**BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL**
**SOUTHERN ZONE, CHENNAI**

**O.A. NO. 199 of 2021 (SZ)**

**IN THE MATTER OF:**

Sri. Shankar Narayanan Bala Krishnan,
Telangana and Ors ...Applicant(s)

Versus

State of Telangana and Ors ...Respondents(s)

**INDEX**

| S.No. | Particulars | Page No. |
|---|---|---|
| 1 | Report filed on behalf of Respondent No.6 | 1-7 |
| 2 | Annexure I – Copy of the Final report submitted by IIT Bombay | 8-88 |
| 3 | Annexure II – Copy of photographs of collection & treatment of leachate from the capped legacy dump | 89-90 |
| 4 | Annexure III – Copy of mail communication to Central Pollution Control Board for submission of Report of Committee of Experts constituted to finalize its viewpoint on capping of legacy dump | 91 |
| 5 | Annexure IV – Copy of letter addressed to the District Forest Officer, Sangareddy on 30.05.2023 | 92-93 |
| 6 | Annexure V – Copy of Tender notice issued by the District Forest Officer, Sangareddy in NavaTelangana News paper. | 94 |
| 7 | Annexure VI – Copy of letter addressed to the District Forest Officer, Sangareddy requesting for details on the number of trees that shall be planted as part of compensatory afforestation | 95-96 |
| 8 | Annexure VII – Copy of the enumeration details of the trees in the diverted forest land | 97-111 |

Place: Hyderabad

Date: 04.08.2023

COUNSEL FOR 6TH RESPONDENT

**BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL**
**SOUTHERN ZONE, CHENNAI**

**O.A. NO. 199 of 2021 (SZ)**

**IN THE MATTER OF:**

Sri. Shankar Narayanan Bala Krishnan,
Telangana and Ors ...Applicant(s)

Versus

State of Telangana
And Ors ...Respondents(s)

**REPORT FILED ON BEHALF OF RESPONDENT NO.6**

I, D Ronald Rose, IAS S/o. Dinakaran Bose, aged about 43 years, Occ: Commissioner, Greater Hyderabad Municipal Corporation, Greater Hyderabad Municipal Corporation, R/o. Hyderabad, do hereby solemnly swear and state on oath as follows:

1. It is respectfully submitted that, I am working as Commissioner of Greater Hyderabad Municipal Corporation (GHMC), Hyderabad. As such, I am well acquainted with the facts of the case. Further, I am deposing this report in view of the orders dated:10.04.2023 of the Hon'ble National Green Tribunal, South Zone in OA No. 199 of 2021 based on the records available with the Respondent Corporation.

2. Placing on record the details of all the earlier status reports filed by the 6th Respondent before the Hon'ble National Green Tribunal, Southern Zone, Chennai.

- Report filed by the 6th Respondent, dated 07.10.2021
- Report filed by the 6th Respondent, dated 07.12.2021
- Report filed by the 6th Respondent, dated 05.03.2022
- Report filed by the 6th Respondent, dated 29.03.2022
- Additional Report filed by the 6th Respondent, dated 25.08.2022

Commissioner,
Greater Hyderabad Municipal Corporation

Commissioner,
Greater Hyderabad Municipal Corporation

(2)

- Reply memo filed by the 6th Respondent, dated 25.08.2022
- Status report filed by the 6th Respondent, dated 23.11.2022
- Report filed by the 6th respondent, dated 17.12.2022
- Report filed by the 6th respondent, dated 08.03.2023

3. It is respectfully submitted that, IIT Bombay has completed its assessment studies on the legacy dump at Jawaharnagar and following is the summary of the final report **(Annexure I)** submitted by IIT Bombay after sampling of Decomposed Municipal Solid Waste (DMSW) and extensive characterization of the DMSW at laboratories in IIT Bombay on suitability of DMSW for bio-mining at Jawaharnagar:

i. The segregation of DMSW samples indicates the dominance of plastics and fine fractions (<10 mm) of the waste matrix up to ≈40 % (each) by weight.

ii. The organic matter (up to 35%) and moisture content (>100%) of the fine fraction are high, which indicates its potential to decompose in the long run.

iii. The specific gravity of the fine fractions is around 2.30, which makes it an un-preferred, if not unsuitable material for infrastructural development (viz., making foundation pads, reclamation etc).

iv. The emission of foam/ gas/ leachate from the JLH (Jawaharnagar Landfill Hyderabad) indicates the ongoing decomposition of MSW. Hence, biomining at this point in time is not recommended.

v. Though the calorific value of most samples of coarse fractions is above >1500 kCal/kg, their ash content is as high as 60%, which is unsuitable for their application as Refuse Derived Fuel.

vi. Higher Na+ concentration in fine fractions would result in sodic soil which when used as a soil amending agent for agricultural applications.

Commissioner,
Greater Hyderabad Municipal Corporation

Commissioner,
Greater Hyderabad Municipal Corporation

vii. Higher TOC, TN and S concentrations in leachate generated from fine fractions indicate their potential for subsequent degradation. Hence, it becomes mandatory to treat the leachates generated in the JLH appropriately.

viii. Based on the present state of the decomposed MSW and foam observed during borehole drilling, it can be concluded that the waste is yet to decompose. Hence, the JLH is not ready for bio-mining.

4. It is respectfully submitted that, IIT Bombay has recommended that the capped legacy dump at Jawaharnagar is not ready for Bio-mining as the waste is yet to decompose and also assessed that the characteristics of the fine & coarse fractions are not suitable for alternate use. Further, with regards to the suggestion of IIT Bombay to treat the leachates generated from dump, it is to submit that Leachate Collection System is provided in the scientific capping of legacy dumpsite at Jawaharnagar by inserting a network of lateral perforated HDPE piped and the treatment of the collected leachate is taking place through 500 kLD Reverse Osmosis (RO) system followed by Multi Effect Evaporator & Agitated Thin Film Drier (MEE- ATFD) systems at the processing plant **(Photographs at Annexure II)**.

5. It is respectfully submitted that, in compliance to the directions of the Hon'ble NGT, New Delhi orders dated 29.09.2022 in OA 606 of 2018, the CPCB has constituted a Committee of Experts who interacted with GHMC, CPCB and TSPCB through video conference on 30.12.2022 in which the capping works were critically examined vis-a-vis the measures being taken by GHMC to protect the environment while keeping in view the fact that the daily generated MSW of GHMC is also being treated and disposed scientifically in the same site. GHMC vide mail dated 07.06.2023

Commissioner,
Greater Hyderabad Municipal Corporation

Commissioner,
Greater Hyderabad Municipal Corporation

(4)

**(Annexure III)** has requested the CPCB to communicate the report of the Expert Committee and the same is awaited.

5. It is respectfully submitted that following is the progress of 3 proposed alternate sites for diversion of MSW received at Jawahar Nagar facility:

A. **Dundigal:**

The Construction of the 14.5 MW Waste to Energy plant at Dundigal is completed. Steam Blow Out Operations for cleaning the boiler and pipelines before introducing steam into the turbine and turbine testing operations are completed. Power Purchase Agreement (PPA) between the Operator of the plant & Telangana State Southern Power Distribution Company of Telangana (TSSPDCL) along with permission for back charging by TSSPDCL is under process subsequent to which the plant shall be back-charged and synchronized with the Grid. Synchronization will happen within a month's time after execution of PPA.

B. **Pyaranagar**:

- The work of laying approach road (in the diverted forest land) to the alternate MSW site at pyaranagar is held up due to delay in felling/ translocation of trees.
- As per the agreement entered between GHMC and the District Forest Officer (DFO), Sangareddy, the latter shall fell & transport / translocate standing tress in the forest area being diverted for the project and GHMC undertook not to touch or fell or translocate them in any manner.
- In view of it coming to the notice of GHMC that there is no response from bidders to the tender floated by the DFO,

Commissioner,
Greater Hyderabad Municipal Corporation

Commissioner,
Greater Hyderabad Municipal Corporation

Sangareddy for the work of felling/ translocating the trees and the willingness submitted by M/s Hyderabad Integrated MSW Ltd. who is the Concessionaire of the Integrated Municipal Solid Waste Management Project of GHMC to take up the same, GHMC on 30.05.2023 **(Annexure IV)** requested the DFO, Sangareddy to look into the possibility of allotting the said work to the Concessionaire for enabling GHMC to expedite the work of laying approach road.

- The DFO, Sangareddy has once again issued tender notice in news paper for the work of felling of trees in the diverted forest land for submission of bids from 05.07.2023 to 15.07.2023 but inview of no response from any bidders, tender was re-called on 02.08.2023 **(Annexure V).**
- Further, with regards to the directions of this Tribunal vide orders dated 10.04.2023 to furnish the details of the trees to be felled/ translocated, the DFO, Sangareddy was requested on 19.05.2023 **(Annexure VI)** to furnish the said details as GHMC made payment of Rs.32,90,192/- towards CAMPA account of Telangana State which includes payment towards compensatory afforestation works and the same is awaited. The number of trees as per the enumeration done in the presence of the officials of forest department is 453 and the list with species names is enclosed at **Annexure VII.**
- Further, as per the agreement between GHMC & DFO, Sangareddy, both parties also agreed, bound and stated that they shall reduce the number of trees to be felled & transported or translocated and shall be as per the enumeration list submitted to the DFO.
- Development of MSW processing facility for diversion of 2000 TPD MSW from Jawahar Nagar with 130 tons per day capacity

Commissioner,
Greater Hyderabad Municipal Corporation

(6)

Raw Biogas facility, 45 tons per day capacity Plastic Recycling facility, 100 tons per day capacity Compost facility and 1000 tons per day capacity RDF facility will be taken up immediately after completion of approach road and will be completed in (06) months. The capacity of the above plant will be doubled in second phase including construction of 15 MW Waste to Energy plant for disposal of RDF which will take (01) year for completion from the date of commissioning of 1st phase.

