Mumbai Region (Post-monsoon Season)**

Calorific value			
Name of the Wards	Max. (Kcal/kg)	Min. (Kcal/kg)	Avg. (Kcal/kg)
A	4563.64	4060.353	4311.997
B	3077.993	2095.633	2586.813
C	4512.76	4182.04	4347.4
D	3825.88	1334.304	2580.092
E	2172.28	1604.453	1888.367
F/S	4436.44	1751.807	3094.124
F/N	4156.6	4109.471	4133.036
G/S	3446.378	2070.52	2758.449
G/N	4919.8	3698.68	4309.24
H/E	4105.72	1309.745	2707.733
H/W	4330.502	3249.906	3790.204
K/E	4716.28	4258.36	4487.32
K/W	3716.28	3421.819	3569.05
L	3825.88	1383.422	2604.651
M/E	2172.28	2169.31	2170.795
M/W	3902.2	2758.39	3330.295
N	3953.08	3749.56	3851.32
P/S	4741.72	3077.933	3909.827
P/N	3393.4	2611.372	3002.386
R/S	4563.16	4011.235	4287.198
R/C	4379.62	1653.571	3016.596
R/N	4379.62	1874.571	3127.096
S	3902.2	2197.72	3049.96
T	3749.56	2071.074	2910.317
Mulund (Old Dumped Waste)	4207.707	3127.111	3667.409
Mulund New (Freshly Dumped Waste)	4379.62	4003.96	4191.79
Deonar (Old Dumped Waste)	3653.41	1584.65	2619.03
Deonar New (Freshly Dumped Waste)	4108.42	4087.04	4097.73

** Calorific value is higher in most of the wards due to presence of enormous amount of rice straw, baggasses, coconut husk and good quality of plastics and paper.

Table 5.115 presents overall monsoon chemical characteristics value of MSW of 24 wards of MCGM including two dump sites.

Table 5.115

Overall Average of Physico-Chemical Characteristics of 24 Wards including Two Dump Sites of MCGM Region (Post Monsoon Season)

Parameters	Max.	Min.	Avg.
Loss on ignition %	91.2	79.46	85.339
Ash Content %	19.46	8.67	14.06
TOC %	54.21	46.26	50.23
Moisture content %	81.69	79.97	80.83
Total Solids %	20.02	18.3	19.16
pH Value	7.6	6.54	7.0
Nitrogen %	3.59	1.93	2.76
Phosphate %	1.39	0.64	1.02
Sulphate %	2.63	2	2.3
Sodium %	19.10	5.2	12.15
Potassium %	51.26	36.35	43.80
C/N %	27.20	24.09	25.65
Calorific value kcal/kg	4320.24	3285.37	3802.80

5.3.3 Heavy Metals of MSW (Post monsoon)

Heavy metal of MSW for the - Monsoon Season of 24 wards including two dumpsites are presented in Tables 5.116 through 5.73 And Graphical Representation for Heavy metal of MSW for the Monsoon Season is Shown in Figure 5.38 through 5.46.

Table 5.116

**Heavy Metal Analysis (Cd) of MSW of 24 Wards including two Dump Sites MCGM Region
(Post-monsoon Season)**

Name of the Wards	Cd (mg/kg)
A	0.09
B	0.08
C	0.31
D	0.33
E	0.37
F/S	0.59
F/N	0.16
G/N	0.10
G/S	0.36
H/E	0.14
H/W	0.38
K/W	0.25
K/E	0.20
L	0.19
M/W	0.07
M/E	0.12
N	0.25
P/S	0.15
P/N	0.49
R/S	0.18
R/C	0.15
R/N	0.56
S	0.13
T	0.14
Mulund (Old Dumped Waste)	0.80
Mulund New (Freshly Dumped Waste)	0.24
Deonar (Old Dumped Waste)	0.08
Deonar New (Freshly Dumped Waste)	0.07

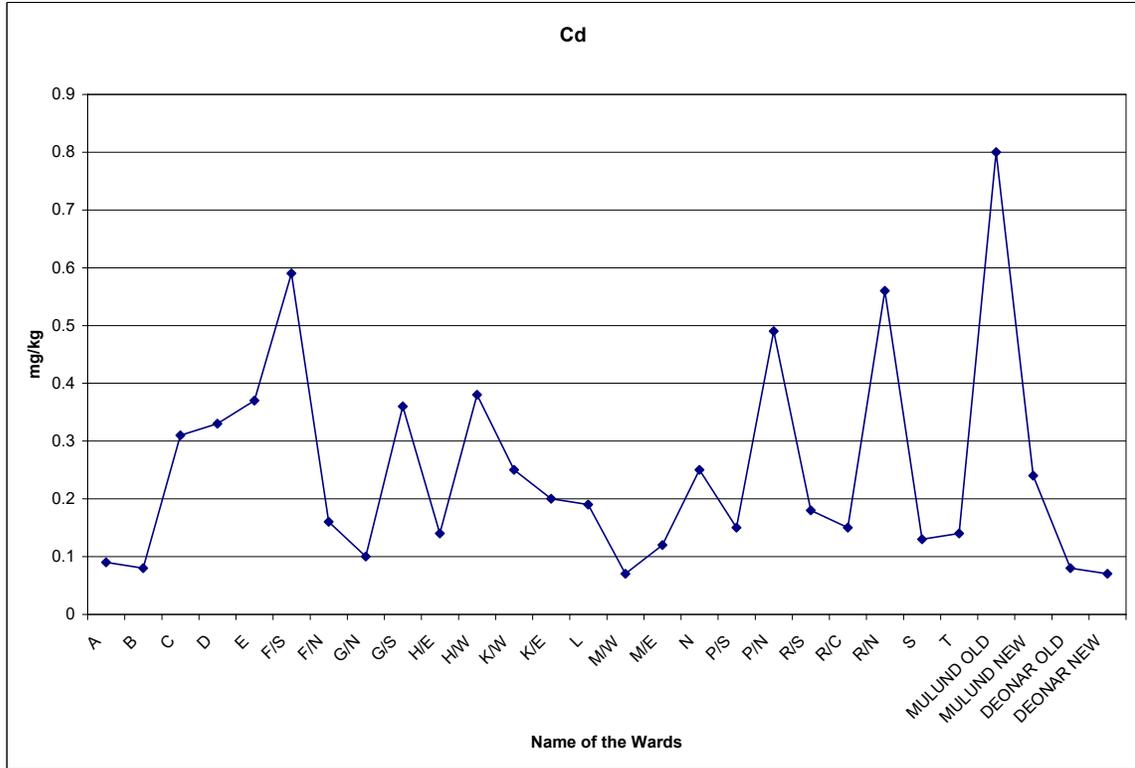


Figure 5.75: Graphical Presentation of Heavy Metal (Cd) of 24 Wards including Two Dump Sites MCGM Region (Post-monsoon Season)

Table 5.117

**Heavy Metal Analysis (Co) of MSW of 24 Wards including two Dump Sites MCGM Region
(Post-monsoon Season)**

Name of the Wards	Co mg/kg
A	2.58
B	1.34
C	5.87
D	8.89
E	1.89
F/S	20.68
F/N	5
G/N	1.17
G/S	7.05
H/E	1.98
H/W	8.99
K/W	4
K/E	4.61
L	6.13
M/W	0.68
M/E	4.87
N	0.91
P/S	4.62
P/N	3.04
R/S	3.63
R/C	2.35
R/N	3.18
S	1.54
T	0.72
Mulund (Old Dumped Waste)	7
Mulund New (Freshly Dumped Waste)	3.23
Deonar (Old Dumped Waste)	1.87
Deonar New (Freshly Dumped Waste)	1.42

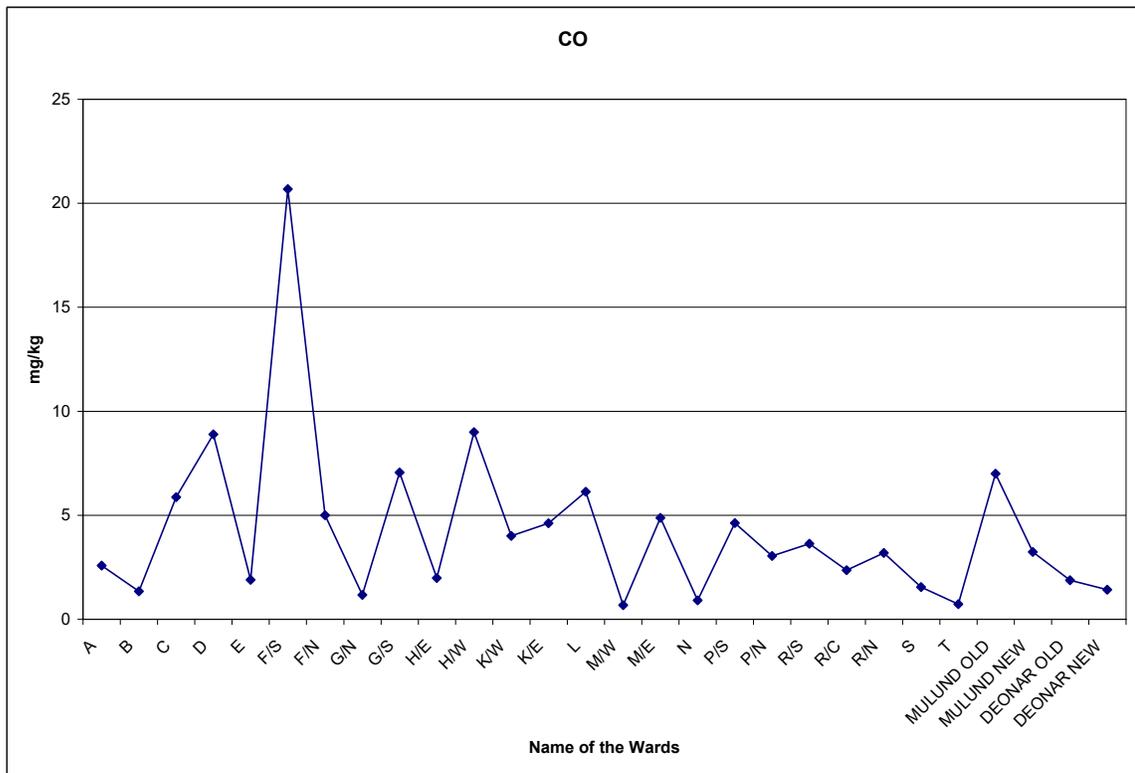


Figure 5.76: Graphical Presentation of Heavy Metal (Co) of 24 Wards including Two Dump sites MCGM Region (Post-monsoon Season)

Table 5.118

**Heavy Metal Analysis (Cr) of MSW of 24 Wards including two Dump Sites MCGM Region
(Post-monsoon Season)**

Name of the Wards	Cr (mg/kg)
A	44.65
B	20.04
C	80.76
D	101.92
E	20.88
F/S	396.30
F/N	74.99
G/N	32.99
G/S	133.18
H/E	24.33
H/W	122.30
K/W	34.83
K/E	63.66
L	162.43
M/W	20.50
M/E	66.77
N	73.55
P/S	96.22
P/N	27.59
R/S	27.53
R/C	28.42
R/N	40.18
S	24.98
T	18.02
Mulund (Old dumped waste)	139.11
Mulund (Freshly dumped waste)	40.07
Deonar (Old dumped waste)	48.93
Deonar (Freshly dumped waste)	24.17

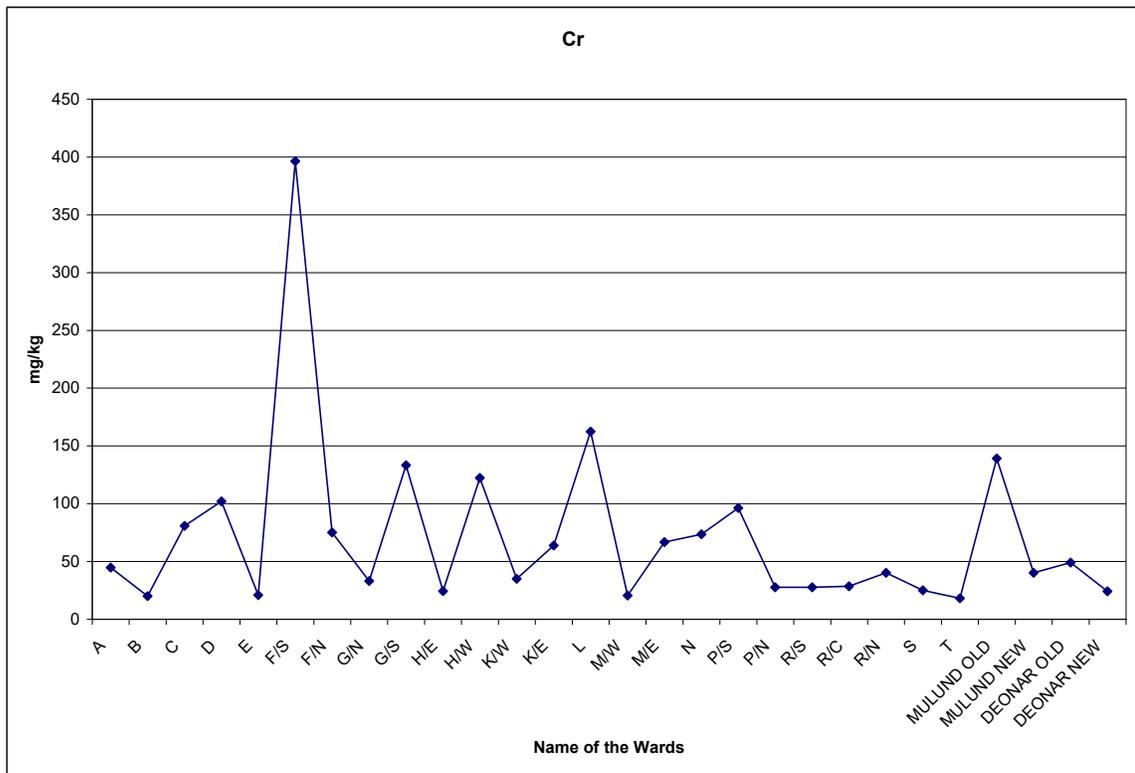


Figure 5.77: Graphical Presentation of Heavy Metal (Cr) of 24 Wards including Two Dump sites MCGM Region (Post-monsoon Season)

Table 5.119

**Heavy Metal Analysis (Cu) of MSW of 24 Wards including two Dumpsites MCGM Region
(Post-monsoon Season)**

Name of the Wards	Cu (mg/kg)
A	1201.33
B	46.48
C	33.54
D	74.93
E	19.72
F/S	624.78
F/N	32.79
G/N	30.25
G/S	69.06
H/E	15.49
H/W	45.03
K/W	37.84
K/E	30.29
L	43.11
M/W	15.73
M/E	28.25
N	18.63
P/S	60.10
P/N	19.70
R/S	45.23
R/C	20.83
R/N	37.12
S	18.94
T	15.69
Mulund (Old dumped waste	87.02
Mulund (Freshly dumped waste)	69.84
Deonar (Old dumped waste)	23.02
Deonar (Freshly dumped waste	24.61

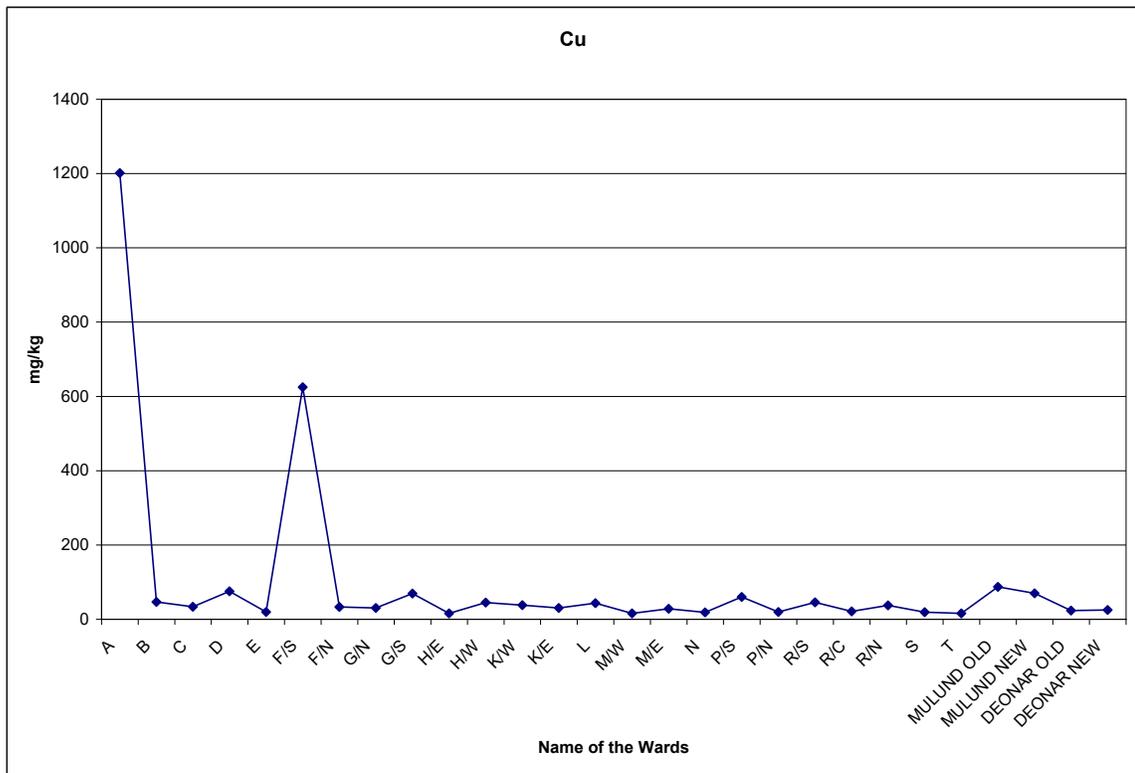


Figure 5.78: Graphical Presentation of Heavy Metal (Cu) of 24 Wards including Two Dump sites MCGM Region (Post-monsoon Season)