C. **Yacharam:**

The request of the project proponent M/s. Sri Venkateshwara Green Power Projects Ltd for granting permission for enhancement of the project capacity from 12 MW to 14 MW for the reason of financial viability is under the consideration of the Government of Telangana. The project is expected to be completed in (01) year's time.

***Submission:***

For the aforementioned facts and circumstances, it is therefore prayed that this Hon'ble Tribunal may be pleased to close the OA No. 199 of 2021 and pass such other order or orders as this Hon'ble Tribunal deems fit and proper in the circumstances of the case and thereby render Justice.

Sworn and signed on this the
04th day of August, 2023 at Hyderabad

Deponent

Commissioner,
Greater Hyderabad Municipal Corporation

(7)

## VERIFICATION

I, D. Ronald Rose, IAS S/o. Dinakaran Bose, aged about 43 years, Occ: Commissioner, Greater Hyderabad Municipal Corporation, R/o Hyderabad, do hereby declare that the contents made in the above paragraphs are true and correct to the best of my knowledge and based on records available with Respondent Corporation and I believe the same to be true and correct. Hence verified on this the 04th day of Aug, 2023.

**Respondent-6**

**Commissioner,**
**Greater Hyderabad Municipal Corporation**

भारतीय प्रौद्योगिकी संस्थान मुंबई
पवई, मुंबई-400 076, भारत
**Indian Institute of Technology Bombay**
Powai, Mumbai-400 076, India

दूरभाष/Phone : (+91-22) 2572 2545
फैक्स/Fax : (+91-22) 2572 3480
वेबसाईट/Website : www.iitb.ac.in

July 05, 2023

To,
**The Municipal Commissioner**
**Greater Hyderabad Municipal Corporation**
Hyderabad
Telangana

**Subject:** Providing Technical Advisory Services in the Bid Process for Biomining of Capped Legacy Dumpsite of GHMC at Jawaharnagar Including Assessment Studies on Suitability for Bio-mining by Retrieval and Characterization of Decomposed Municipal Solid Waste

**Our Reference:** DRD/CE/DNS-11/22-23 dated 15.06.2022

Dear sir,

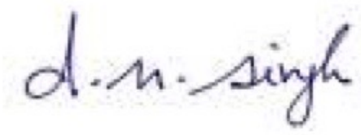
It was a pleasure to be associated with you and your colleagues on this so very important project.

The proposed studies have been completed successfully, within the stipulated time, and I am submitting the final report **Studies on Suitability of Decomposed Municipal Solid Waste for Bio-mining at Jawaharnagar Capped Dumpsite, Hyderabad** to you for your kind perusal and records.

In case you have any queries/clarification, please contact the undersigned.

Also, as the project has been completed, please release the remaining 10% amount as per the MoU.

Regards!



**Dr. D. N. Singh** FNAE, FASCE, FICE(UK)
***D.L. Shah Chair Professor for Innovation***
Department of Civil Engineering
Cell: +919820758508
Email: dns@civil.iitb.ac.in
www.civil.iitb.ac.in/~dns

*A Report*

*on*

# Studies on Suitability of Decomposed Municipal Solid Waste for Bio-mining at Jawaharnagar Capped Dumpsite, Hyderabad

*Submitted to*

**Greater Hyderabad Municipal Corporation (GHMC)**

*by*

**Goli Venkata Siva Naga Sai**
**Mrunal Sunil Bokade**
**Yogendra Narayanan**
**Sinny Manohar**
**Kamran Ilahi**
**Prithvendra Singh**
(Research Scholars)

**Pintu Kumar Saw**
(Undergraduate student)

and

**Prof. D. N. Singh**
Principal Investigator
&
D.L. Shah Chair Professor for Innovation

**ENVIRONMENTAL GEOTECHNOLOGY LABORATORY**
**DEPARTMENT OF CIVIL ENGINEERING**
**INDIAN INSTITUTE OF TECHNOLOGY BOMBAY**
**MUMBAI- 400076, INDIA**

**July 5, 2023**

## Table of Contents

List of Figures ..... ii
List of Plates ..... iii
List of Tables ..... iv
1. Background ..... 1
2. Scope of work ..... 1
3. Reconnaissance survey ..... 2
4. Proposed Investigations ..... 4
4.1 Geophysical Investigations ..... 4
4.2 Retrieval of Decomposed MSW from JLH and Characterization ..... 4
4.3 Characterization of the DMSW samples ..... 5
4.3.1 Physical Characteristics ..... 5
4.3.2 Chemical Characteristics ..... 5
5. Details of the Investigations and Results ..... 5
5.1 Geophysical Investigations ..... 5
6. Details of the MSW sampling and on-site segregation ..... 18
7. Processing and characterization of the DMSW @ IIT Bombay Laboratory ..... 27
7.1 Characteristics of the fine fractions ..... 29
7.1.1 Moisture Content ..... 29
7.1.2 Organic Matter ..... 30
7.1.3 Specific Gravity ..... 31
7.1.4 Analysis of Leachates ..... 32
7.2 The calorific value of the coarse fraction ..... 36
8. Conclusions and the way forward ..... 39
Appendix A ..... 40
Appendix B ..... 54
Appendix C ..... 68
References ..... 74

## List of Figures

**Figure 5.1** MASW analysis results of Line-1 .....7
**Figure 5.2** MASW analysis results of Line-2 .....7
**Figure 5.3** MASW analysis results of Line-3 .....8
**Figure 5.4** MASW analysis results of Line-4 .....8
**Figure 5.5** MASW analysis results of Lines-6 and 7 .....9
**Figure 5.6** MASW analysis results of Line-8 .....9
**Figure 5.7** MASW analysis results of Line-9 .....10
**Figure 5.8** MASW analysis results of Line-10 .....10
**Figure 5.9** MASW analysis results of Line-11 .....11
**Figure 5.10** MASW analysis results of Line-12 .....11
**Figure 5.11** MASW analysis results of Line-13 .....12
**Figure 5.12** MASW analysis results of Line-14 .....12
**Figure 5.13** 2D- electrical resistivity imaging map for Line-1 .....13
**Figure 5.14** 2D- electrical resistivity imaging map for Line-2 .....14
**Figure 5.15** 2D- electrical resistivity imaging map for Line-3 .....14
**Figure 5.16** 2D- electrical resistivity imaging map for Line-4 .....14
**Figure 5.17** 2D- electrical resistivity imaging map for Line-6 .....15
**Figure 5.18** 2D- electrical resistivity imaging map for Line-7 .....15
**Figure 5.19** 2D- electrical resistivity imaging map for Line-8 .....15
**Figure 5.20** 2D- electrical resistivity imaging map for Line-9 .....16
**Figure 5.21** 2D- electrical resistivity imaging map for Line-10 .....16
**Figure 5.22** 2D- electrical resistivity imaging map for Line-11 .....16
**Figure 5.23** 2D- electrical resistivity imaging map for Line-12 .....17
**Figure 5.24** 2D- electrical resistivity imaging map for Line-13 .....17
**Figure 5.25** 2D- electrical resistivity imaging map for Line-14 .....17

## List of Plates

**Plate 3.1** Photographs depicting the site visit.....3

**Plate 4.1** The Google Earth map of the JLH depicting the locations selected for Geophysical investigations.....4

**Plate 5.1** The Google Earth map exhibiting the actual stretches of the MASW and ERT investigations.....6

**Plate 6.1** Images depicting the flight auger and the sample collection procedure.....19

**Plate 6.2** Images depicting the on-site segregation, weighing and packing of the samples being witnessed by the GHMC.....21

**Plate 6.3** The photographs depicting the borehole and its closure.....26

**Plate 6.4** The photographs depicting the leachate and bubble formation and bursting by landfill gas emission the release of foam/bubbles/liquid from a typical borehole.....26

**Plate 7.1** Images depicting the laboratory segregation process of coarse fractions.....27

## List of Tables

**Table 5.1** Coordinates for start and end points of MASW and ERT investigations .....6

**Table 5.2** The expected lithology for corresponding shear wave velocities provided by FGTL .....13

**Table 6.1** Details of the boreholes and number of samples collected……..20

**Table 6.2** Details of the coarse- and fine- samples obtained from the in-situ segregation .....22

**Table 7.1** Results obtained for the coarse-fractions of the MSW……28

**Table 7.2** The moisture content of the fine-fractions .....30

**Table 7.3** Borehole-wise variation in the organic matter of fine fractions .....31

**Table 7.4** Borehole-wise variation in the specific gravity of fine fractions .....32

**Table 7.5** The values of pH, EC, TDS, Salinity, Hardness and Chlorides for leachates of the representative samples from different bore-holes .....33

**Table 7.6** The concentration of leachable elements from the fine-fractions .....34

**Table 7.7** The calorific value and ash content of the coarse-fractions .....36

**Table A.1** Moisture content analysis results for Borehole-01……40

**Table A.2** Moisture content analysis results for Borehole-02.....41

**Table A.3** Moisture content analysis results for Borehole-03.....42

**Table A.4** Moisture content analysis results for Borehole-04.....43

**Table A.5** Moisture content analysis results for Borehole-05.....44

**Table A.6** Moisture content analysis results for Borehole-06.....45

**Table A.7** Moisture content analysis results for Borehole-07.....46

**Table A.8** Moisture content analysis results for Borehole-08.....47

**Table A.9** Moisture content analysis results for Borehole-09.....47

**Table A.10** Moisture content analysis results for Borehole-10.....47

**Table A.11** Moisture content analysis results for Borehole-11.....49

**Table A.12** Moisture content analysis results for Borehole-12.....50

**Table A.13** Moisture content analysis results for Borehole-13.....51

**Table A.14** Moisture content analysis results for Borehole-14.....52

**Table A.15** Moisture content analysis results for Borehole-15.....53

**Table A.16** Moisture content analysis results for Borehole-16.....53

**Table B.1** Organic matter results for Borehole-01……...54

**Table B.2** Organic matter results for Borehole-02.....55

**Table B.3** Organic matter results for Borehole-03 ..... 56
**Table B.4** Organic matter results for Borehole-04 ..... 57
**Table B.5** Organic matter results for Borehole-05 ..... 58
**Table B.6** Organic matter results for Borehole-06 ..... 59
**Table B.7** Organic matter results for Borehole-07 ..... 60
**Table B.8** Organic matter results for Borehole-08 ..... 61
**Table B.9** Organic matter results for Borehole-09 ..... 61
**Table B.10** Organic matter results for Borehole-10 ..... 62
**Table B.11** Organic matter results for Borehole-11 ..... 63
**Table B.12** Organic matter results for Borehole-12 ..... 64
**Table B.13** Organic matter results for Borehole-13 ..... 65
**Table B.14** Organic matter results for Borehole-14 ..... 66
**Table B.15** Organic matter results for Borehole-15 ..... 66
**Table B.16** Organic matter results for Borehole-16 ..... 67
**Table C.1** Specific gravity results for fine fraction retrieved from Borehole-01 ..... 68
**Table C.2** Specific gravity results for fine fraction retrieved from Borehole-02 ..... 68
**Table C.3** Specific gravity results for fine fraction retrieved from Borehole-03 ..... 68
**Table C.4** Specific gravity results for fine fraction retrieved from Borehole-04 ..... 69
**Table C.5** Specific gravity results for fine fraction retrieved from Borehole-05 ..... 69
**Table C.6** Specific gravity results for fine fraction retrieved from Borehole-06 ..... 70
**Table C.7** Specific gravity results for fine fraction retrieved from Borehole-07 ..... 70
**Table C.8** Specific gravity results for fine fraction retrieved from Borehole-08 ..... 70
**Table C.9** Specific gravity results for fine fraction retrieved from Borehole-09 ..... 71
**Table C.10** Specific gravity results for fine fraction retrieved from Borehole-10 ..... 71
**Table C.11** Specific gravity results for fine fraction retrieved from Borehole-11 ..... 71
**Table C.12** Specific gravity results for fine fraction retrieved from Borehole-12 ..... 72
**Table C.13** Specific gravity results for fine fraction retrieved from Borehole-13 ..... 72
**Table C.14** Specific gravity results for fine fraction retrieved from Borehole-14 ..... 73
**Table C.15** Specific gravity results for fine fraction retrieved from Borehole-15 ..... 73
**Table C.16** Specific gravity results for fine fraction retrieved from Borehole-16 ..... 73

## 1. Background

Landfill biomining (LFM) of existing dumpsites and landfills has been encouraged to avoid the contamination of the geoenvironment (soil, groundwater, and air), recover the precious land occupied by these facilities, and utilization of landfill-mined residues (LMRs) such as plastics, glass, metals and combustibles and soil-like materials for different applications. Nevertheless, to decide on the feasibility of LFM, it is crucial to ascertain the state of decomposition of the MSW in the landfill/dumpsite. This would not only help in understanding the utilization potential of LMRs but also help in finding the answers to questions such as whether the MSW in the landfill is suitable to be mined, ascertaining possible issues that can arise during mining operations, and the methodology to be adopted for landfill mining, etc. In this context, the state of MSW in a landfill/dumpsite can be determined easily by characterizing the samples of DMSW collected from a landfill for their physical and chemical characteristics. Based on these investigations, a further decision on LFM should be taken. Further, geophysical investigations such as Multi-channel Analysis of Surface Waves (MASW) and Electrical resistivity tomography (ERT) would help in understanding the subsurface properties of the landfill. This would also help to identify leachate and gas pockets that could become an issue during mining activity if not known in advance.

As per the directions of the National Green Tribunal (NGT) Principal Bench, Greater Hyderabad Municipal Corporation (GHMC) is prepared to take up the biomining of capped Jawaharnagar Dumpsite, Hyderabad and called for tenders. However, as the dumpsite has been capped recently (i.e., 2018), the GHMC approached Prof. D. N. Singh, Department of Civil Engineering, Indian Institute of Technology Bombay, for help in several technical aspects such as evaluating the readiness of the capped dumpsite for biomining, evaluating the technical proposal received for biomining operation, establishing the methodology for biomining, etc. Keeping these in view, a scientific study on capped dumpsite at Jawaharnagar, Hyderabad, is planned by the Indian Institute of Technology Bombay under the supervision of Prof. D. N. Singh, IIT Bombay. In this regard, to evaluate the readiness of the capped dumpsite at Jawaharnagar, Hyderabad, for biomining, a study has been proposed by IIT Bombay. The technical aspects of the study proposed are mentioned below.

## 2. Scope of work

The broad scope of this proposal is to help GHMC in the bid process and carry out geophysical investigations, retrieval, and characterization of the decomposed MSW (DMSW) samples at Jawaharnagar landfill Hyderabad (referred to as JLH).

The detailed scope of the work is mentioned below:

- Guiding GHMC in the bidding process for the work of biomining of the capped legacy dumpsite.
- Conducting geophysical investigations, namely Multichannel Analysis of Surface Waves (MASW) and 2-dimensional Electrical Resistivity Tomography (2D-ERT) on the dumpsite at different locations to understand the subsurface features.
- Extensive sampling of DMSW samples from different locations.
- Segregation and characterization of the DMSW samples for their Physico-chemical parameters.
- Establishing the present state of the decomposition of the MSW.
- Characterization of leachate samples (if any) during the sampling of the DMSW from different boreholes.
- A critical analysis of the way forward.

## 3. Reconnaissance survey

Based on the data shared by GHMC on 22.04.2022, a proposal was prepared by IIT Bombay and shared to conduct the investigations within the scope mentioned above. The study broadly involves conducting geophysical (MASW and ERT) investigations and retrieving and characterizing the DMSW samples.

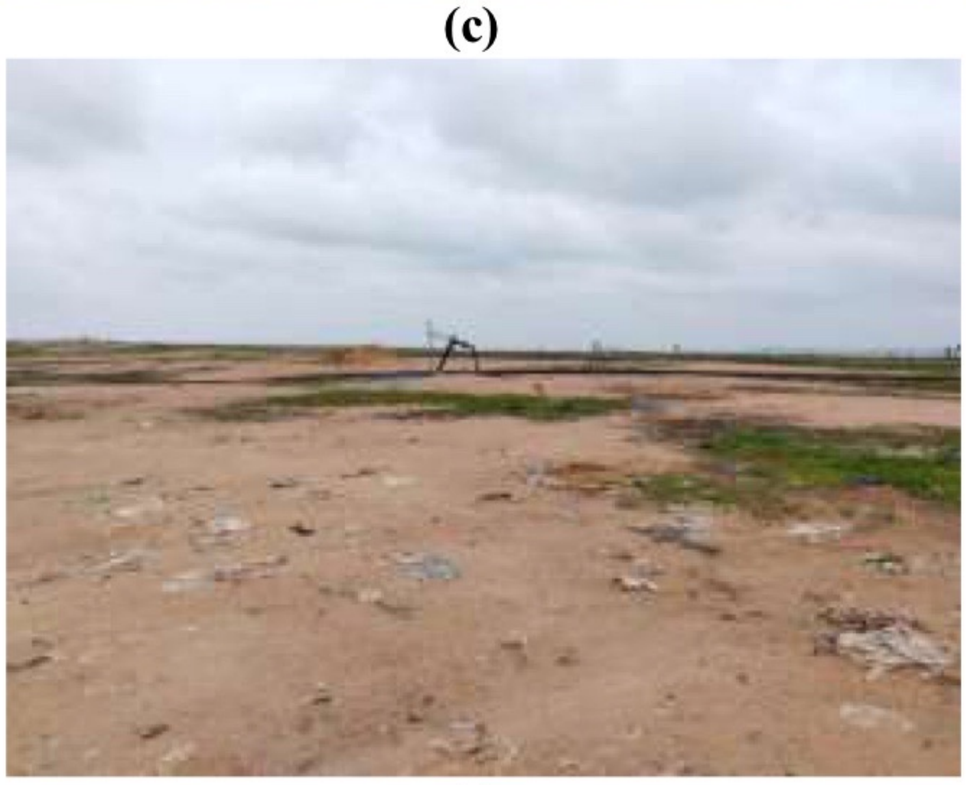
In this context, the IIT Bombay team, along with the representatives of **M/s. Ramky Enviro Engineers Ltd. (REEL)**, **Environmental Protection Training and Research Institute, Hyderabad (EPRTI)**, and **GHMC** visited the site to select the locations for conducting Geophysical investigations at the JLH site (refer to Plate 3.1). This exercise would help in selecting the subsequent locations for retrieving the samples from the landfill without causing much harm to the existing cover, gas and leachate collection systems.