Table 5.120

**Heavy Metal Analysis (Fe) of MSW of 24 Wards including two Dumpsites MCGM Region
(Post-monsoon Season)**

Name of the Wards	Fe (mg/kg)
A	4210.94
B	735.21
C	4296.28
D	6867.38
E	2271.65
F/N	5562.94
F/S	10377.38
G/N	1298.66
G/S	3831.65
H/E	2470.72
H/W	7585.89
K/W	4641.50
K/E	3350.32
L	5083.74
M/W	741.79
M/E	2641.49
N	1568.08
P/S	2622.62
P/N	3261.24
R/S	2999.08
R/C	2381.62
R/N	3385.34
S	2354.61
T	713.40
Mulund (Old dumped waste	8023.23
Mulund (Freshly dumped waste)	2969.22
Deonar (Old dumped waste)	616.80
Deonar (Freshly dumped waste	1684.04

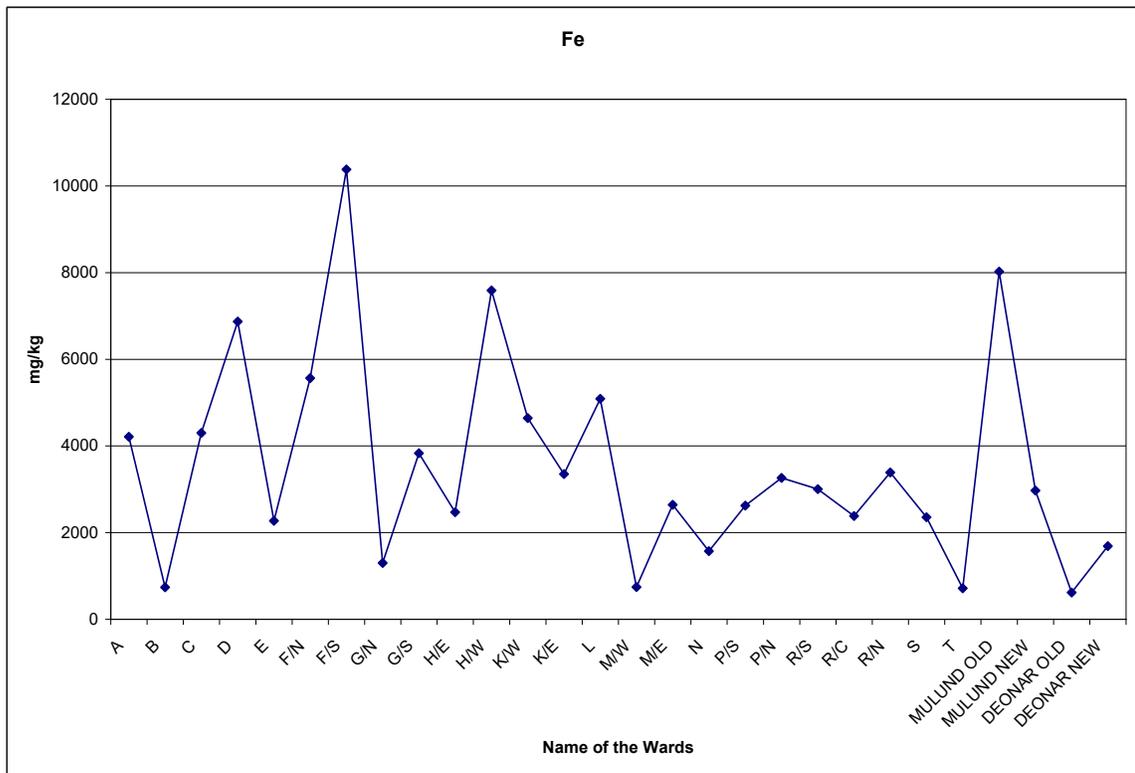


Figure 5.79: Graphical Presentation of Heavy Metal (Fe) of 24 Wards including Two Dump sites MCGM Region (Post-monsoon Season)

Table 5.121

**Heavy Metal Analysis (Mn) of MSW of 24 Wards including two Dumpsites MCGM Region
(Post-monsoon Season)**

Name of the Wards	Mn (mg/kg)
A	97.69
B	85.19
C	110.61
D	179.67
E	65.37
F/S	298.15
F/N	125.15
G/N	78.12
G/S	250.52
H/E	69.35
H/W	216.45
K/W	112.97
K/E	100.52
L	173.02
M/W	47.41
M/E	167.63
N	54.98
P/S	84.27
P/N	103.21
R/S	95.44
R/C	99.59
R/N	105.64
S	162
T	36.61
Mulund (Old dumped waste)	173.42
Mulund (Freshly dumped waste)	87.37
Deonar OLD(Old dumped waste)	78.67
Deonar (Freshly dumped waste)	70.02

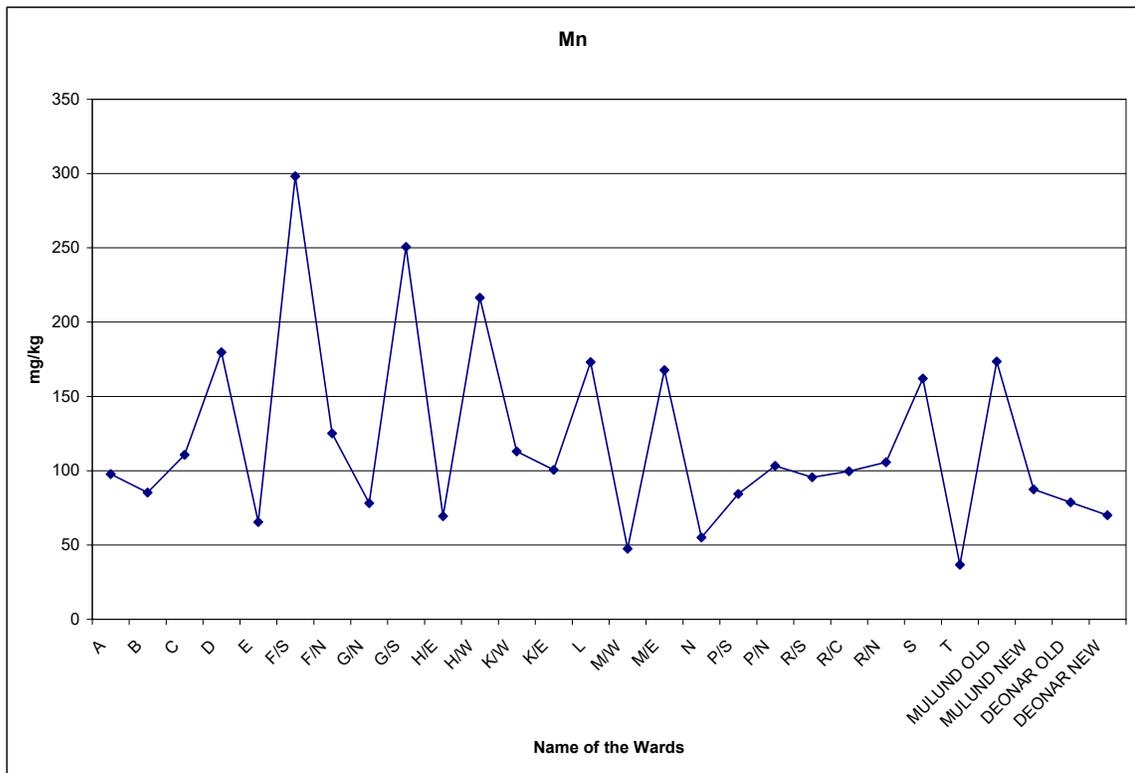


Figure 5.80: Graphical Presentation of Heavy Metal (Mn) of 24 Wards including Two Dump sites MCGM Region (Post-monsoon Season)

Table 5.122

**Heavy Metal Analysis (Ni) of MSW of 24 Wards including two Dumpsites MCGM Region
(Post-monsoon Season)**

Name of the Wards	Ni (mg/kg)
A	18.66
B	8.29
C	29.20
D	41.06
E	8.32
F/S	284.72
F/N	31.43
G/S	44.50
G/N	13.43
H/E	10.25
H/W	52.48
K/W	14.99
K/E	26.25
L	64.66
M/W	8.10
M/E	28.37
N	5.52
P/S	46.35
P/N	11.57
R/S	11.06
R/C	13.19
R/N	17.42
S	9.98
T	7.72
Mulund (Old dumped waste)	61.19
Mulund (Freshly dumped waste)	16.39
Deonar (Old dumped waste)	17.67
Deonar (Freshly dumped waste)	10.39

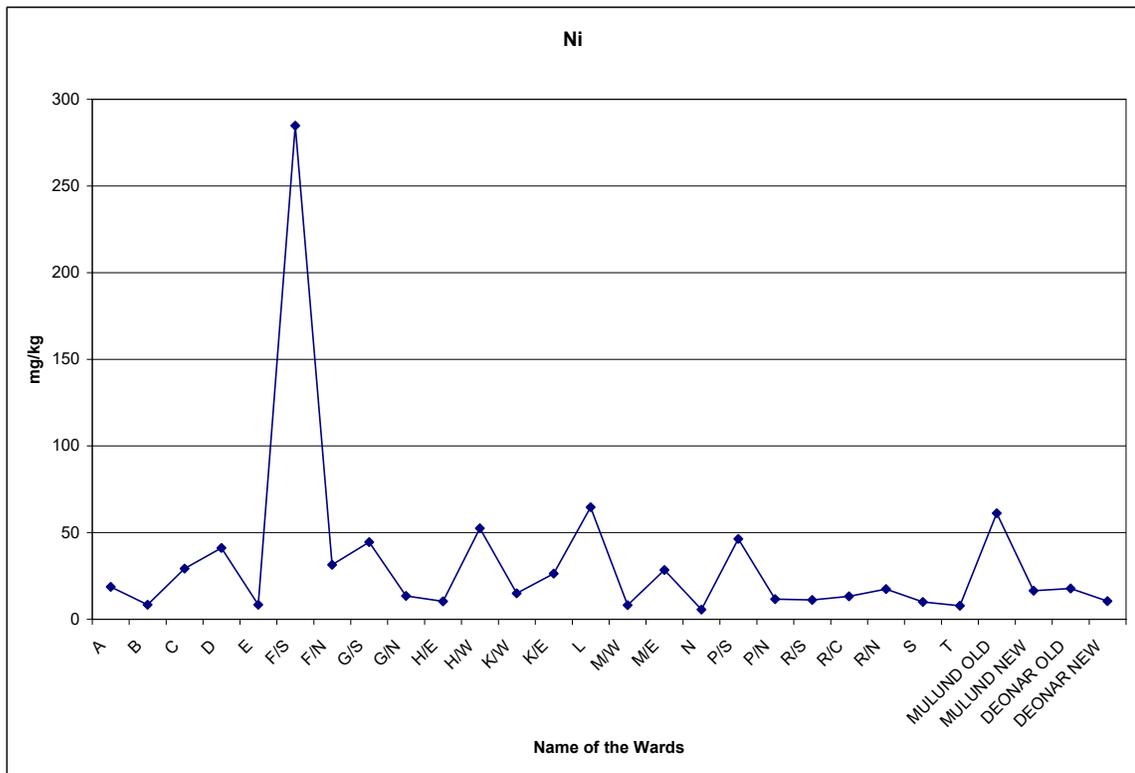


Figure 5.81: Graphical Presentation of Heavy Metal (Ni) of 24 Wards including Two Dump Sites MCGM Region (Post-monsoon Season)

Table 5.123

**Heavy Metal Analysis (Pb) of MSW of 24 Wards including Two Dumpsites MCGM Region
(Post-monsoon Season)**

Name of the Wards	Pb (mg/kg)
A	0.01
B	1.68
C	3.44
D	0.88
E	3.74
F/S	21.10
F/N	1.87
G/N	7.93
G/S	5.24
H/E	2.42
H/W	3.38
K/W	2.76
K/E	2.55
L	1.92
M/W	3
M/E	1.69
N	17.41
P/S	2.74
P/N	2.55
R/S	10.57
R/C	2.39
R/N	17.83
S	5.71
T	3.01
Mulund (Old dumped waste)	3.26
Mulund (Freshly dumped waste)	1.21
Deonar OLD(Old dumped waste)	2.74
Deonar (Freshly dumped waste)	5.83

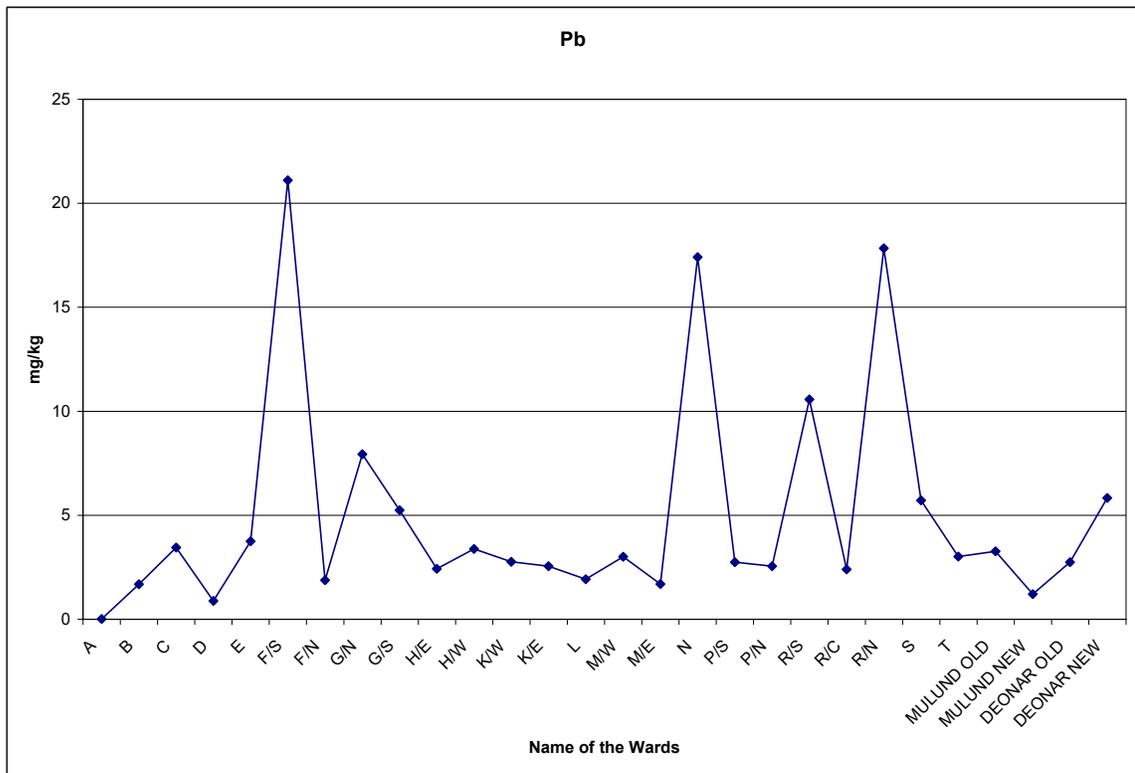


Figure 5.82: Graphical Presentation of Heavy Metal (Pb) of 24 Wards including Two Dump sites MCGM Region (Post-monsoon Season)