(a)

(b)

(c)

(d)



(e)

(f)

**Plate 3.1** Photographs depicting the site visit

## 4. Proposed Investigations

### *4.1 Geophysical Investigations*

Based on the site visit and the information given by the REEL, EPTRI and GHMC representatives, locations for the Geophysical investigations have been selected, as represented in

Plate ***4.1***. Please refer to Lines 1 to 5 (designated as L1 to L5). Lines L1 to L4 have been selected based on the maximum height of the landfill at these locations, whereas L5 has been selected to identify the presence/absence of leachate pockets as it is a low-lying area previously and close to leachate ponds. The preliminary site survey helped us estimate that each MASW and ERT investigation should be conducted for 3000 meters.

**Plate 4.1** The Google Earth map of the JLH depicting the locations selected for Geophysical investigations

### *4.2 Retrieval of Decomposed MSW from JLH and Characterization*

The top cover (including vegetative and clay cover) and other geotextile layers will be removed manually. Followed by a flight auger (diameter ranging between 100 and 300 mm), attached to a pile-driving unit, will be inserted in the capped landfill to drill a borehole using hydraulic equipment (Mohammad et al., 2021). The DMSW and leachates obtained at different borehole depths will be collected. Borehole drilling from the top of the landfill will be initiated by inserting a mild steel casing. The casing helps in stabilizing the borehole during the drilling operation. The drilling would be continued as deep as possible based on the site conditions, considering the safety of buried utilities. A sampling of MSW will be done every 2-3 m or

wherever changes in the strata. The landfill operator should seal the boreholes after the sampling is completed. The retrieved samples will be spread on a clean geomembrane (near the borehole on the two loops) and divided into four quarters with the help of a shovel. Furthermore, the MSW samples (≈5-10 kg) would be randomly collected for *three quarters* for laboratory testing. The leftover samples of MSW should be backfilled into the boreholes. Depending upon the state of the exhumed MSW samples, their storage at 4 °C, in a refrigerator at the site will be done. Subsequently, the samples will be transported to the IIT Bombay laboratory for their characterization, as mentioned in the following.

### *4.3 Characterization of the DMSW samples*

#### *4.3.1 Physical Characteristics*

The DMSW was proposed to sieve through a 20 mm size sieve followed by the manual segregation of the retained portion into various fractions such as plastics, textiles, metals, glass, paper, etc. Further, the <20 mm fraction considered as soil-like materials was proposed to be tested for moisture content and specific gravity.

#### *4.3.2 Chemical Characteristics*

The biochemical processes involved in the decomposition of MSW in a landfill transform the organic matter (OM) present in it. With this in view, the chemical parameters of MSW, namely, volatile solids, elemental content, total organic carbon, ammonium and nitrate nitrogen and heavy metals, were proposed to be performed on the MSW samples retrieved from the landfill. In addition to the characterization of MSW, testing of a few leachate samples for their chemical parameters (viz., pH, EC, TOC, COD, sulfates, phosphates, nitrate-nitrogen, ammonium-nitrogen, and heavy metals) was proposed.

Based on the above-mentioned comprehensive testing protocol, the readiness of the JLH for booming will be established. If the dumpsite can be mined, the recommendations for initiating mining was proposed to be submitted to GHMC.

## 5. Details of the Investigations and Results

### *5.1 Geophysical Investigations*

IIT Bombay engaged Fugro Geotech India Pvt. Ltd. (FGTL) to conduct MASW and 2-dimensional ERT as a part of geophysical investigations and the results are presented in the following. Please note that the results of geophysical investigations for Line-5 are not generated appropriately. So, data for line-5 is missing from the report.

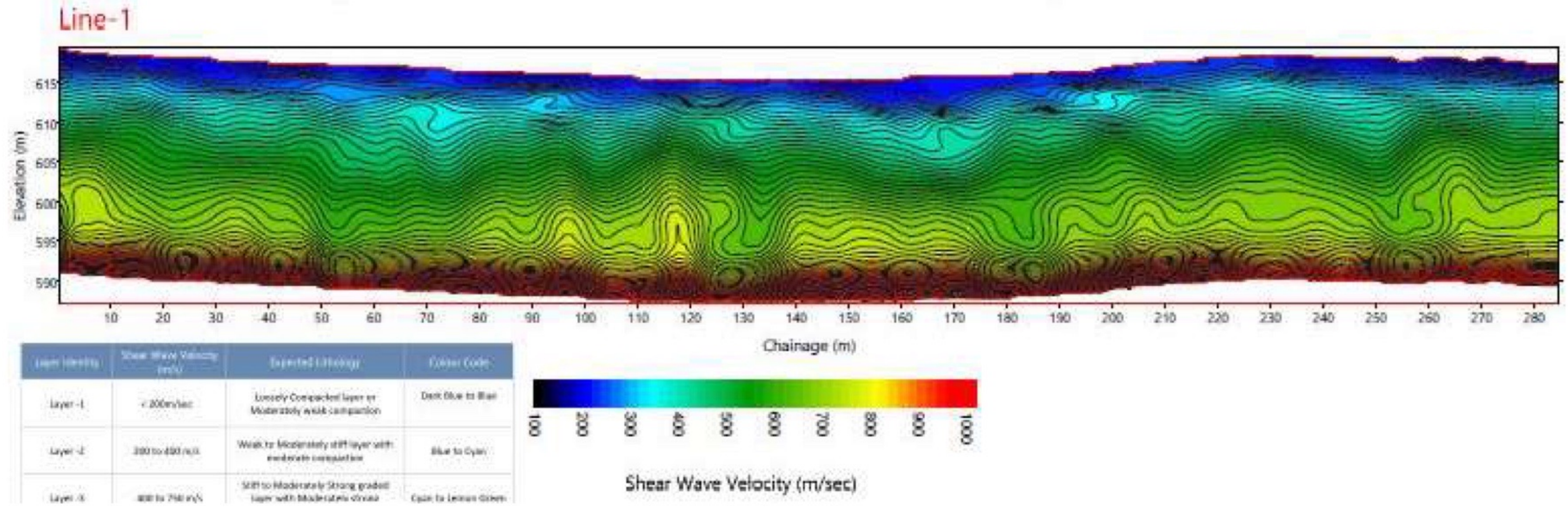
Different representative locations and stretches on the JLH were selected, refer to Plate ***5.1***, and a total of 3000 m length was covered. The coordinates of the start and end points for each stretch are mentioned in Table 5.1.

**Plate 5.1** The Google Earth map exhibiting the actual stretches of the MASW and ERT investigations

**Table 5.1** Coordinates for start and end points of MASW and ERT investigations

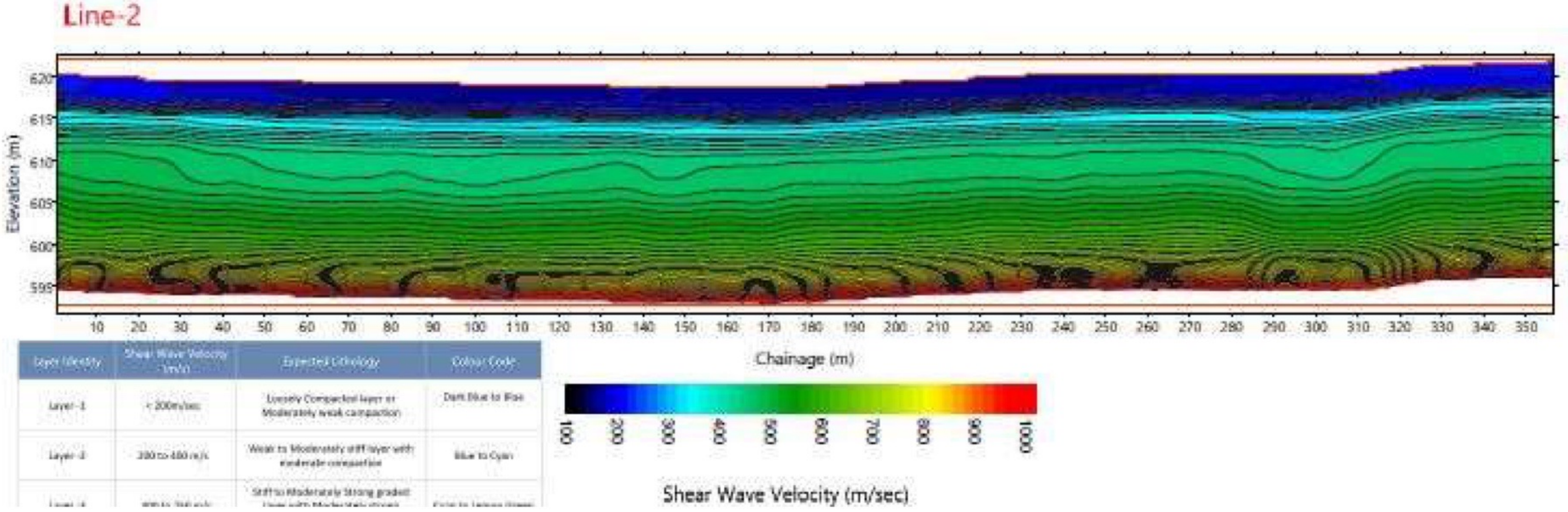
| Line Name | Start Coordinates | | End Coordinates | | Line Length (m) |
|---|---|---|---|---|---|
| | Easting | Northing | Easting | Northing | |
| Line No 01 | 244483.17 | 1938999.8 | 244554.78 | 1938725.6 | 284 |
| Line No 02 | 244463.67 | 1939005.7 | 244538.64 | 1938657.9 | 356 |
| Line No 03 | 244509.12 | 1938654.7 | 244453.77 | 1939005.8 | 356 |
| Line No 04 | 244627.65 | 1939043.2 | 244724.49 | 1938854.1 | 216 |
| Line No 06 | 244747.97 | 1938687.1 | 244769.86 | 1938790.4 | 108 |
| Line No 07 | 244768.09 | 1938692.5 | 244799.6 | 1938793.8 | 108 |
| Line No 08 | 244303.79 | 1939060.6 | 244330.64 | 1938704.7 | 356 |
| Line No 09 | 244041.55 | 1939193.8 | 244004.74 | 1939094.2 | 108 |
| Line No 10 | 244498.79 | 1938955.8 | 244357.72 | 1938962.6 | 144 |
| Line No 11 | 244518.41 | 1938875 | 244375.79 | 1938876.6 | 144 |
| Line No 12 | 244557.57 | 1938838.2 | 244355.08 | 1938772.7 | 216 |
| Line No 13 | 244580.39 | 1938707.8 | 244368.13 | 1938706.5 | 216 |
| Line No 14 | 244395.78 | 1939035.7 | 244481.63 | 1938619.3 | 428 |

The results obtained from the analysis are depicted in Figure 5.1 to 5.12.




| Layer Identity | Shear Wave Velocity (m/s) | Expected Lithology | Colour Code |
|---|---|---|---|
| Layer -1 | < 200m/sec | Loosely Compacted layer or Moderately weak compaction | Dark Blue to Blue |
| Layer -2 | 200 to 400 m/s | Weak to Moderately stiff layer with moderate compaction | Blue to Cyan |
| Layer -3 | 400 to 750 m/s | Stiff to Moderately Strong graded layer with Moderately dense | Cyan to Lemon Green |

**Figure 5.1** MASW analysis results of Line-1




| Layer Identity | Shear Wave Velocity (m/s) | Expected Lithology | Colour Code |
|---|---|---|---|
| Layer -1 | < 200m/sec | Loosely Compacted layer or Moderately weak compaction | Dark Blue to Blue |
| Layer -2 | 200 to 400 m/s | Weak to Moderately stiff layer with moderate compaction | Blue to Cyan |
| Layer -3 | 400 to 750 m/s | Stiff to Moderately Strong graded layer with Moderately dense | Cyan to Lemon Green |