Table 5.124

**Heavy Metal Analysis (Zn) of MSW of 24 Wards including two Dumpsites MCGM Region
(Post-monsoon Season)**

Name of the Wards	Zn (mg/kg)
A	84.13
B	42.50
C	50.93
D	372.77
E	192.33
F/S	388.86
F/N	58.06
G/N	57
G/S	140.45
H/E	51.51
H/W	82.53
K/W	34.26
K/E	46.39
L	155.77
M/W	64.07
M/E	75
N	98.69
P/S	131.17
P/N	152.31
R/S	145.38
R/C	51.15
R/N	146.38
S	109.14
T	42.96
Mulund (Old dumped waste)	137.22
Mulund (Freshly dumped waste)	128.2
Deonar (Old dumped waste)	40.44
Deonar (Freshly dumped waste)	54.75

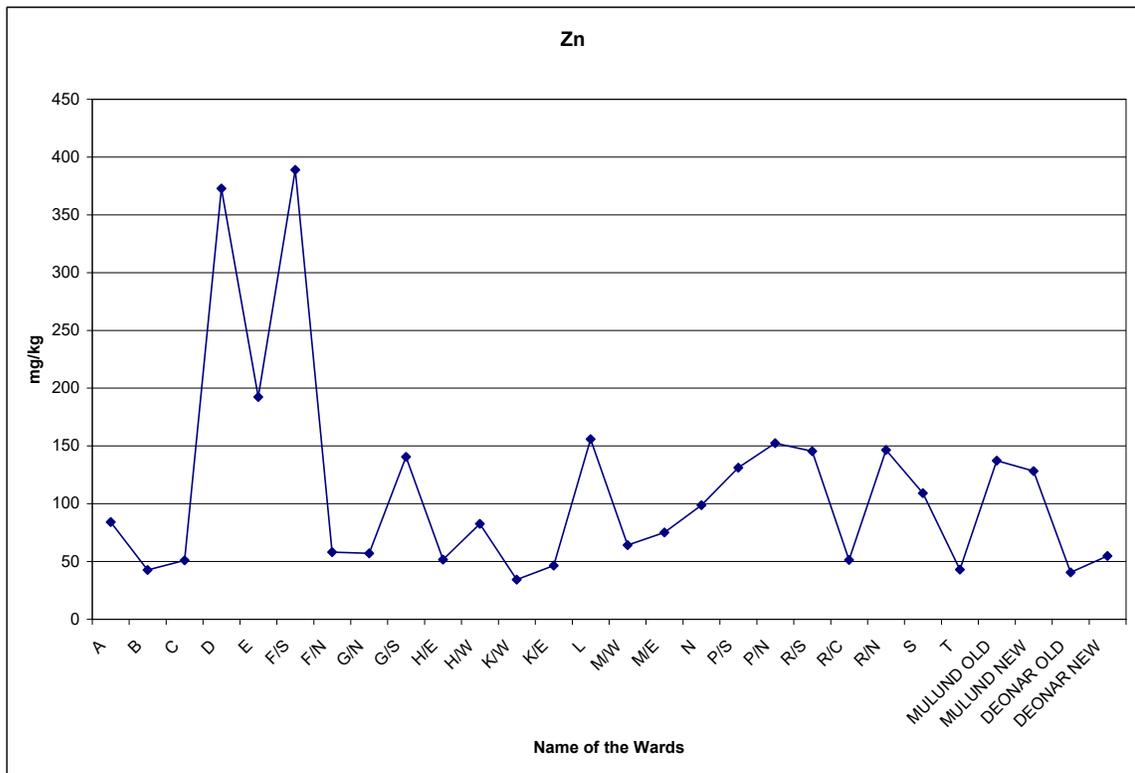


Figure 5.83: Graphical Presentation of Heavy Metal (Zn) of 24 Wards including Two Dump sites MCGM Region (Post-monsoon Season)

5.4 Seasonal Variations of Physico-chemical Characteristics of MSW and its Statistical Analysis (Pre-monsoon, Monsoon, Post-monsoon Seasons)

Seasonal variation and statistical analysis for different season has been done by taking mean average value for all the seasons for 24 wards including two dump sites. It is shown in the Table 5.125 through 5.136. Graphical representation of seasonal variation is shown in the Figure 5.84 through 5.106. Statistical analysis has been done by using Minitab One Way Anova and the individual value plot generated is shown in the Figure 5.85 through 5.107.

Table 5.125**Seasonal Variation of (Loss on ignition) of MSW of 24 Wards including Two Dumpsites
MCGM Region**

Loss on Ignition			
Name of the Wards	Pre Monsoon Avg. (%)	Monsoon Avg. (%)	Post Monsoon Avg. (%)
A	84.17	89.07	91.5
B	81.68	87.2	87.5
C	80.04	89.2	82.5
D	86.68	89.2	85
E	78.7	83.31	83
F/S	77.65	82.34	84.5
F/N	76.13	76.62	91
G/S	78.62	88.21	81
G/N	78.61	77.28	87.5
H/E	82.25	90.13	81
H/W	80.13	89.69	88
K/E	79.28	74.71	85.5
K/W	78.74	90.11	81
L	79.07	81.9	86
M/E	74.56	85.04	82
M/W	78.13	82.51	91
N	71.48	91.26	93
P/S	78.54	78.28	83
P/N	77.21	83.97	81.5
R/S	73.76	63.31	88.5
R/C	75.51	75.73	90.5
R/N	81.58	67.78	100
S	79.24	86.71	87.5
T	72.25	90.11	79
Mulund (Old dumped waste)	56.18	70.955	79
Mulund (Freshly dumped waste)	77.16	76.59	86
Deonar (Old dumped waste)	55	73.69	80
Deonar (Freshly dumped waste)	79.45	78.82	85

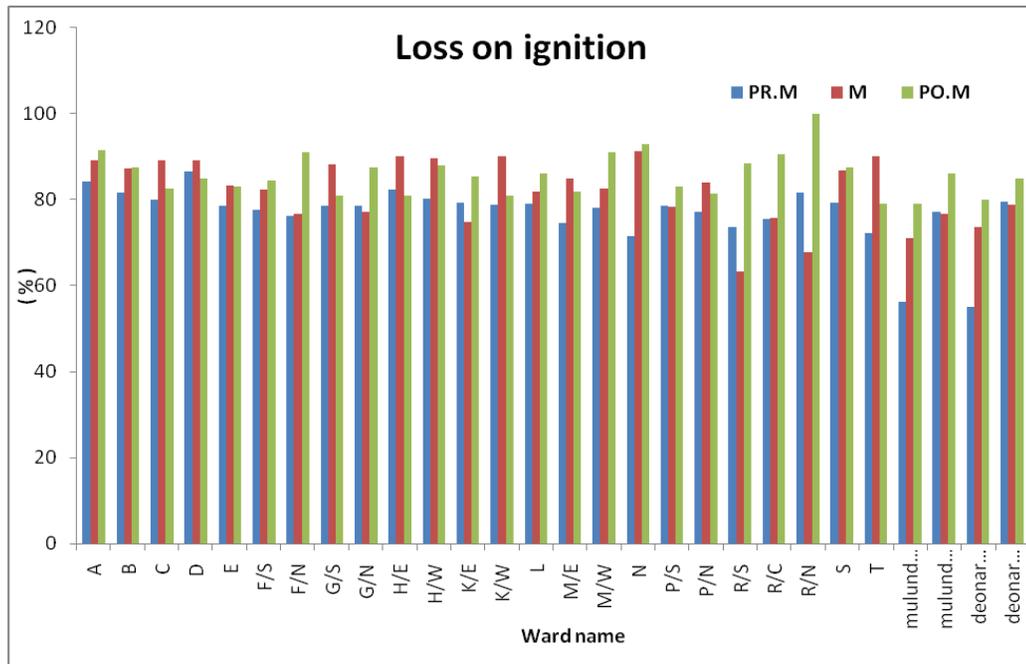


Figure 5.84: Graphical Representation of Seasonal Variation of (Loss on Ignition) of 24 wards including Two Dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

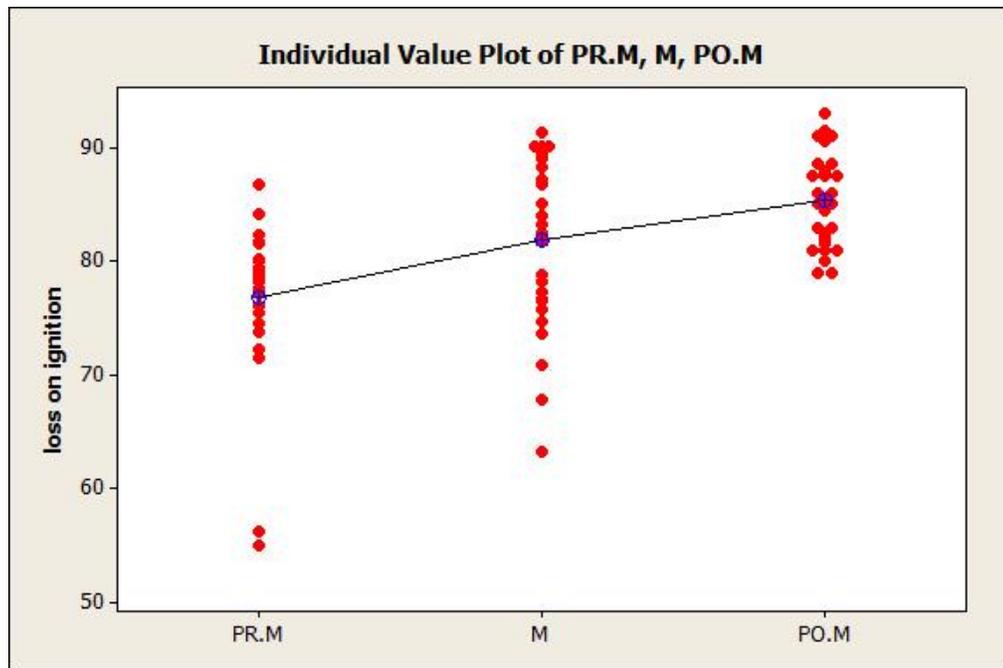


Figure 5.85: Statistical Graph using minitab to show Seasonal Variation of (Loss on Ignition) of 24 Wards including Two Dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

Table 5.126**Seasonal Variation (Ash Content) of MSW of 24 Wards including Two Dumpsites MCGM Region**

Name of the Wards	ASH Content		
	Pre Monsoon Avg. (%)	Monsoon Avg. (%)	Post Monsoon Avg. (%)
A	15.84	10.925	8.5
B	18.32	12.795	12.5
C	19.96	10.795	17.5
D	13.32	10.795	15
E	21.3	16.685	17
F/S	22.35	17.655	19.5
F/N	23.87	23.375	9
G/S	20.8	11.785	19
G/N	21.4	22.715	12.5
H/E	17.75	9.865	19
H/W	19.87	10.305	12
K/E	20.72	25.285	14.5
K/W	21.26	9.885	19
L	20.93	18.095	14
M/E	25.44	14.955	18
M/W	21.87	17.485	9
N	28.52	8.735	17
P/S	21.47	21.715	18.5
P/N	22.8	16.025	11.5
R/S	26.24	36.685	9.5
R/C	24.5	24.265	9
R/N	18.42	32.215	17
S	20.76	13.285	12.5
T	27.65	9.885	11
Mulund (Old dumped waste	43.82	29.045	10
Mulund (Freshly dumped waste)	22.85	23.41	16
Deonar OLD(Old dumped waste)	45.01	26.31	19.5
Deonar (Freshly dumped waste	20.56	21.18	6.5

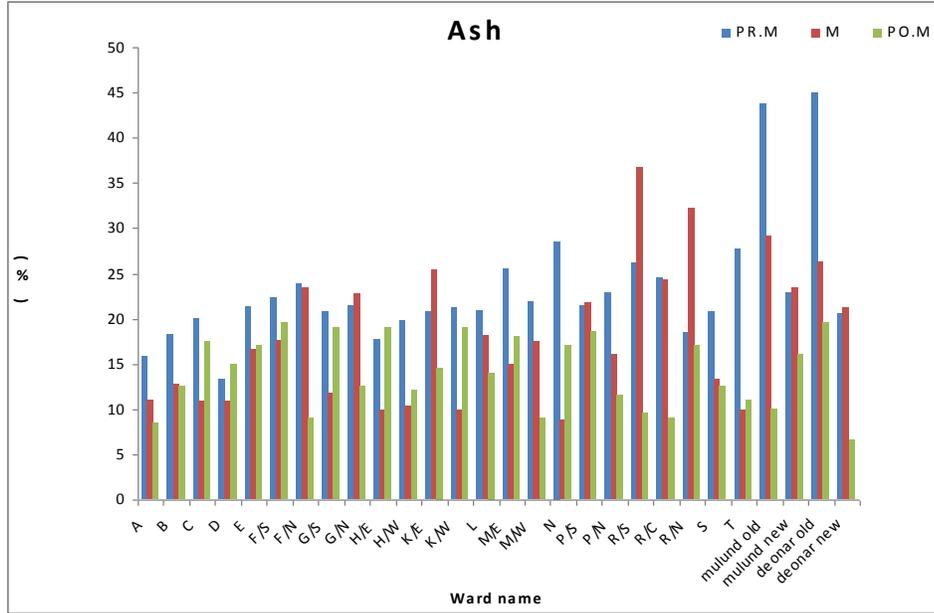


Figure 5.86: Graphical Representation of Seasonal variation Ash Content of 24 wards including Two dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

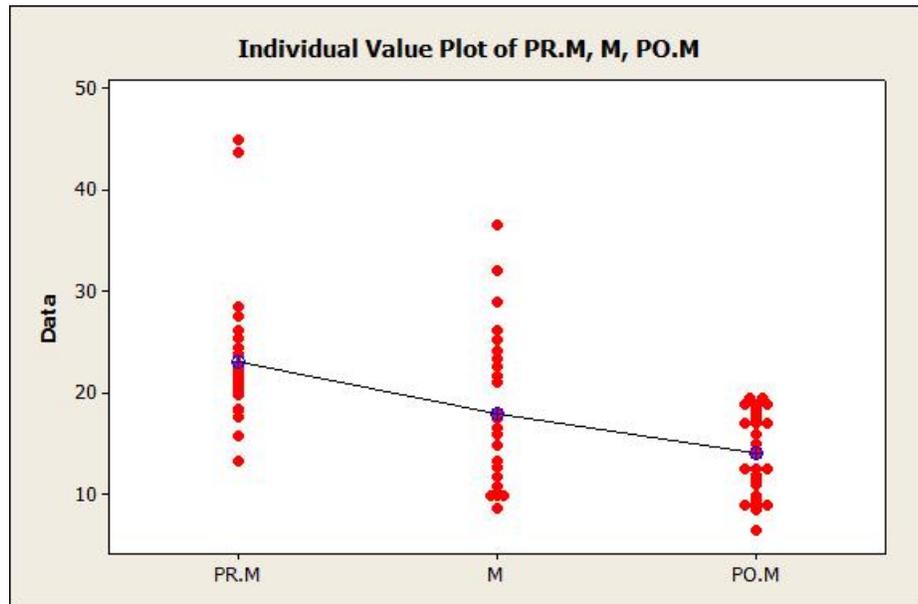


Figure 5.87: Statistical Graph (individual value plot) using minitab to show seasonal variation (Ash Content) of 24 wards including two dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

Table 5.127

Seasonal Variation (TOC) of MSW of 24 Wards including two Dumpsites MCGM Region

Name of the Wards	TOC		
	Pre Monsoon Avg. (%)	Monsoon Avg. (%)	Post Monsoon Avg. (%)
A	48.82	51.4	53.07
B	47.38	50.73	50.75
C	46.43	51.06	47.85
D	50.28	54.15	49.3
E	45.65	49.76	48.14
F/S	46.45	47.3	46.69
F/N	44.16	43.235	52.88
G/S	45.6	49.66	46.98
G/N	45.59	44.73	50.75
H/E	48.59	51.43	46.98
H/W	50.8	50.81	50.75
K/E	45.99	47.31	49.59
K/W	45.68	51.28	46.98
L	45.86	48.03	49.88
M/E	43.25	51.5	47.56
M/W	45.32	46.77	52.78
N	41.46	51.23	53.94
P/S	45.55	46.33	48.14
P/N	44.78	45.09	47.27
R/S	42.78	34.92	51.33
R/C	43.8	43.67	52.49
R/N	47.32	38.72	58
S	45.96	50.815	50.75
T	41.95	50.6	54.77
Mulund (old dumped waste)	32.59	37.55	50.67
mulund new(Freshly dumped waste)	44.75	40.62	50.14
Deonar old Dumped waste	31.9	33.4	51.44
Deonar new(Freshly dumped waste)	46.08	42.43	46.84