**Figure 5.2** MASW analysis results of Line-2

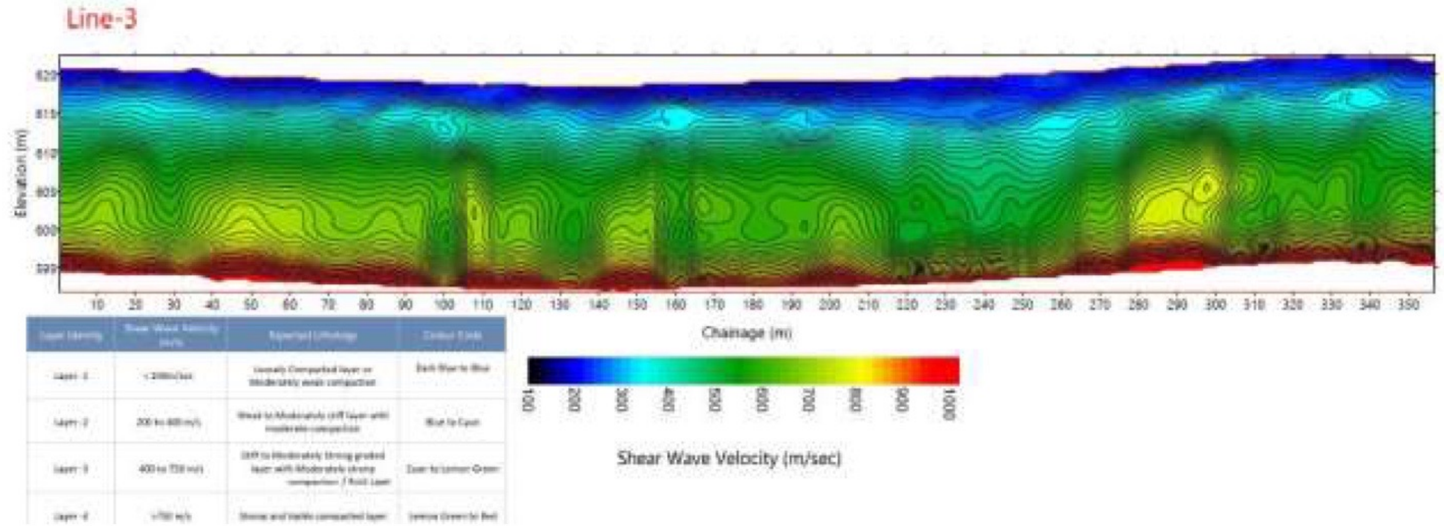



**Figure 5.3** MASW analysis results of Line-3

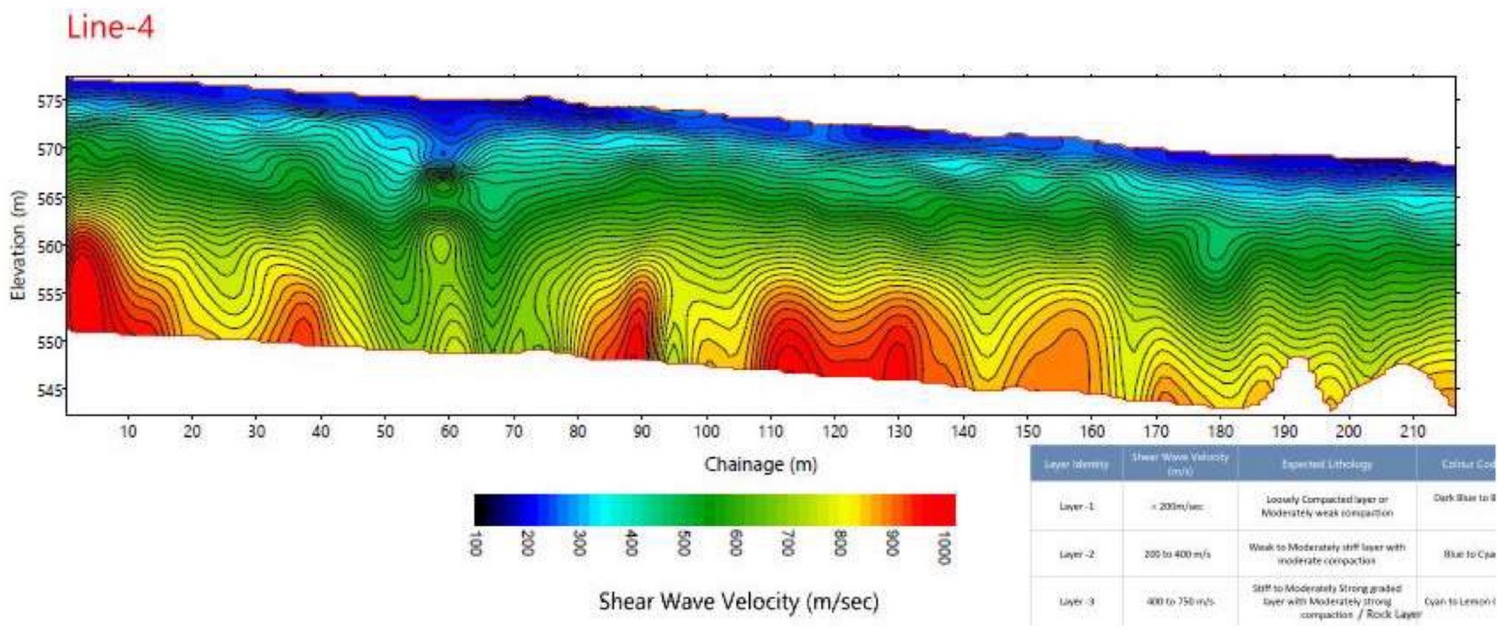



**Figure 5.4** MASW analysis results of Line-4

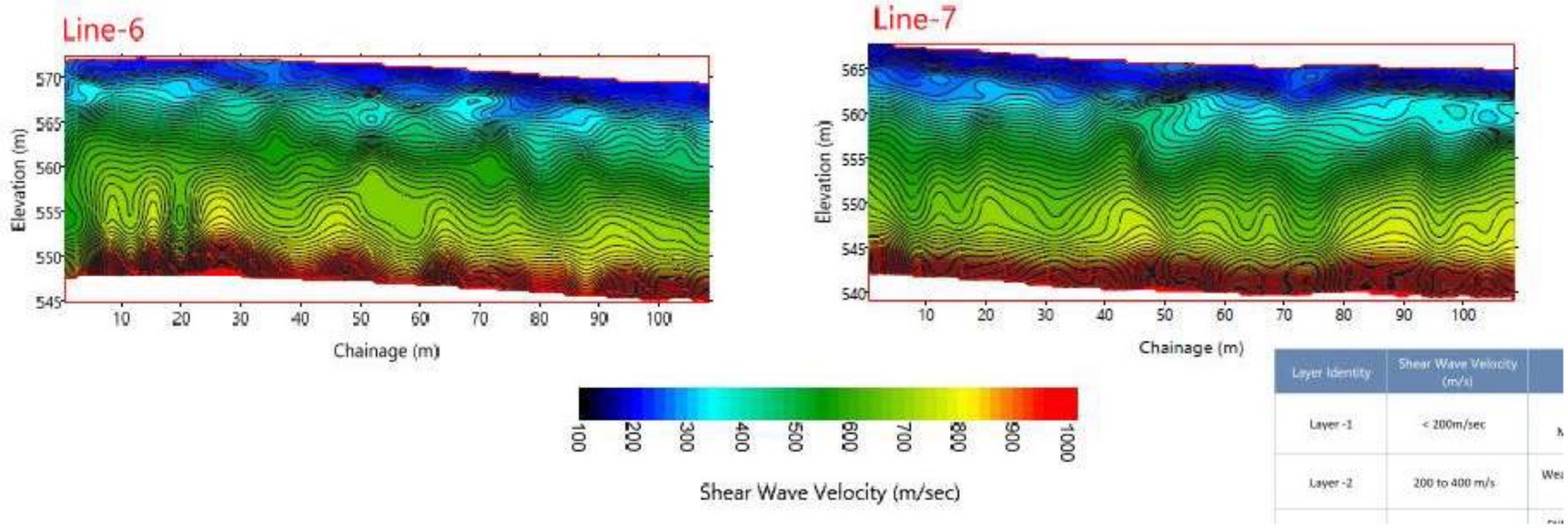



**Figure 5.5** MASW analysis results of Lines-6 and 7

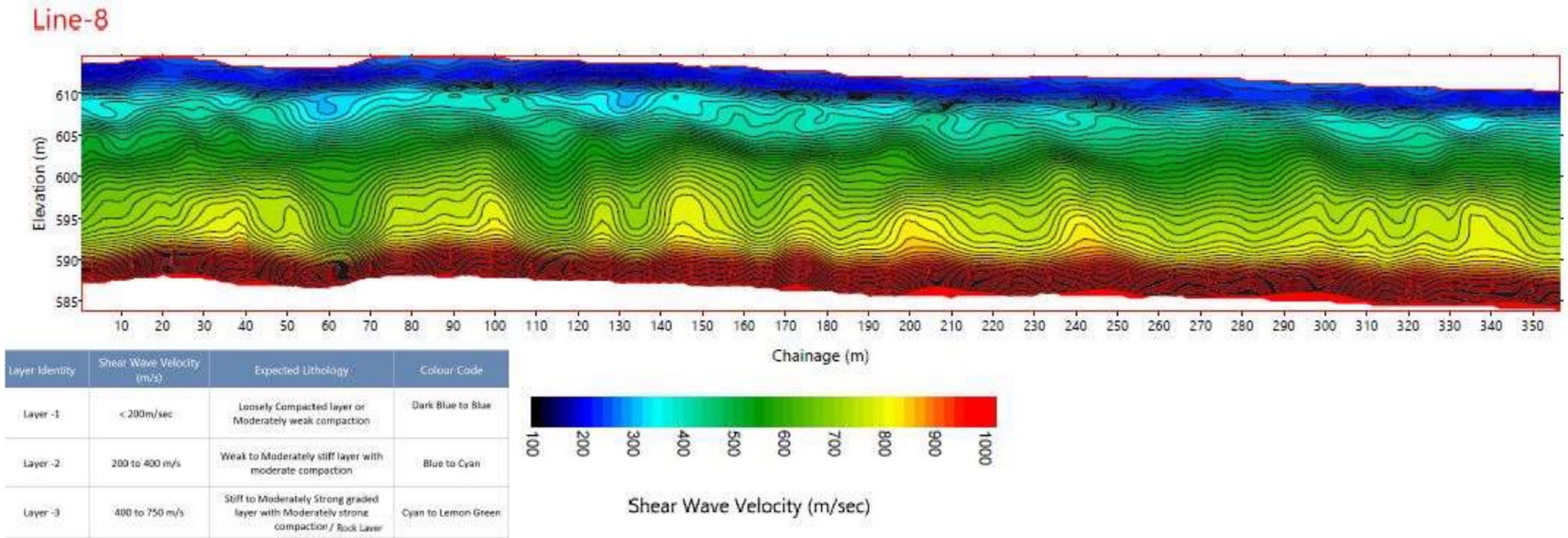



**Figure 5.6** MASW analysis results of Line-8

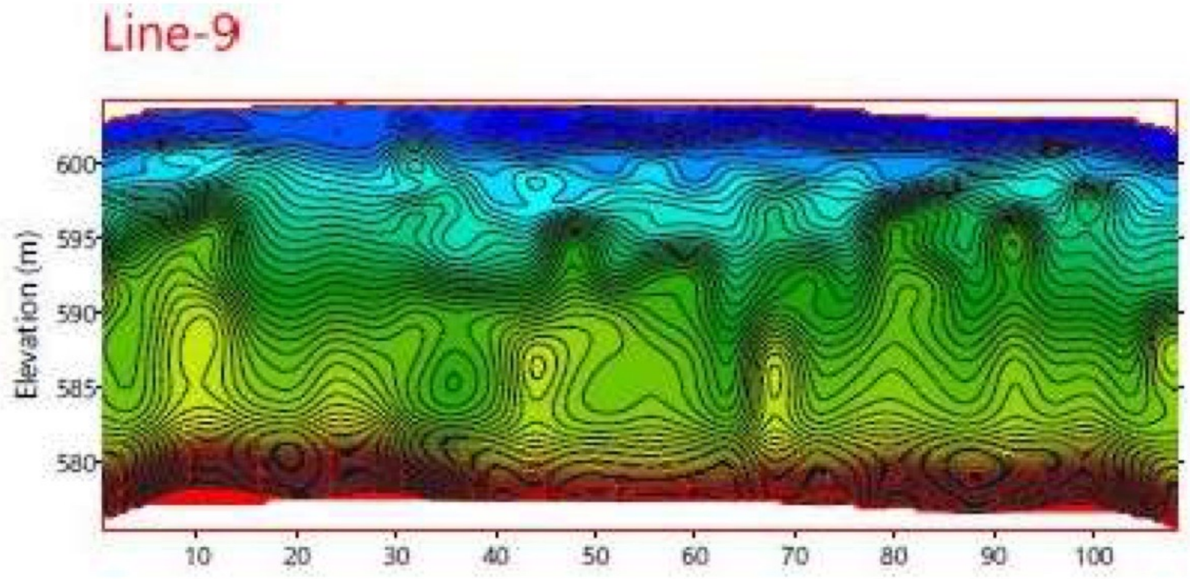



**Figure 5.7** MASW analysis results of Line-9

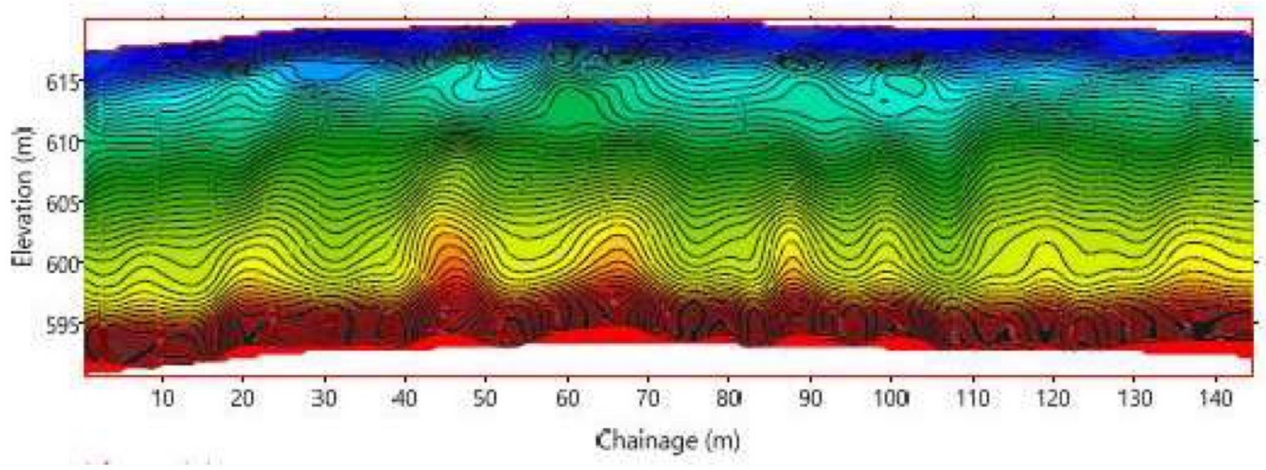



**Figure 5.8** MASW analysis results of Line-10

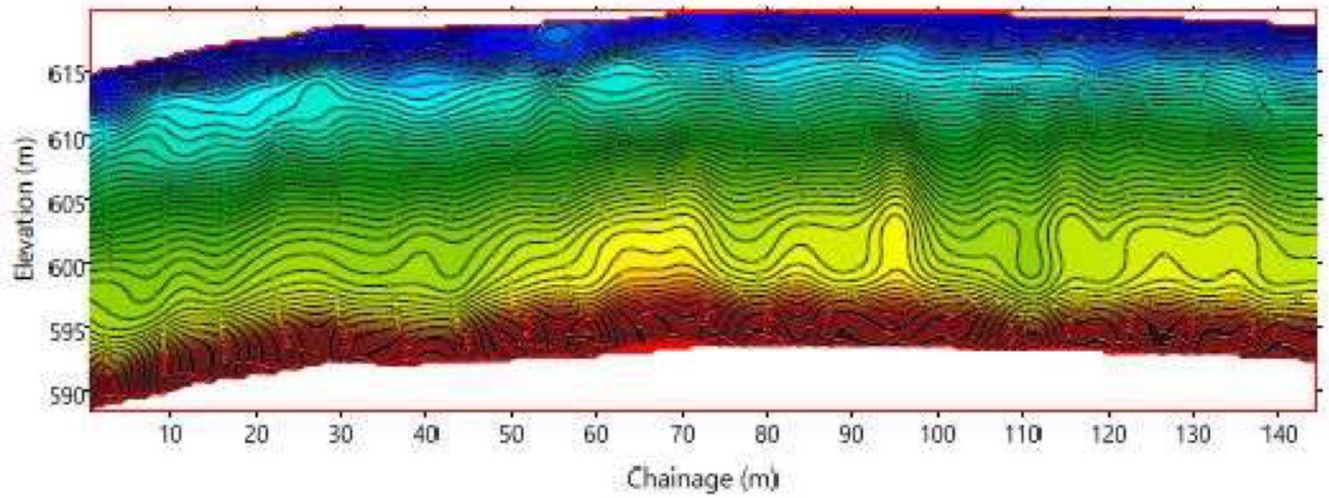



**Figure 5.9** MASW analysis results of Line-11

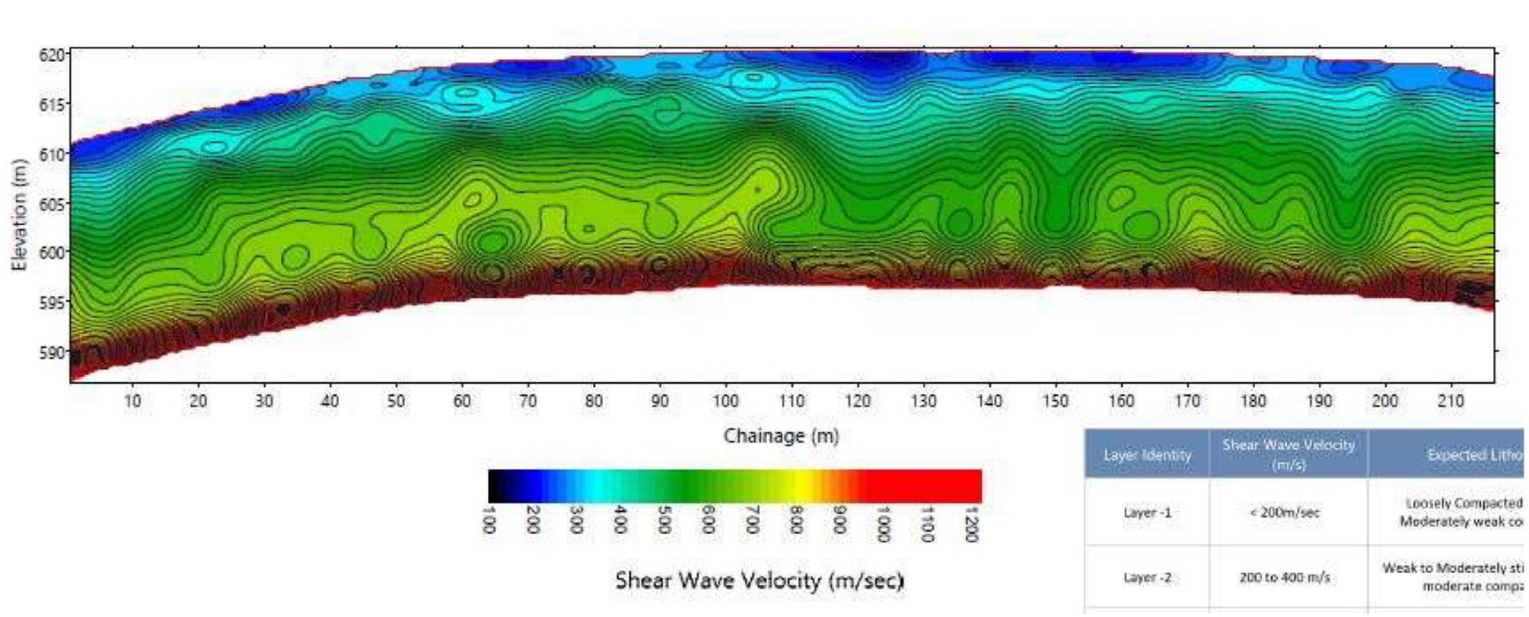



**Figure 5.10** MASW analysis results of Line-12

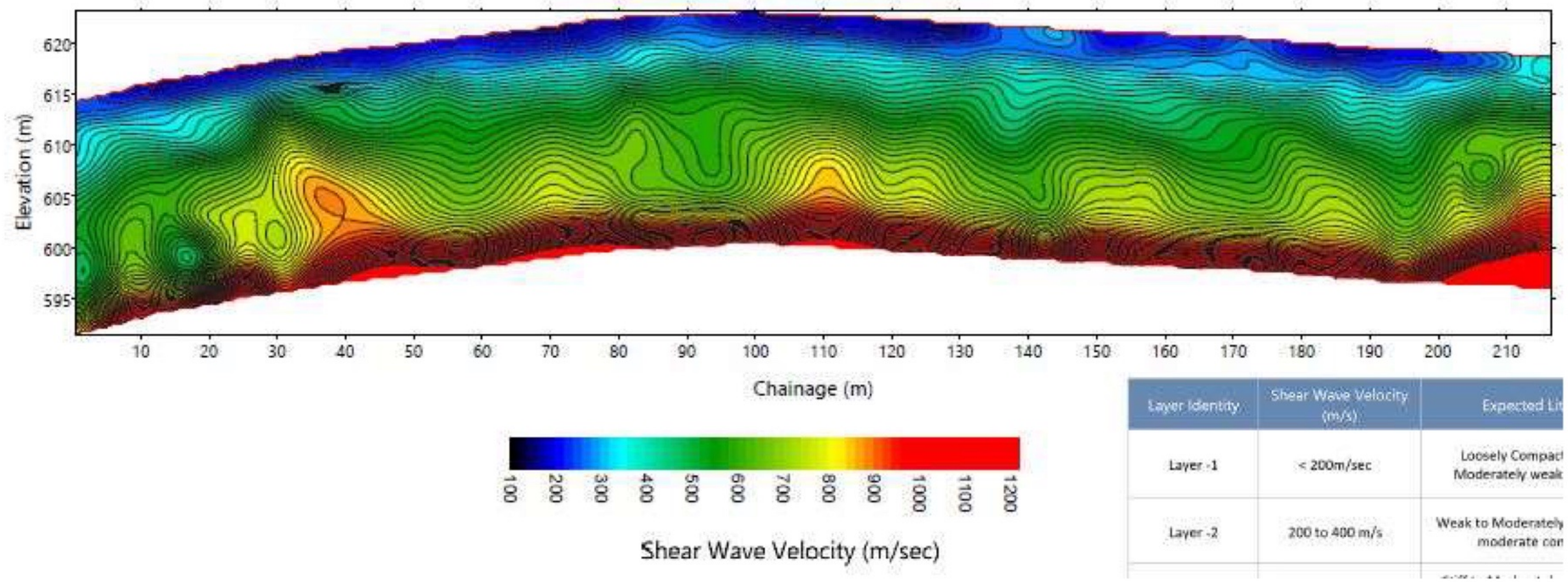



**Figure 5.11** MASW analysis results of Line-13

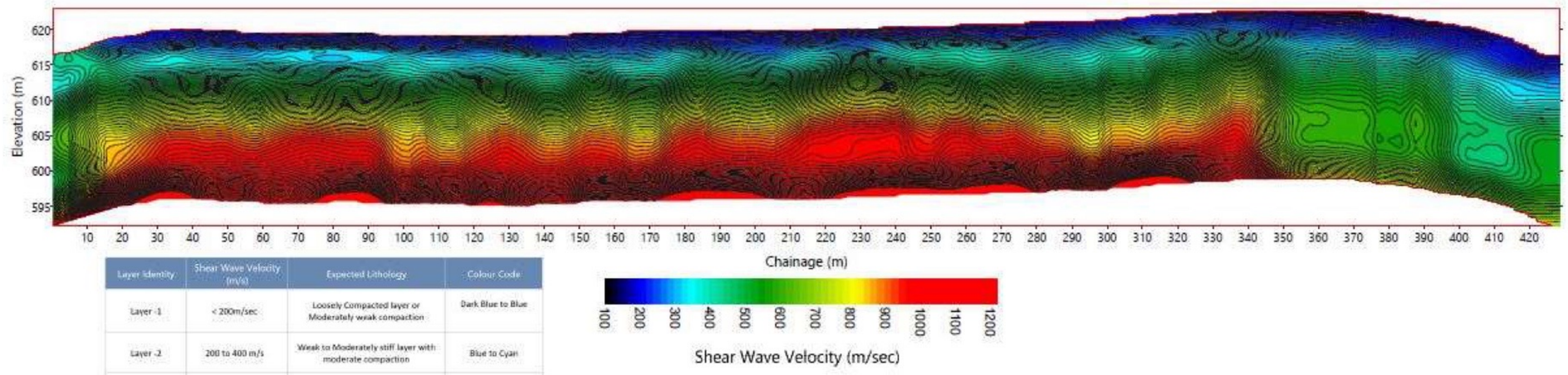



**Figure 5.12** MASW analysis results of Line-14

Details of the subsurface properties obtained from the MASW are listed in Table 5.2. It can be observed from Table 5.2 and Figure 5.1 to Figure ***5.12*** that the majority portion of the JLH contains loosely compacted material, which can be due to the (i) presence of a high percentage of leachates and (ii) undecomposed MSW.

**Table 5.2** The expected lithology for corresponding shear wave velocities provided by FGTL

| Layer Identity | Shear Wave Velocity (m/s) | Expected Lithology | Colour Code |
|---|---|---|---|
| Layer -1 | < 200m/sec | Loosely Compacted layer or Moderately weak compaction | Dark Blue to Blue |