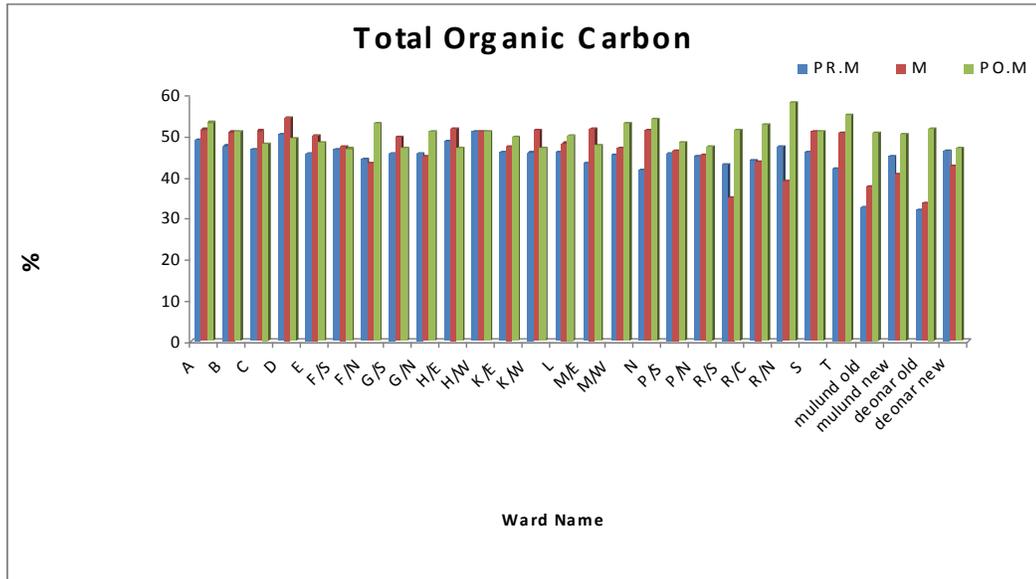


Figure 5.88: Graphical Representation of Seasonal Variation Total Organic Carbon of 24 Wards including Two Dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

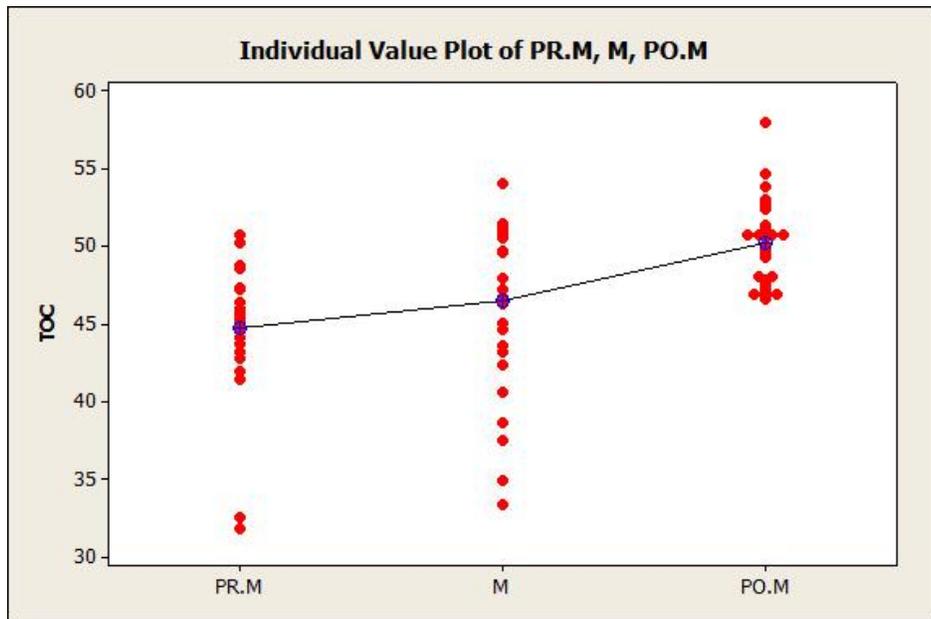


Figure 5.89: Statistical Graph (individual value plot) using minitab to show seasonal variation (Total Organic Carbon) of 24 Wards including Two Dump sites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

Table 5.128**Seasonal Variation of (Moisture Content) of 24 Wards including Two Dumpsites MCGM Region**

Name of the Wards	Moisture Content		
	Pre Monsoon Avg. (%)	Monsoon Avg. (%)	Post Monsoon Avg. (%)
A	76.8	87.06	79.63
B	75.205	84.09	77.89
C	71.28	83.11	80.98
D	73.52	88.47	84.1
E	69.37	84.67	77.04
F/S	69	85.06	84.3
F/N	70.17	86.27	78.78
G/S	65.58	83.1	78.01
G/N	77.17	87.31	82.96
H/E	72.1	85.27	84.5
H/W	75.12	86.23	83.58
K/E	75.42	85.12	79.11
K/W	75.84	87.065	79.28
L	76.4	88	79.82
M/E	72.76	88.7	77.46
M/W	73.52	87.23	80
N	70.31	85.61	84.15
P/S	71.77	85.12	78.27
P/N	71.97	88.76	80.28
R/S	73.95	87.23	83.33
R/C	72.87	85.33	84.1
R/N	75.35	86.22	78.72
S	72.46	86.16	83.3
T	73.85	85.37	79.16
Mulund (Old dumped waste)	66.96	85.92	84.11
Mulund (Freshly dumped waste)	79.08	87.32	81.6
Deonar (Old dumped waste)	65.48	84.62	79.41
Deonar (Freshly dumped waste)	71.92	87.82	79.52

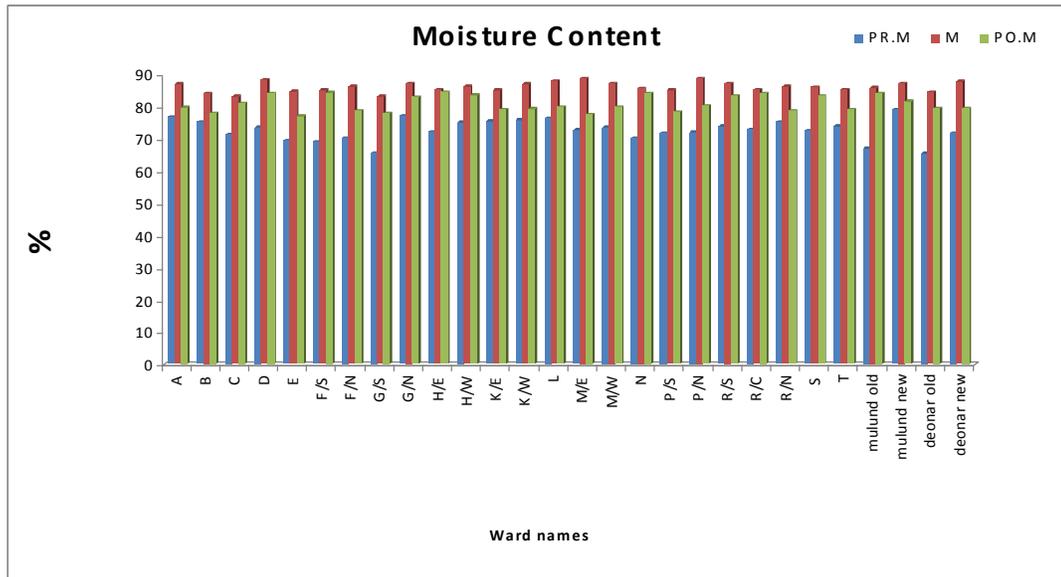


Figure 5.90: Graphical Representation of Seasonal Variation (Moisture Content) of 24 wards including two dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

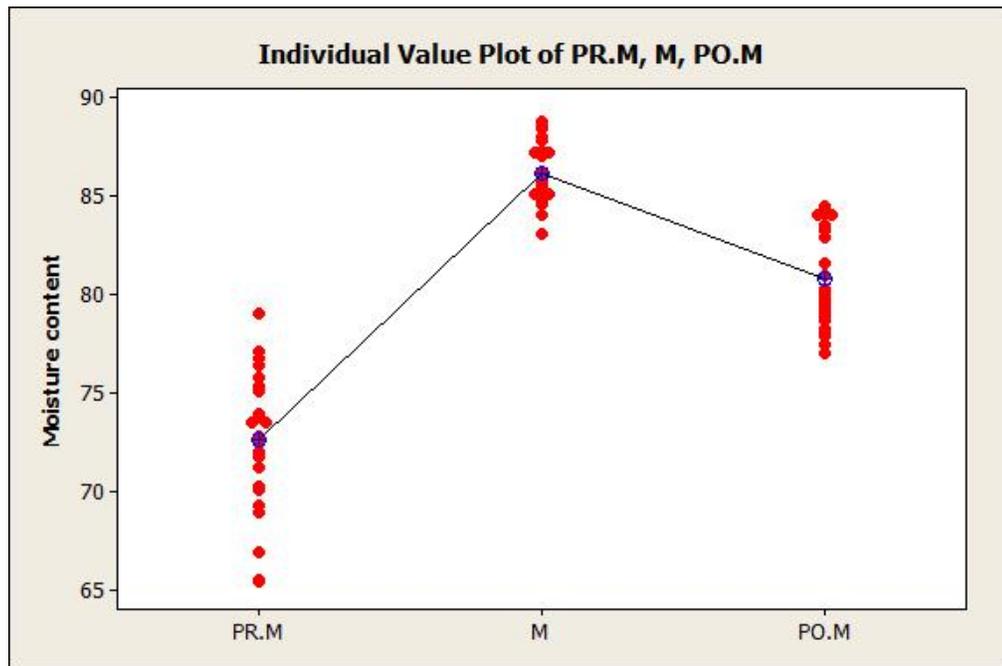


Figure 5.91: Statistical Graph (individual value plot) using minitab to show Seasonal Variation (Moisture Content) of 24 Wards including Two Dumpsites (Pre-monsoon, Monsoon Post-monsoon Seasons)

Table 5.129**Seasonal Variation (pH value) of 24 Wards including Two Dumpsites MCGM Region**

Name of the Wards	pH value		
	Pre Monsoon Avg. (%)	Monsoon Avg. (%)	Post Monsoon Avg. (%)
A	6.88	6.21	6.85
B	7.27	5.35	6.83
C	6.77	5.51	6.35
D	7.87	5.57	6.85
E	6.71	7.02	7.23
F/S	6.93	7.09	6.67
F/N	8.04	6.75	7.85
G/S	6.48	7.37	7.38
G/N	7.74	7.55	7.13
H/E	7.35	9.01	6.32
H/W	7.09	6.53	7.24
K/E	6.87	8.33	4.72
K/W	6.36	7.19	6.99
L	7.83	6.63	7.97
M/E	6.55	5.95	7.16
M/W	8.24	7.72	6.99
N	8.13	6.36	7.24
P/S	6.76	8.15	7.03
P/N	6.32	7.22	7.26
R/S	6.75	6.68	7.04
R/C	7.25	6.51	7.41
R/N	7.45	7.18	6.63
S	7.33	7.38	7.29
T	8.29	7.3	7.79
Mulund (Old dumped waste)	7.36	9.76	6.93
Mulund (Freshly dumped waste)	7.98	8.34	7.3
Deonar (Old dumped waste)	6.51	9.59	7.9
Deonar (Freshly dumped waste)	7.22	9.68	7.82

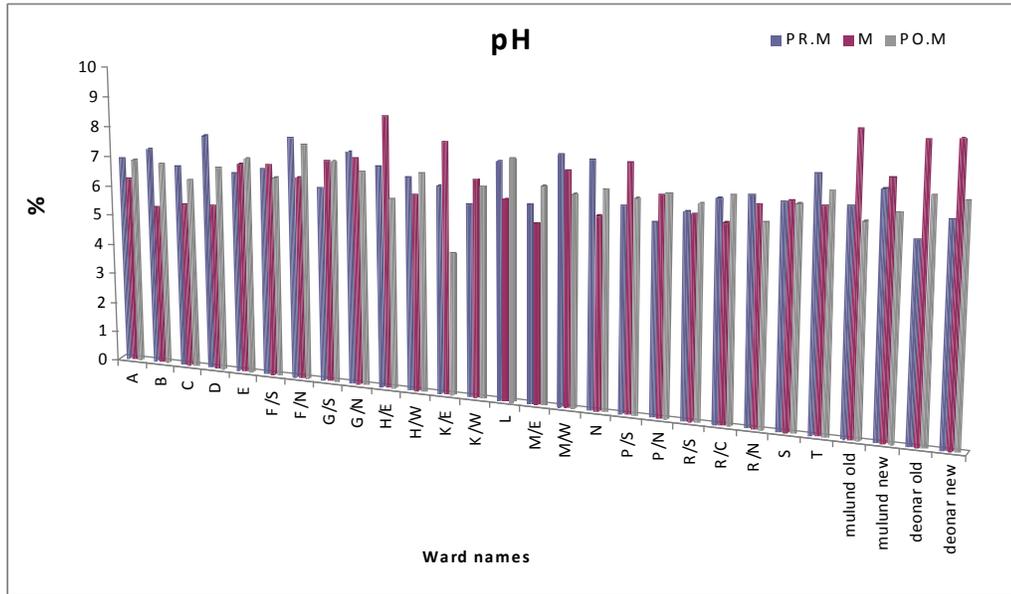


Figure 5.92: Graphical Representation of Seasonal Variation (pH Value) of 24 wards including two dumpsites (Pre-monsoon, Monsoon Post-monsoon Seasons)

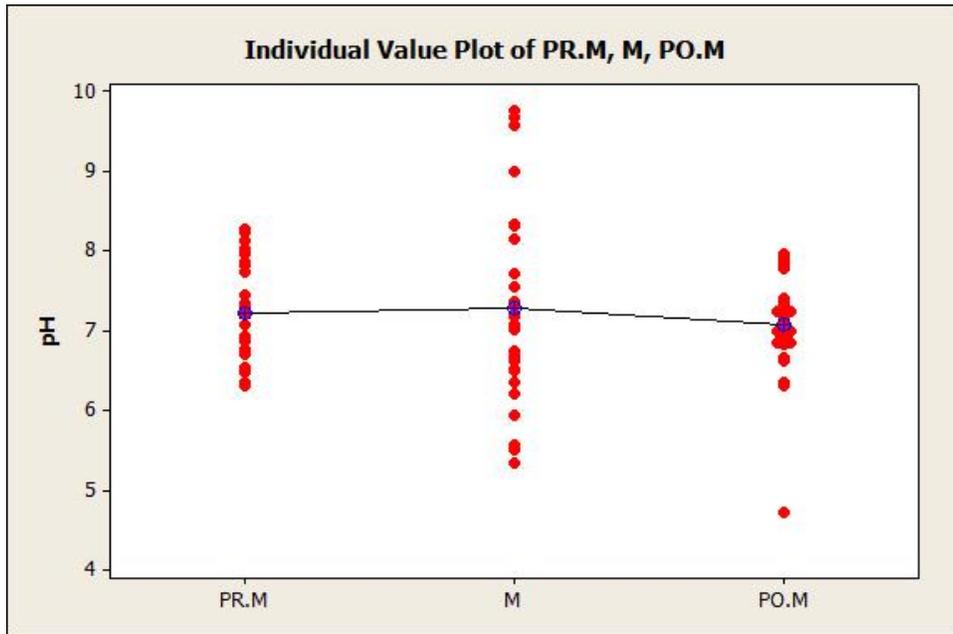


Figure 5.93: Statistical Graph (individual value plot) using minitab to show Seasonal Variation (pH Value) of 24 wards including Two Dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

Table 5.130**Seasonal Variation (Nitrogen) of MSW of 24 Wards including Two Dumpsites MCGM Region**

Name of the Wards	Nitrogen		
	Pre Monsoon Avg. (%)	Monsoon Avg. (%)	Post Monsoon Avg. (%)
A	1.58	1.8	3.53
B	2.4	1.44	2.67
C	1.8	1.59	3.23
D	1.57	1.56	2.62
E	2.03	0.92	2.89
F/S	2.29	1.12	2.02
F/N	2.12	1.07	2.56
G/S	1.98	1.38	2.98
G/N	1.72	1.525	2.1
H/E	1.72	1.69	3.05
H/W	1.81	0.98	2.82
K/E	2	1.76	2.83
K/W	1.94	1.81	2.29
L	1.83	3.05	2.35
M/E	1.47	3.35	2.66
M/W	1.76	1.42	3.5
N	1.51	2.11	2.82
P/S	1.85	1.34	3.56
P/N	1.76	1.05	2.13
R/S	1.91	1.53	2.73
R/C	1.89	0.69	2.62
R/N	1.78	1.52	2.68
S	1.75	1.42	2.61
T	1.73	0.455	2.56
Mulund (Old dumped waste	0.94	1.59	2.87
Mulund (Freshly dumped waste)	1.89	1.02	3.76
Deonar (Old dumped waste)	1.27	1.95	2.47
Deonar (Freshly dumped waste	2.02	2.25	2.54

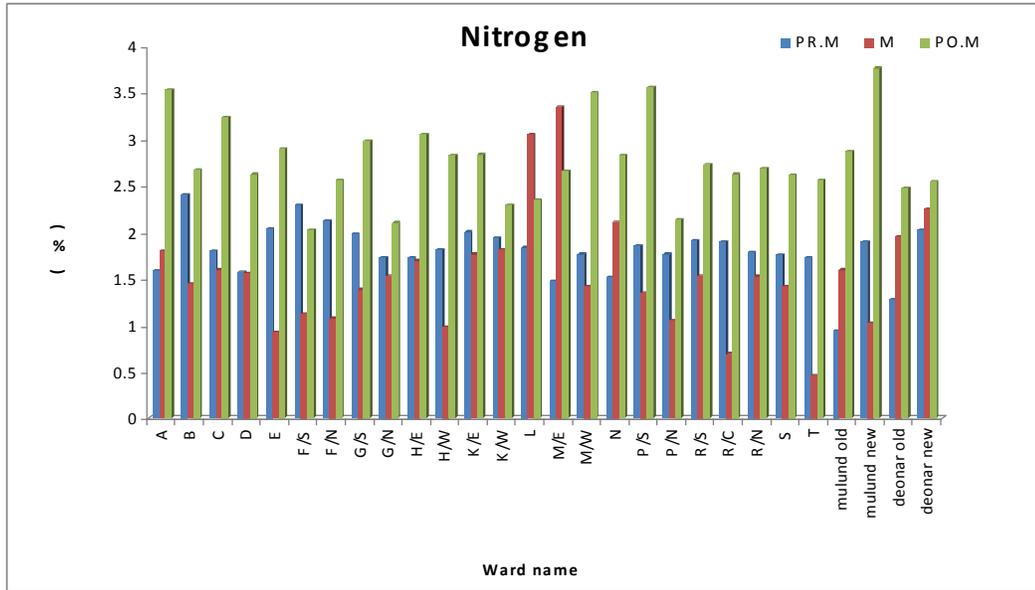


Figure 5.94: Graphical Representation of Seasonal Variation (Nitrogen) of 24 wards including two dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

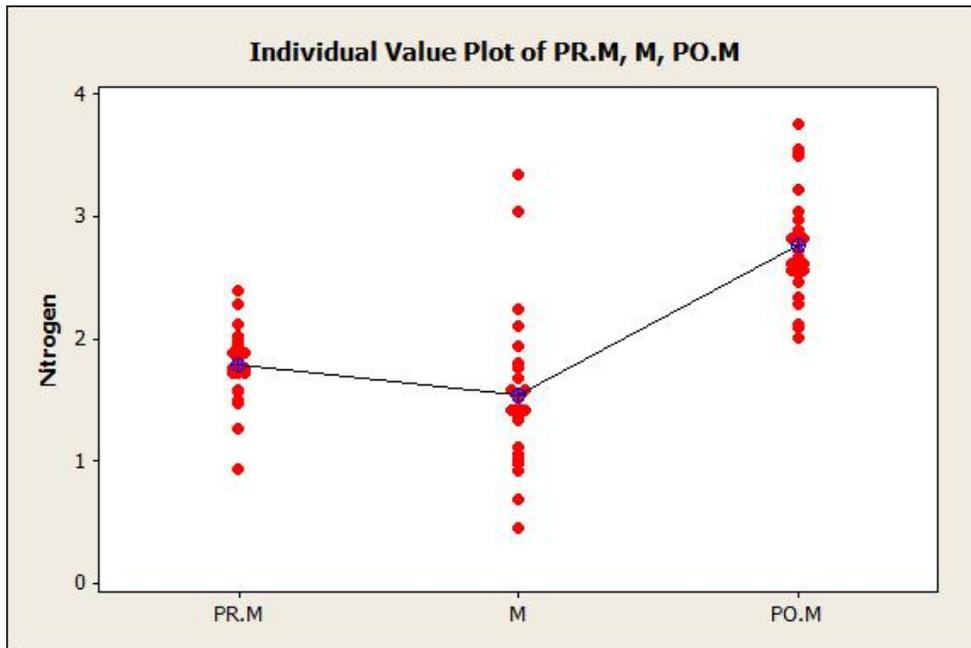


Figure 5.95: Statistical Graph (individual value plot) using minitab to show Seasonal Variation (Nitrogen) of 24 wards including two dumpsite (Pre-monsoon, Monsoon, Post-monsoon Seasons)

Table 5.131**Seasonal Variation (Phosphorus) of MSW of 24 Wards including Two Dumpsites MCGM Region**

Phosphorous			
Name of the Wards	Pre Monsoon Avg. (%)	Monsoon Avg. (%)	Post Monsoon Avg. (%)
A	1.48	1.31	6.48
B	2.16	0.65	7.21
C	1.16	0.65	6.9
D	0.76	1.12	6.63
E	1.11	0.93	7.36
F/S	1.21	1.52	7.92
F/N	1.14	1.21	6.57
G/S	0.75	1.55	7.2
G/N	0.91	1.1	5.9
H/E	1.2	0.86	6.35
H/W	1.33	1.58	6.4
K/E	1.16	1.44	6.94
K/W	1.25	1.02	6.27
L	1.16	2.2	5.85
M/E	1.28	1.64	6.67
M/W	1.36	1.89	7.51
N	1.23	1.17	7.43
P/S	1.14	0.55	6.09
P/N	1.27	1.53	5.91
R/S	0.91	0.97	6.62
R/C	1.12	1.53	6.69
R/N	1.23	1.22	7.12
S	1.11	0.33	6.58
T	1.13	0.97	7.37
Mulund (Old dumped waste	2.07	0.4	5.88
Mulund (Freshly dumped waste)	1.32	0.9	6.22
Deonar (Old dumped waste)	2.21	0.38	7.53
Deonar (Freshly dumped waste	1.24	1.28	7.45

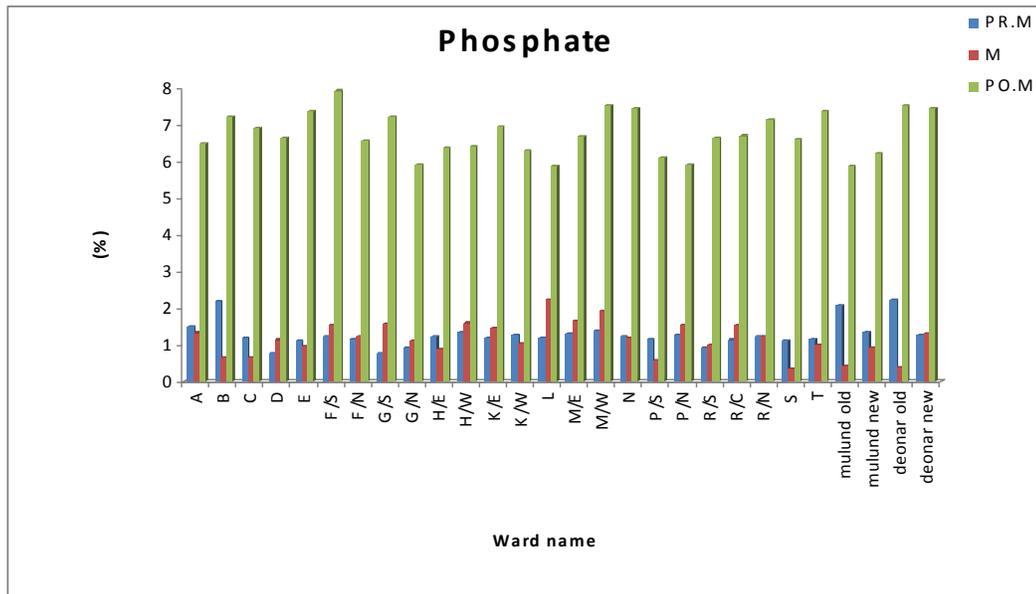


Figure 5.96: Graphical Representation of Seasonal Variation (Phosphate) of 24 Wards including Two Dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

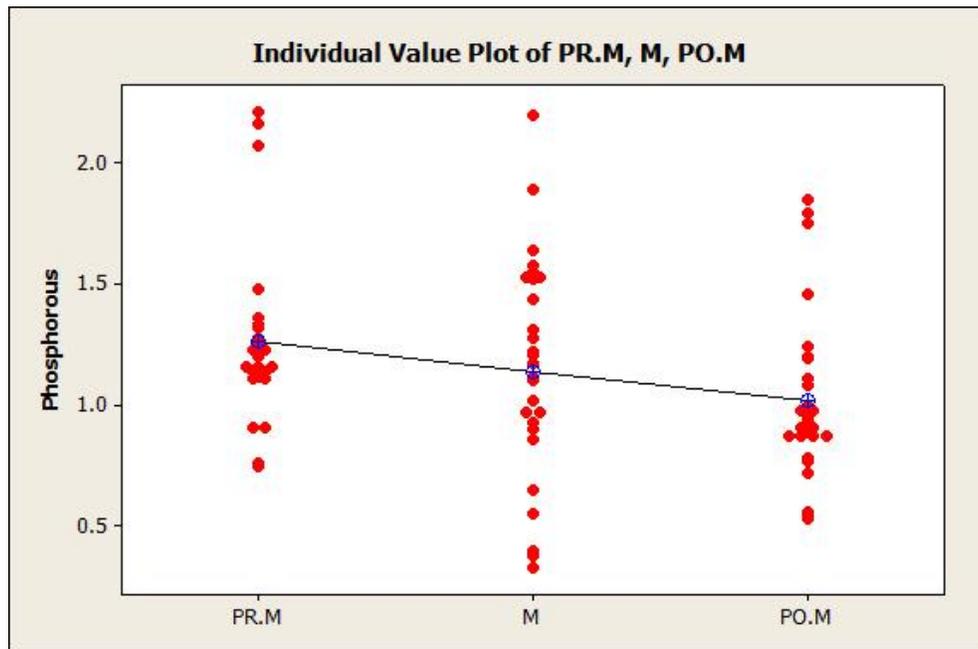


Figure 5.97: Statistical Graph (individual value plot) using minitab to show Seasonal Variation (Phosphate) of 24 wards including two dumpsite (Pre-monsoon, Monsoon, Post-monsoon Seasons)

Table 5.132**Seasonal Variation (Sulphur) of MSW of 24 Wards including Two Dumpsites MCGM Region**

Name of the Wards	Sulphur		
	Pre Monsoon Avg. (%)	Monsoon Avg. (%)	Post Monsoon Avg. (%)
A	2.2	8.02	12.6
B	2.4	8.13	11.54
C	4.98	9.32	32.08
D	2.41	7.06	30.32
E	1.96	9.14	30.63
F/S	2.53	10.05	48.2
F/N	2.96	7.97	24.91
G/S	2.97	9.66	37.21
G/N	2.88	8.34	16.88
H/E	2.54	8.83	18.67
H/W	3.05	9.95	19.01
K/E	2.76	7.95	16.26
K/W	2.7	7.99	40.95
L	2.35	8.22	11.9
M/E	2.78	8.66	46.28
M/W	2.55	9.95	49.7
N	2.96	8.04	39.7
P/S	3	8.35	31.68
P/N	2.81	9.77	15.65
R/S	3.16	7.98	19.41
R/C	2.75	8.12	16.61
R/N	2.49	9.27	24.4
S	2.21	10.28	43.93
T	3.14	11	41.56
Mulund (Old dumped waste	2.6	7.72	33.01
Mulund (Freshly dumped waste)	2.34	8.54	31.01
Deonar (Old dumped waste)	3.87	8.87	13.68
Deonar (Freshly dumped waste	3.15	10.02	24.23

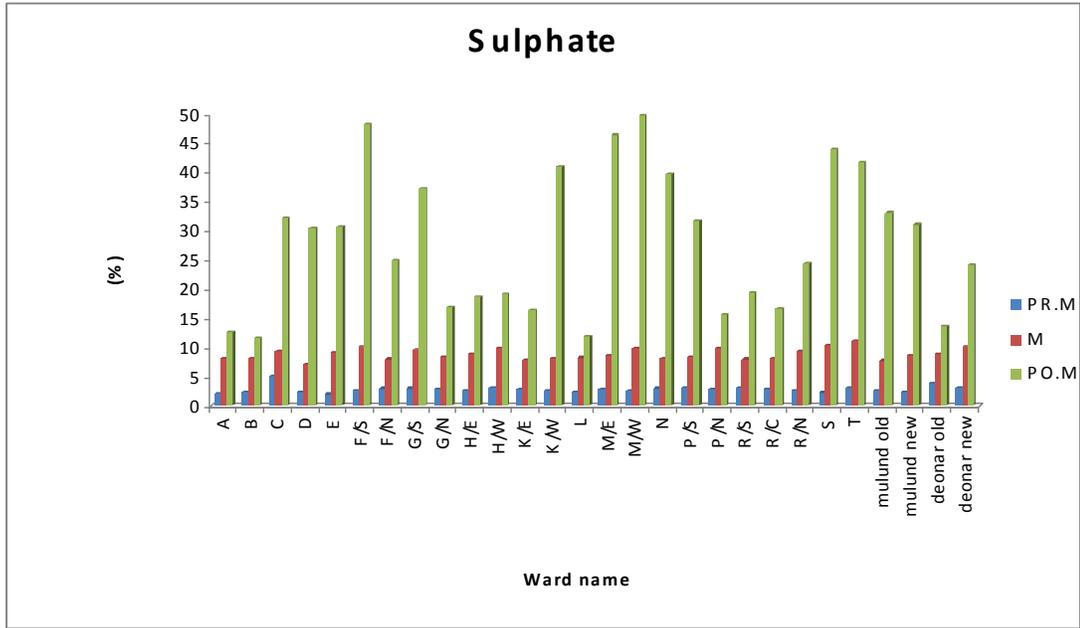


Figure 5.98: Graphical Representation of Seasonal Variation (Sulphur) of 24 Wards including Two Dumpsites (Pre-monsoon, Monsoon Post-monsoon Seasons)

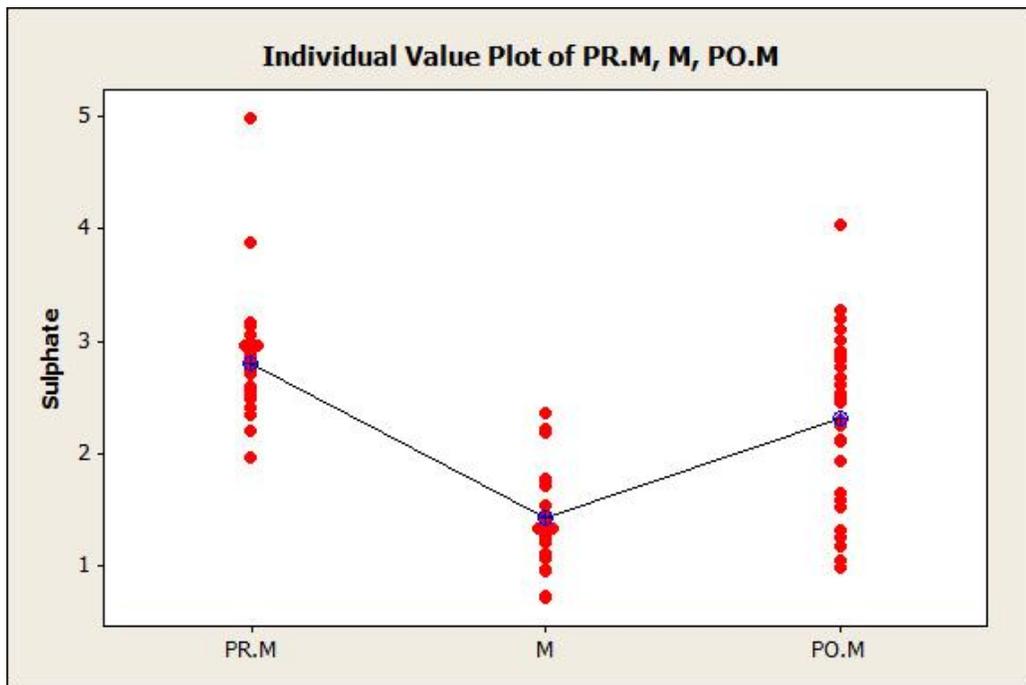


Figure 5.99: Statistical Graph (individual value plot) using minitab to show Seasonal Variation (Sulphur) of 24 Wards including Two Dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

Table 5.133**Seasonal Variation (C/N) of MSW of 24 Wards including Two Dumpsites MCGM Region**

Name of the Wards	C/N Ratio		
	Pre Monsoon Avg. (%)	Monsoon Avg. (%)	Post Monsoon Avg. (%)
A	31.02	26.6	28.295
B	20.84	26.085	26.71
C	28.71	26.325	25.535
D	34.16	27.855	25.955
E	24.39	25.34	25.51
F/S	23.19	24.21	24.355
F/N	25.86	22.1525	27.715
G/S	23.03	25.52	24.975
G/N	28.02	23.1275	26.425
H/E	28.5	26.56	25.015
H/W	28.25	25.895	26.785
K/E	23.94	24.535	26.205
K/W	26.98	26.545	24.635
L	25.75	25.54	26.11
M/E	31.66	27.425	25.105
M/W	26.67	24.095	28.135
N	27.6	26.67	28.375
P/S	26.52	23.835	25.845
P/N	26.19	23.07	24.7
R/S	22.69	18.225	27.03
R/C	23.32	22.18	27.55
R/N	27.16	20.12	30.34
S	27.16	26.1175	26.675
T	24.62	25.5275	28.66
Mulund (Old dumped waste	35.55	19.57	26.765
Mulund (Freshly dumped waste)	23.78	20.82	17.83
Deonar (Old dumped waste)	25.23	17.675	19.195
Deonar (Freshly dumped waste	24.77	22.34	17.81

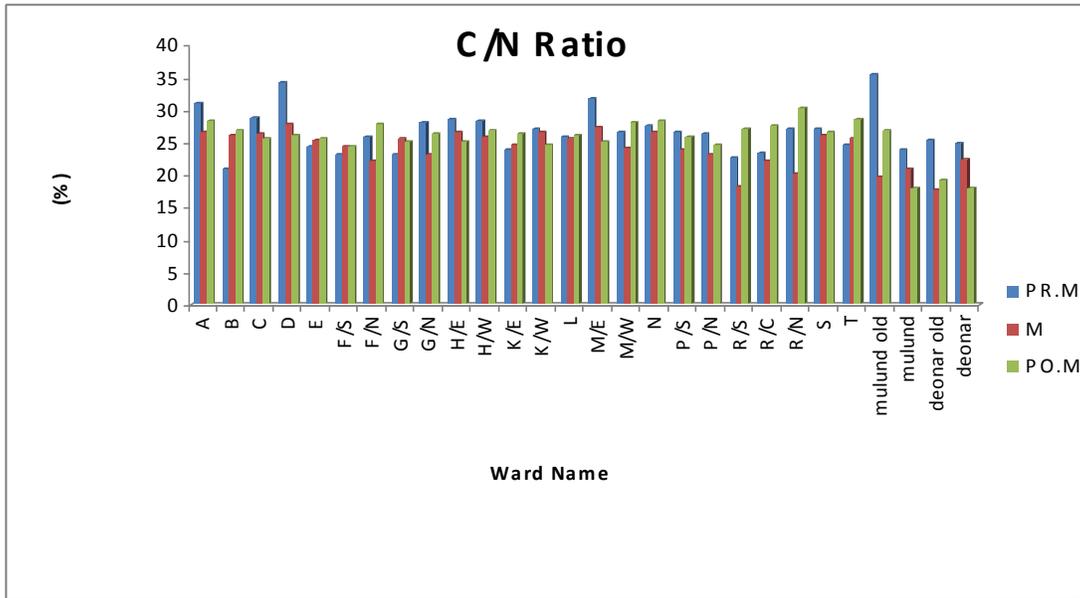


Figure 5.100: Graphical Representation of Seasonal Variation (C/N) of 24 Wards including Two Dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

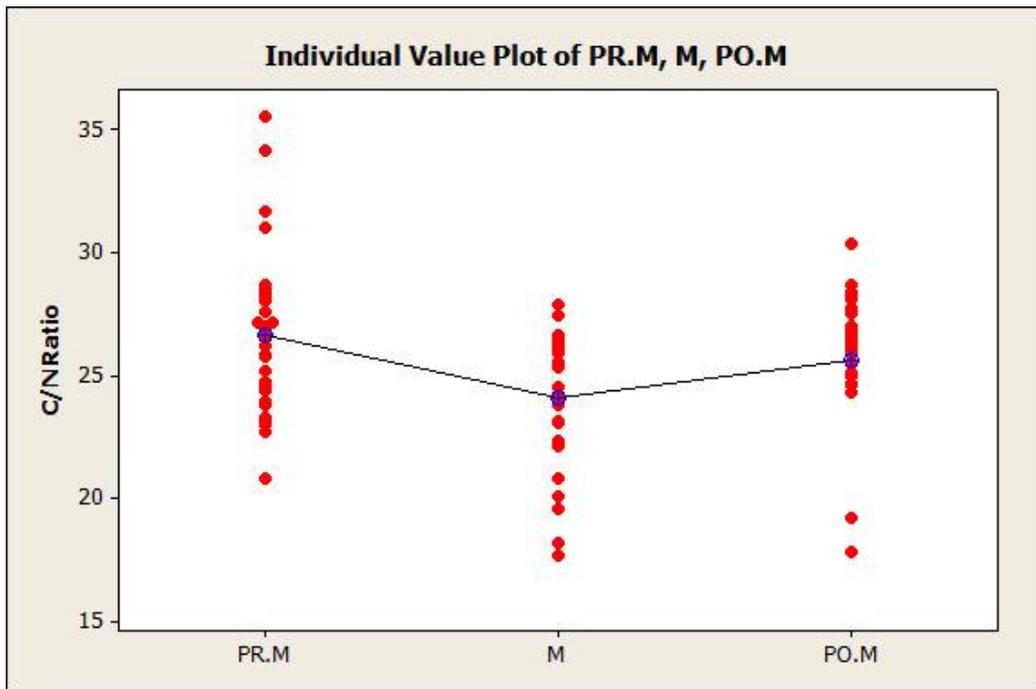


Figure 5.101: Statistical Graph (individual value plot) using minitab to show Seasonal Variation (C/N Ratio) of 24 Wards including Two Dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

Table 5.134**Seasonal Variation (Sodium) of MSW of 24 Wards including Two Dumpsites MCGM Region**

Name of the Wards	Sodium		Post Monsoon Avg. (%)
	Pre Monsoon Avg. (%)	Monsoon Avg. (%)	
A		24.4	14.03
B		22.9	26.1
C		16.17	10.2
D		12.35	11.2
E		1.18	22.8
F/S		7.5	21.7
F/N		1.48	8.65
G/S		1.54	9.5
G/N		3.7	9.2
H/E		13.9	4.3
H/W		19.5	9.58
K/E		4.7	10.15
K/W		6.95	10.95
L		15.75	17.5
M/E		47.5	10.72
M/W		15.5	22.06
N		5	2.9
P/S		19	27.95
P/N		9.95	1.59
R/S		1.31	3.975
R/C		8.5	5.8
R/N		6.75	5.04
S		1.34	32.05
T		2.05	5.58
Mulund (Old dumped waste		11.45	6.85
Mulund (Freshly dumped waste)		9.75	6.79
Deonar (Old dumped waste)		16.93	13.41
Deonar (Freshly dumped waste		10.85	9.77

** Sodium for the Pre-monsoon season has not been done.

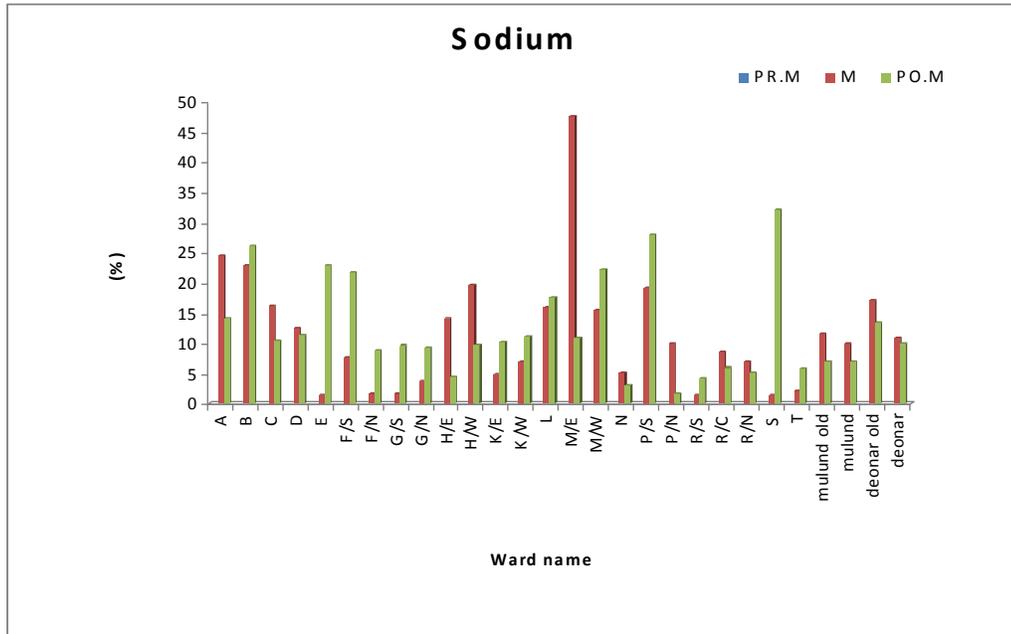


Figure 5.102: Graphical Representation of Seasonal Variation Sodium of 24 Wards including Two Dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

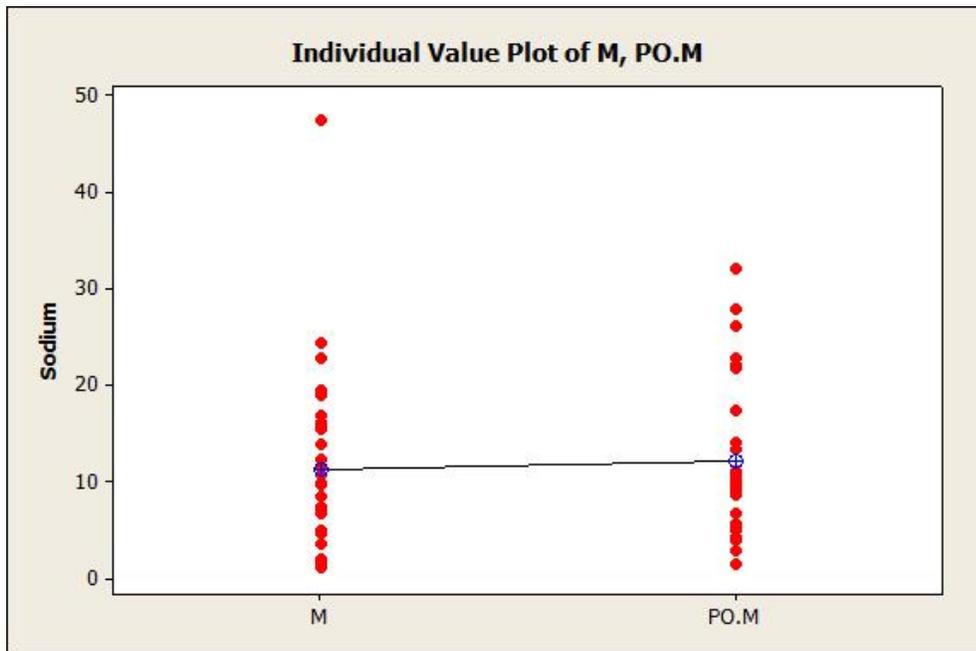


Figure 5.103: Statistical Graph (individual value plot) using minitab to show Seasonal Variation (Sodium) of 24 Wards including Two Dumpsites (Pre-monsoon, Monsoon Post-monsoon Seasons)

Table 5.135**Seasonal Variation (Potassium) of MSW of 24 Wards including Two Dumpsites MCGM Region**

Potassium			
Name of the Wards	Pre Monsoon Avg. (%)	Monsoon Avg. (%)	Post Monsoon Avg. (%)
A	6.5	0.8	38.05
B	9.2	0.6	39.4
C	8.9	0.31	32.1
D	4.6	1.9	41.35
E	7.5	3.015	46.6
F/S	7.6	1.36	54.55
F/N	8	2.75	38.5
G/S	4.1	3.37	35.3
G/N	7.5	1.22	33.45
H/E	8	2.33	36.85
H/W	7.8	2.01	36.1
K/E	8.4	0.77	34
K/W	9	3.25	60.65
L	8.5	0.55	81.65
M/E	5.9	1.22	56.5
M/W	7.4	2.2	47.5
N	7	1.62	27.4
P/S	7.6	0.61	128
P/N	6.8	2.6	34.2
R/S	7.5	1.33	36.6
R/C	6.4	1.31	36.4
R/N	8.5	1.66	32.4
S	7.8	1.41	37.15
T	7	1.45	39.55
Mulund (Old dumped waste)	11.4	1.71	32.1
Mulund (Freshly dumped waste)	7.2	0.71	42.6
Deonar (Old dumped waste)	12.9	1.36	38.15
Deonar (Freshly dumped waste)	6	0.83	29.5

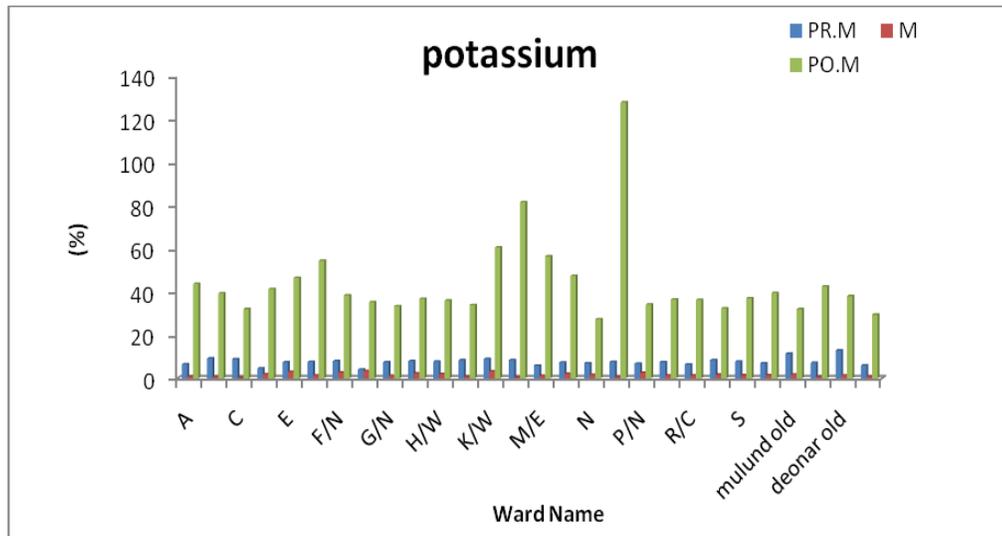


Figure 5.104: Graphical Representation of Seasonal Variation (Potassium) of 24 Wards including Two Dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

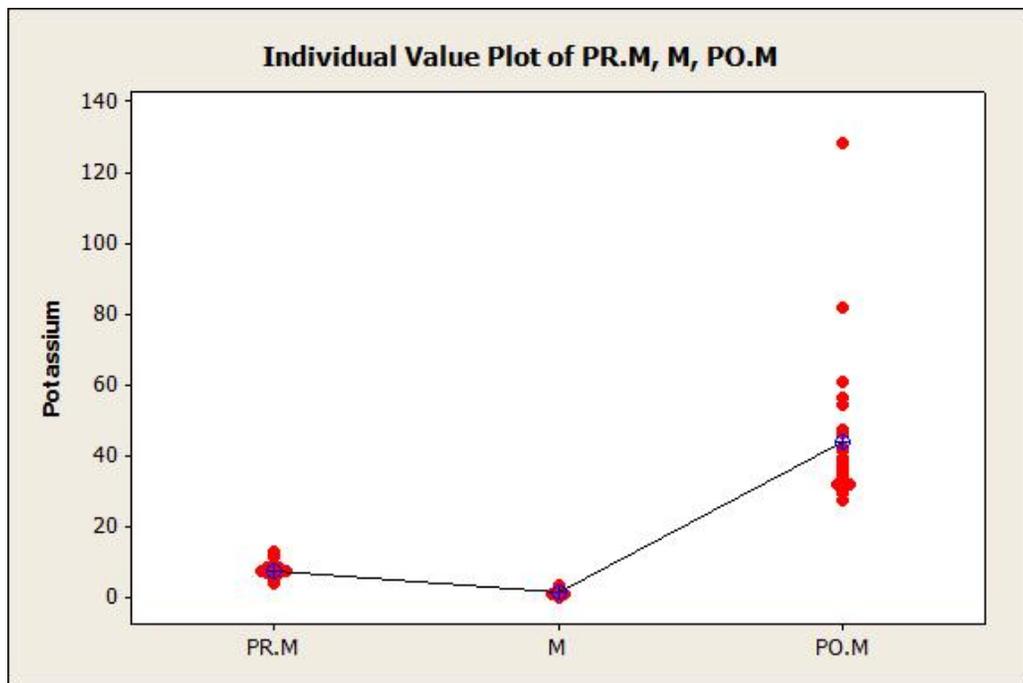


Figure 5.105: Statistical Graph (individual value plot) using minitab to show Seasonal Variation (Potassium) of 24 wards including Two Dumpsites (Pre-monsoon, Monsoon Post-monsoon Seasons)

Table 5.136**Seasonal Variation (Calorific Value) of MSW of 24 Wards including Two Dumpsites MCGM Region**

Calorific value (On Dry Weight Basis)			
Name of the Wards	Pre Monsoon (kcal/kg)	Monsoon Avg. (kcal/kg)	Post Monsoon (kcal/kg)
A	4036	4323.125	3861.997
B	3990	1458.175	3086.812
C	3979	2198.28	3847.4
D	4029.5	4222.57	3858.442
E	3975	3637.55	3888.367
F/S	3798	3959.49	4094.124
F/N	3950	4270.06	3633.036
G/S	3985.5	3938.275	3758.449
G/N	4024	3574.525	4309.24
H/E	3893	2291.38	3757.733
H/W	3821	4117.025	3790.204
K/E	3998.5	3699.445	3987.32
K/W	3944	3529.91	3569.05
L	3945.5	3383.54	4104.651
M/E	3905	3583.225	3570.795
M/W	3899	4582.9	4330.295
N	3848	3756.43	4351.32
P/S	3842	1526.22	3909.827
P/N	3874	4044.97	4002.386
R/S	3887.5	1976.225	3787.198
R/C	3809.5	3324.455	3316.596
R/N	3964.5	4138.795	4127.096
S	3990.5	4172.48	4049.96
T	4018	2427.92	3410.317
Mulund (Old dumped waste	3922.5	3927.675	3667.409
Mulund (Freshly dumped waste)	3932.5	4097.97	3691.79
Deonar (Old dumped waste)	3903.5	3873.68	3119.03
Deonar (Freshly dumped waste	3964.5	3514.3	3597.73

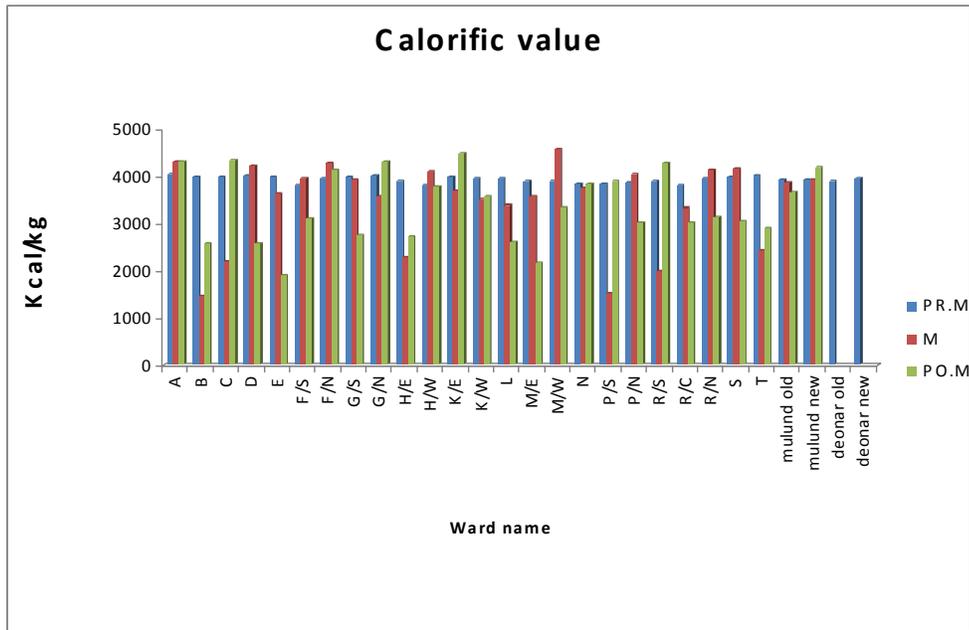


Figure 5.106: Graphical Representation of Seasonal Variation Calorific Value of 24 Wards including Two Dumpsites (Pre-monsoon, Monsoon, Post-monsoon Seasons)

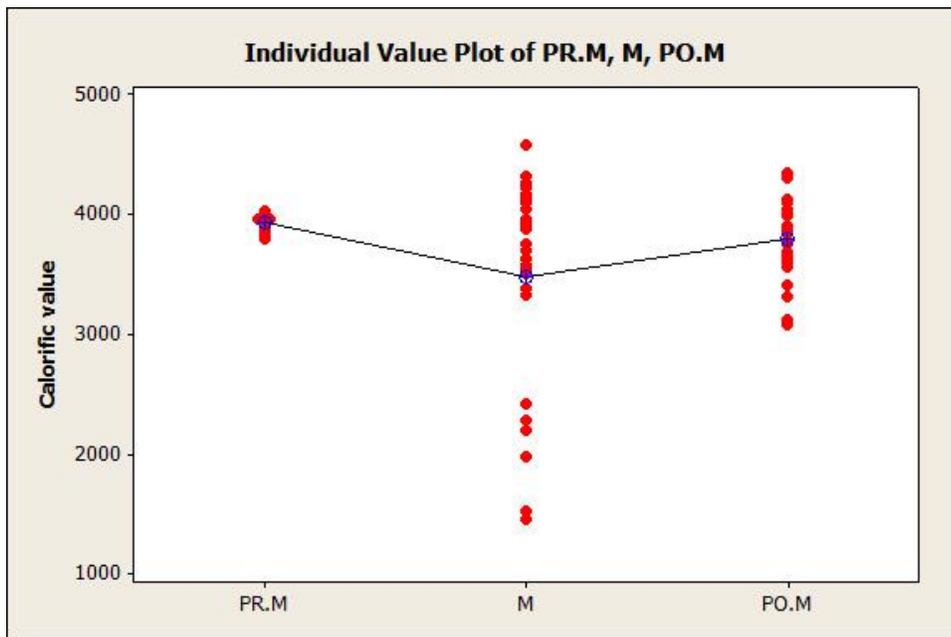


Figure 5.107: Statistical Graph (individual value plot) using minitab to show Seasonal Variation (Calorific Value) of 24 Wards including Two Dumpsites (Pre-monsoon, Monsoon Post-monsoon Seasons)

Overall average physical characteristics for two seasons in all the wards including two dump sites are presented in Table 5.137.

Table 5.137

Physical Characteristics for (Pre-monsoon and Post-monsoon Seasons)

Component	Pre Monsoon	Post Monsoon
Food waste	72.6	78.185
Paper	3.51	4.72
Plastics	3.24	3.475
Metal and glasses	3.28	2.65
Inerts	17.37	11.395

* Physical Characteristics of monsoon season has not been performed due to heavy rain during that period

Overall average chemical characteristics for all three seasons of all wards including two dump sites is shown in Table 5.138. Table 5.139 presents calorific value of MSW samples collected in all the seasons from all the wards as well as dump sites (Mulund and Deonar) of MCGM region.

Table 5.138

Chemical Characteristics for all three seasons (Pre-monsoon, Monsoon, Post-monsoon Seasons)

Parameters	Pre monsoon	Monsoon	Post monsoon
Moisture content (%)	72.69	86.15	80.83
Total solids (%)	27.31	13.8	19.16
Loss on Ignition (%)	76.85	81.91	85.34
Ash (%)	23.15	18.07	14.06
Calorific value (kcal/kg)	3930.77	3484	3802.80
Nitrogen (%)	1.8	1.55	2.76
C/N Ratio	26.63	24.07	25.65
Sulphur	2.8	1.43	2.3
Phosphorous	1.26	1.14	1.02
Potassium	0.77	1.58	43.80

Table 5.139**Calorific Value of MSW Samples in all the Seasons
(Pre-monsoon, Monsoon, Post-monsoon Seasons)**

Calorific Value (kcal/kg)*			
Ward Name	Pre-Monsoon	Monsoon	Post-Monsoon
A	936	730	878
B	997	168	572
C	1143	337	827
D	1068	631	410
E	1218	499	434
F/S	1177	669	492
F/N	1178	542	877
G/S	1372	580	607
G/N	919	492	734
H/E	1086	341	420
H/W	951	533	622
K/E	983	444	938
K/W	953	399	739
L	914	495	526
M/E	1047	284	489
M/W	1009	495	666
N	1154	465	610
P/S	1092	432	850
P/N	1114	526	592
R/S	1059	632	715
R/C	1016	520	480
R/N	2899	223	665
S	1099	588	509
T	1051	308	607
Deonar (Old[#] Dumped waste)	1348	596	583
Deonar (New[#] Dumped waste)	1113	428	771
Mulund (Old[#] Dumped Waste)	1296	604	539
Mulund (New[#] Dumped Waste)	823	499	839
*Wet weight basis;			
# Values expressed based on 3 nos. of samples collected from dumpsite of varying areas.			

5.5 B. Discussions

5.5.1 Discussion on Physical characteristics

The physical characteristics of waste sample in pre- monsoon season shows that an average MSW contains 72.60 % food waste and the values were in the range of 37.61-82.4%. The average percentage of paper was observed to be 3.51% with maximum 5.55% and minimum value 2.07% respectively. On an average, 3.24 % of plastics was present in MSW samples with maximum percentage as 7.18% while the lowest value as 1.53%. The proportion of metals and glasses was observed to be 3.28% (average) with the values varying between 0.89% - 13.67%. The average percentage of inerts was observed as 17.37% with maximum and minimum values as 39.26 and 6.5%, respectively.

The physical characterization of monsoon season was not done due to heavy rainfall during that period.

The physical characterization of MSW sample in post- monsoon season revealed that an average MSW contains 78.18% food waste and the values were in the range of 71.97% - 84.14%. The average percentage of paper was observed to be 4.72% with maximum being 5.47% and the lowest as 3.97%. On an average, 3.47 % of plastics was present in MSW samples with maximum percentage being 4.31% while the lowest being 2.64%. The proportion of metals and glasses was observed to be 2.65% (average) with the values varying between 1.91% - 3.39%. The average percentage of inerts was observed as 11.4% with maximum and minimum values as 12.56 and 10.23%, respectively.

From the result of Physical Characterization of waste sample, it is observed that the percentage of food waste is highest in all the seasons, also there is not much fluctuation in the average percentage of paper and plastics in different seasons. The average % of metals and glasses minimum might be due to rag picking. It is also observed that a large portion of MSW comprises inert material indicating that segregation of waste is not appropriate which indicates inappropriate segregation practice.

5.5.2 Discussion on Statistical Seasonal Variations (Pre-monsoon, monsoon, Post-monsoon,) of Chemical Characteristics and heavy metals in MSW

The interpretation of seasonal variation of chemicals and heavy metals was done through One way ANOVA which is used to compare the average values of different groups of datasets (pre-monsoon, monsoon and post-monsoon seasons). For interpretation of data, degree of freedom, sum of squares, F- statistic, mean of square, MS of errors, p-value were taken into consideration.

Proximate analysis

1) Moisture Content and Total Solid:

Mean average value for moisture content of MSW for the monsoon season is 86.151 which is greater than pre-monsoon and post-monsoon season. Mumbai is a high humid region which experiences a good rainfall in the monsoon season, ultimately leads to high moisture content in MSW collected during that period likewise Total solid of monsoon season is very low as it is inversely proportion to moisture content. Higher percentage of moisture content leads to low Total solid content

2) Ash

The mean value of ash is less in post- monsoon season i.e. 14.071 might be due to higher percentage of organic material in post monsoon season.

3) Loss on Ignition and Total Organic Carbon:

Mean average value for the Loss on Ignition and TOC is higher for the post monsoon season which might be due presence of higher percentage of food waste comprising vegetables, fruits and also large amount of paper and plastics.

C/N ratio

The mean average value of C/N ratio of all the season is slightly varying which could be seen in Pre - monsoon as nitrogen content is less in this period and carbon content is higher which leads to higher mean value during this period.

Chemical analysis

1) Calorific value

The calorific value of MSW collected from different wards of MCGM region during pre-monsoon, monsoon and post-monsoon seasons are in the range 914-2889 kcal/kg, 168-730 kcal/kg and 410-

938 kcal/kg on wet weight basis, respectively. The calorific value of dumped waste at both Mulund and Deonar dump sites of MCGM region during pre-monsoon, monsoon and post-monsoon seasons are in the range 823-1748 kcal/kg, 428-604 kcal/kg and 539-839 kcal/kg, respectively. The calorific values expressed are based on 3 nos. of samples collected from dumpsite of varying areas. The calorific values were high in pre-monsoon and post-monsoon seasons which might be due to presence of enormous amount of rice straw, baggasses, coconut husk and good quality of plastics and papers as these components have high calorific value.

2) pH

The mean value of pH is neutral for almost all the season as the MSW is dried, shredded and then grinded to make stabilized leachate. The stabilized leachate shows constant pH with little variations. This might be the reason that pH in all the season is neutral.

3) Phosphate

The mean value of phosphate does not so much variation and throughout the season as phosphate is an essential component for growth of plants

4) Sodium

The mean average value of sodium is nearly equal in the pre and post monsoon season as the main source of the sodium in the solid wastes is organic matter, fine earth, ash and inorganic salt these constituents were present in the municipal solid waste.

5) Potassium

The mean average value of the potassium is almost equal in all the seasons, with little fluctuation in the mean average of MSW. The source of Potassium contents in the solid waste are organic and inorganic materials like fine earth, ash, vegetable matter, rubber, metals and other components that's why remarkable amount of potassium could be seen in SWM in all the seasons.

5) Sulphate

The mean value of sulphate is nearly equal in all the seasons except slight increase in the mean average of pre and post-monsoon season. The sulphate content of MSW mainly depends on the decomposition of organic matter present in the waste as the physical characterization shows that pre

and post monsoon season has higher percentage of food waste which might be the reason that mean average value of sulphur is quite higher during that period.

6) Nitrogen

The mean value of nitrogen in waste sample is higher in post- monsoon season, might be due to presence of higher percentage of different types fruits and vegetable during post monsoon season. For production of fruits and vegetables synthetic fixed nitrogen fertilizer is used which results into double the flow of excessive nitrogenous material into the community which ultimately enters into the waste disposal system.

Heavy Metals

The mean average value of heavy metals in MSW is different from each other because of various materials present in the MSW in the area selected for the study. i.e., MSW was heterogeneous in nature. Fresh MSW shows dissolution of exposed lattice structures and surface forms which are stable under stable toxic conditions. i.e., the accumulation of heavy metals in phases which are stable under toxic conditions creates a reservoir of heavy metal which may be mobilized under changing condition.

6

RANKING OF MUNICIPAL SOLID WASTE TREATMENT OPTIONS IN MMR REGION

By seeing the physical, chemical characteristics of MSW and its seasonal variation of MSW of Mumbai season following options are ranked accordingly for the processing of waste. The ranking was calculated on the basis of generating a Rating Index (RI) considering various terms *viz.*, individually preferred values depending on eminent intuition (X_{pref}), ideal treatment option value depending on various literatures and rules (X_{ideal}), standard or commonly suitable treatment options which are more site-specific (X_{std}), and respective weights (W_i) assigned to individual treatment options.

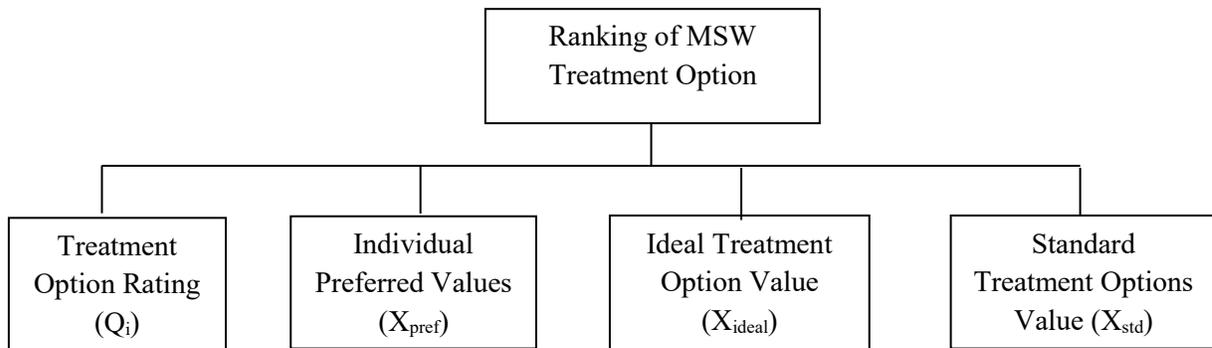


Figure 5.108: Ranking of MSW treatment options

The treatment option rating (Q_i) and weights for different treatment options (W_i) are obtained from the following relationships:

$$Q_i = \frac{X_{pref} - X_{ideal}}{X_{std} - X_{ideal}} \times 100$$

Where,

X_{pref} – represents fraction preferred by individual based on their intuition ($X_{ideal} < X_{pref} \leq X_{std}$)

X_{ideal} – represents fraction collectable for the particular treatment option

X_{std} – represents fraction of waste suitable for particular treatment option

1. Anaerobic Digestion

Most preferred was termed for “Anaerobic digestion”, because of the high organic fraction in the total MSW generated. This technique seemed to be most appropriate for the treatment of MSW as this is an environment friendly technology and also quite cheaper than other available technologies. The MSW of MMR contains higher percentage of organic matter. The anaerobic digestion of organic waste would yield methane, CO₂ and solid compost which can be used as a soil conditioner. Further treatment of gases could also solve the problem of CNG and LPG. The treatment of biodegradable fraction wastes can be an important component of an integrated solid waste management which would reduce both toxicity and volume of waste.

2. Incineration

Most preferred was termed for “Incineration”, because of the high calorific value in the total MSW generated. Incineration is also an efficient way to reduce the waste volume and landfill space. It can be located near the centre of waste generation thus reducing the waste transportation but this one is not as favorable as the other available options as this treatment process involves heavy investment and high operating costs and also it requires highly skilled person and careful maintenance. Air pollution also remains a major problem in implementation of incineration as a treatment process for SW.

3. Recycling Options

Preferred was termed for “Recycling Options”, because of the less amount of recycling material in the total MSW generated. As the nature of MSW is heterogeneous in nature so recycling can also be a good option for the treatment of waste. MSW of Mumbai shows a remarkable amount of paper and plastics along with other waste so recycling option can, not only help to reduce the environmental burden, but also will help to use less primary raw material.

5. Composting

Preferred was termed for “Composting”, because of the good amount of organic fraction in the total MSW generated. Composting is also a feasible option for the treatment of waste though this process is cheaper and environment friendly but it cannot be operated at a large scale.

6. Pyrolysis

Least preferred was termed for “Pyrolysis”, because of the very less amount of plastic fraction in the total MSW generated This technique can also be used for treatment of waste as it is more

environment friendly than incineration and Landfilling and many other gasification process. It takes trash and converts it into oil, carbon and gas. Metals and glasses can be recovered before and after the process. But the major drawback in this treatment process is that it requires homogenous organic compounds but as the nature of MSW is heterogeneous and hence proper segregation must be needed before introducing the MSW for treatment in pyrolysis.

6. Sanitary Landfill

Least preferred was termed for “Sanitary Landfill”, because of the less reaction of inerts in the total MSW generated Sanitary landfill doesn't seem much favorable option because it ultimately leads to environmental burden, land encroachment and also liberates landfill gases (LFGs) which ultimately emits green house gases resulting into green house effect and global warming. It can be only used when scientific engineered land fill option is available.

7

CONCLUSION & RECOMMENDATIONS

- The accountability and responsibility for effective MSWM should be delivered by respective local body.
- The Three principles (Reduce, Recycle and Recover) should be mandatory at every nooks and corner of the locality of the city.
- Source segregation to be made obligatory, as it prevents the mixing of organic and inorganic waste. Without proper segregation a large part of SW results into inert which reduces the recycling process.
- The stake holders and traders in the recycling of MSW should be encouraged through legal process.
- Active citizen's Participation should be motivated in the proper and effective Management of MSW in the city
- Dumping of waste at the dumpsite is not the solution for the theme CLEAN UP! Proper technologies for the Waste to Energy should be applied to treat the waste.

Pre Monsoon



Exhibit 1. 1: MSW collection in Pre-monsoon Season

Monsoon



Exhibit 1. 2: MSW Collection in Monsoon Season

Post Monsoon



Exhibit 1. 3: MSW Collection in Post Monsoon Season

A-2.1 Method Adopted for Sampling of MSW

The sampling has been done as per the Central Public Health and Environmental Engineering Organization (CPHEEO) guidelines 2000. Approximately, 20 kilogram (kg) of grab samples were collected from the identified secondary collection points for each of the above-mentioned categories. For each of the categories, MSW samples were collected from 3 different secondary collection points. Care was taken to ensure that the composite sample collected from these pre-determined locations was not less than 20 kg by weight.

For physical and chemical analysis, the collected sample was then thoroughly mixed (on a tarpaulin) by manual mixing using a shovel to make its characteristics more uniform. A conical heap was prepared of this mixed sample and randomly a portion was selected - typically one quarter - of the mixed waste (quartering). Physical analysis included segregating the waste sample into Food waste, Vegetable waste, Paper, Plastics, metal & glass and inerts.

A 5 kg of the representative mixed waste sample was sent to the laboratory for chemical analysis. Samples collected were coded prior to transporting them to NEERI, Nagpur Zonal Laboratory.

A total of 24 samples were collected from the identified HIG, MIG, CAs, RS and analyzed in the laboratory for its chemical properties.

A.2.2 Preparation of Samples for Chemical Analysis

The municipal organic waste collected from different areas was oven dried for 48 hrs at 80 °C in a hot air oven. The oven dried samples were further grinded to fine powder and then desiccated to cool down.

For the chemical analysis of samples, extracts were prepared by dissolving 10 gm of the sample in 100 ml of distilled water and shaken for 8 hrs in a rotary shaker in order to ensure full dissolution of sample into distilled water. The solution was then filtered in Whatman No. 42 filter paper and the filtrate was used for chemical analysis. Chemical analysis was done as prescribed by Bureau of Indian Standards (BIS No. 10158-1982).

A.2.3 pH

Principle

pH is the negative logarithm of hydrogen ion concentration. It is expressed as $\text{pH} = -\log_{10}(\text{H}^+)$. For

pH below 7, the H concentration exceeds OH and the range is acidic. When the OH concentration is more than H, pH lies between 7 and 14 and the range is alkaline. A potential measurement in the range of +420 mv to -420 mv is needed since a potential difference of 59.1 mv is developed for a difference of one pH unit.

Procedure

10 gram of air-dried sample was taken in a 50 ml beaker and 25 ml of distilled water was added to it. The solution was kept undisturbed for 1 hr for sedimentation. A digital pH meter (**Exhibit 2.1**) was inserted into the solution to measure pH of solution.



Exhibit 2.1: Photograph of pH Meter 3.0

A.2.4 Moisture Content

Principle

Moisture content is the quantity of water contained in a material. It is the amount of water lost from the material upon drying to a constant weight and expressed as the weight per unit of dry sample or as the volume of water per unit bulk volume of the sample.

Procedure

The sample was weighed immediately after collection and recorded as wet weight of sample (A). The sample was dried to a constant weight at a temperature not exceeding 100 °C for 48 hr in a hot air oven. The samples were taken out of oven and kept inside the desiccators for 4 to 5 hrs to allow it to cool. The samples were weighed again the weights recorded as dry weight of the sample (B).

Calculation

The moisture content of the sample is calculated using the following equation:

$$\%W = [(A-B)/A] * 100$$

Where,

$\%W$ = Percentage of moisture in the sample,

A= Weight of wet sample (gm), and

B= Weight of dry sample (gm)

A.2.5 Measurement of C, N and C/N Ratio

Principle

The basic principle of quantitative CHNS analysis is high temperature combustion of organic solid samples. The gaseous combustion products are purified, separated into their various components and analyzed with a suitable detector (Thermo-conductivity detector (TCD) in this case).

Methods

Carbon and nitrogen in MSW samples were analyzed using Vario EL III CHNOS analyzer (**Exhibit 2.2**). 4-6 mg of MSW sample was packed into tin boats and was dropped into the combustion tube at temperatures up to 1200°C. The use of tin vessels further elevates the sample's combustion temperature up to 1800°C.

The helium carrier gas transfers the gaseous combustion products into the copper tube. The nitrogen oxides are reduced to nitrogen and the gaseous mixture enters the dynamic separation system. The nitrogen travels directly to the TC detector while the CO₂, H₂O and SO₂ are retarded in specific adsorption traps. When the TCD's signal for nitrogen returns to baseline, the adsorption traps are thermally desorbed and the corresponding gases detected sequentially. Overlapping of separated gases is prevented by waiting for the TCD to return to baseline before desorbing the next trap. This approach ensures the largest dynamic range in the shortest analysis time possible. Variations in concentration ranges and measuring modes - CHNS, CNS, CHN, etc. are possible by simply changing adsorption traps. The detector signals are integrated by using the calibration curves stored in the PC. The concentrations of the various elements were calculated, displayed and stored in memory.



Exhibit 2.2: A Pictorial View of CHNS Analyzer

Calculation:

Concentration of C, H, N and S are represented after the run in percentage composition.

Calculation of C/N Ratio

After calculation of the percentage of carbon and nitrogen in MSW samples, C/N ratio was determined by dividing the corresponding values.

A.2.6 Measurement of Phosphorus

The Phosphorous content of the sample was measured using stannous chloride method.

Procedure

100 ml of sample (extract solution free from colour and turbidity) was taken and added with 0.05 ml of phenolphthalein indicator solution. Strong acid solution was added drop wise to discharge the colour, if sample turned pink. To the solution added 4 ml of molybdate reagent and 0.5 ml of SnCb reagent. After 10 minutes absorbance of the sample solution was measured at 690 nm against distilled water as blank in a spectrophotometer (**Exhibit 2.3**). The light path used was 1 cm. The absorbance obtained was compared with the calibration curve.



Exhibit 2.3: Measurement of Phosphorous in Spectrophotometer 6.0

A.2.7 Estimation of Potassium (K)

The estimation of potassium is done using flame photometric method.

Principle

The sample solution is sucked by an atomizer under controlled conditions. The radiation from the flame entered a dispersing device in order to isolate the desired region of the spectrum. The intensity of isolated radiation can be measured by a phototube. After carefully calibrating the photometer with solution of known composition and concentration, it was possible to correlate the intensity of a given spectral line of the unknown with the amount of an element present that emitted the particular radiation.

Procedure

The flame photometer (**Exhibit 2.4**) was switched on and the air supply started and stabilized. The fuel gas was switched on and the gas fuel mixture was maintained so that the cone of blue flame was visible through the viewing window. The distilled water was aspirated and the galvanometer reading was adjusted to zero. The instrument was calibrated by aspirating the standard and adjusting the galvanometer reading. The concentration of P was directly recorded from the digital screen.



Exhibit 2.4: Photographic View of a Flame Photometer

A.2.8 Heavy Metal Analysis

Heavy metal content in MSW samples was analyzed using inductively coupled plasma atomic emission spectroscopy (ICP-OES).

Sample Preparation

EPA Method 3051A (Microwave Digestion with HNO_3)

0.5 g of sample was weighed into a fluorocarbon microwave vessel equipped with a controlled pressure relief mechanism. 10 ml concentrated HNO_3 was added to the vessel and was sealed. The vessel was properly placed in the microwave system. Samples were digested at $175\text{ }^\circ\text{C}$ for

10 min. After cooling, vessels were uncapped and placed in fume cupboard in order to vent. The mixture was transferred quantitatively to a 50 ml volumetric flask, and the mark was made up with Milli-Q water and then the solution was filtered. The filtrate thus obtained was introduced into the capillary tube of ICP-OES.

The samples introduced were analyzed for heavy metals at the following wave lengths:

Cd: 228.802 nm, Co: 228.616 nm, Cr: 267.716 nm, Cu: 327.393 nm, Fe: 238.204 nm

Mn: 257.610 nm, Ni: 231.604 nm, Pb: 220.353 nm, Zn: 213.857 nm and then their

Concentrations were displayed in the attached computer (**Exhibit 2.5**).



Exhibit 2.5: Photographic View of ICP-OES

Procedure

After drying the sample in hot air oven at 80 °C for 24 hr, it was powdered and then kept inside the Muffle Furnace at 600 °C for 2 hrs. Initial weight of the sample kept inside the muffle furnace was noted (A) and then the final weight after keeping the sample inside muffle furnace for 2 hrs at 600 °C was noted (B). The hot air oven and muffle furnace are shown in **Exhibits 2.6 and 7**

Calculation

$$\% \text{ Loss on Ignition} = (A-B)/A * 100$$

$$\% \text{ Ash Content} = 100 - \% \text{ Loss on Ignition}$$



Exhibit 2.6: Photograph Hot Air Oven



Exhibit 2.7: Photograph of Muffle Furnace

Appendix- III

Table 3: Shows the methods use to provide options for ranking of MSW treatment options in MMR Region

Sr. No.	Options Available	Individual Preferred Values (X_{pref})	Ideal Treatment Option Value (X_{ideal})	Standard Treatment Options Value (X_{std})	Reasons	Rank
1.	Incineration	0.8	0.9	0.75	Most Preferred	2
2.	Pyrolysis	0.7	0.75	0.6	Least Preferred	5
3.	Anaerobic Digestion	0.9	1	0.65	Most Preferred	1
4.	Sanitary Landfilling	0.55	0.6	0.3	Least Preferred	6
5.	Composting	0.7	0.75	0.62	Preferred	4
6.	Recycling Options	0.8	0.9	0.7	Preferred	3
X _{pref} –Fraction preferred by individual based on their intuition ($X_{std} < X_{pref} \leq X_{ideal}$)						
X _{ideal} –Fraction collectable for the particular treatment option						
X _{std} –Fraction of waste suitable for particular treatment option						

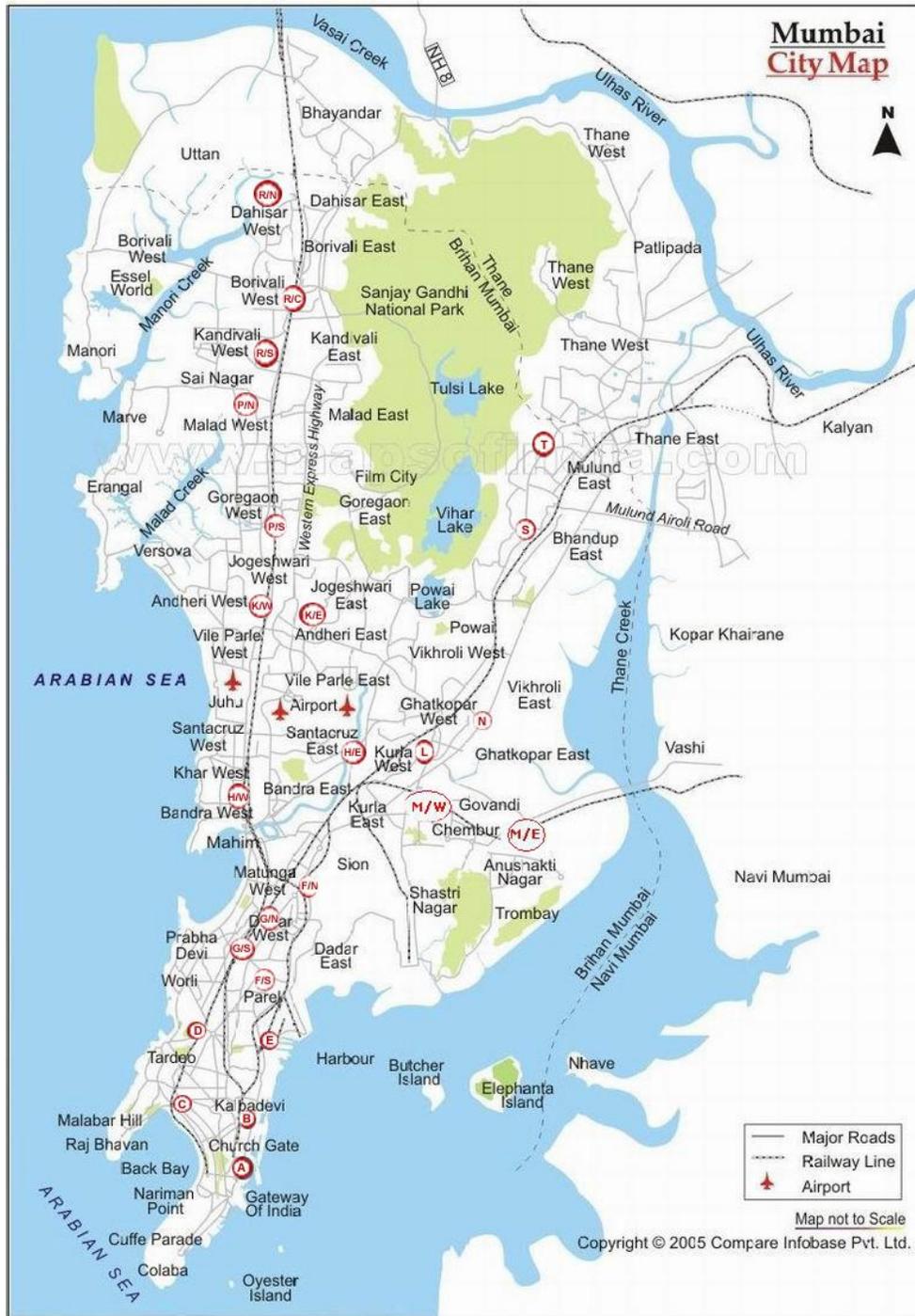


Exhibit 4.1: Map of MCGM, Mumbai Region Showing Different Wards for Collection of MSW