| Layer -2 | 200 to 400 m/s | Weak to Moderately stiff layer with moderate compaction | Blue to Cyan |
| Layer -3 | 400 to 750 m/s | Stiff to Moderately Strong graded layer with Moderately strong compaction | Cyan to Lemon Green |
| Layer -4 | >750 m/s | Strong and highly compacted layer | Lemon Green to Red |

Further, to identify the presence of leachate and the state of the MSW, 2D-ERT investigations were conducted and the results are presented in the following (Lines 1 to 14 in Figure 5.13 to 5.25).

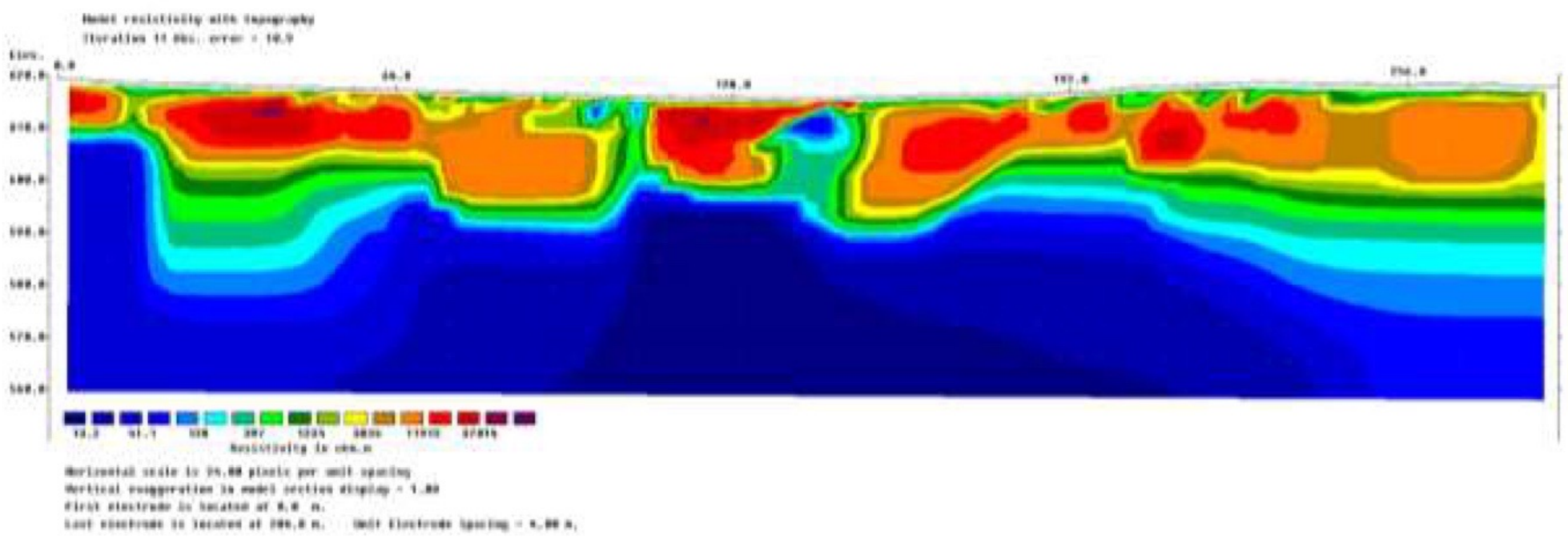


**Figure 5.13** 2D- electrical resistivity imaging map for Line-1

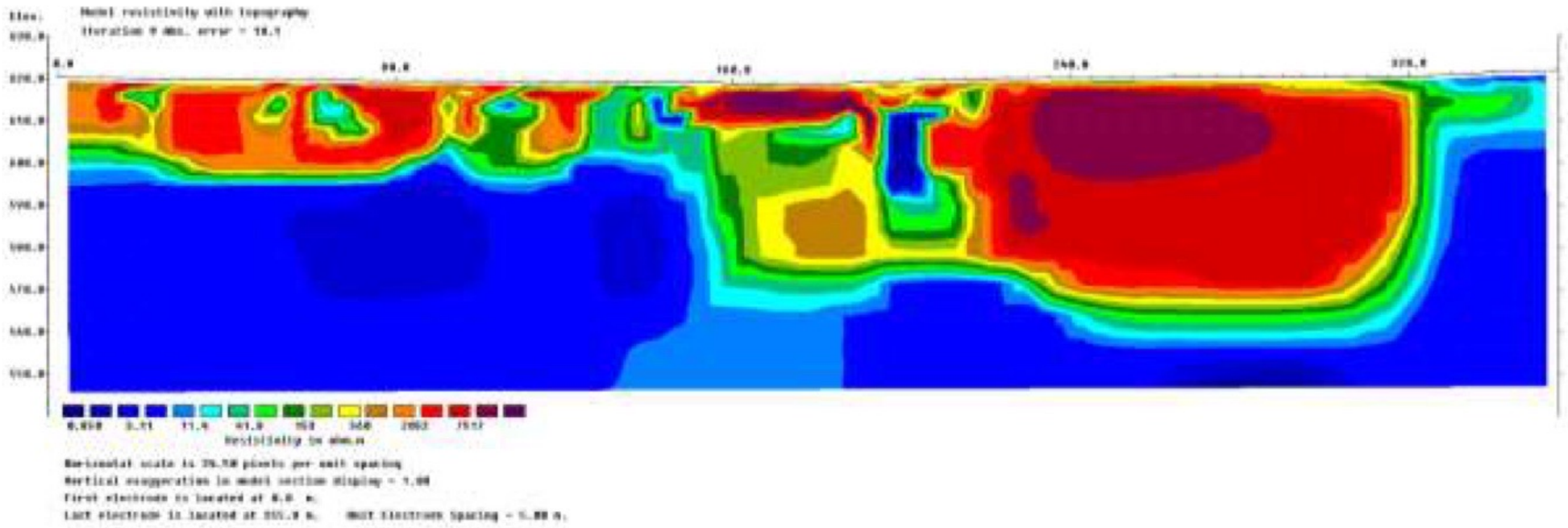



**Figure 5.14** 2D- electrical resistivity imaging map for Line-2

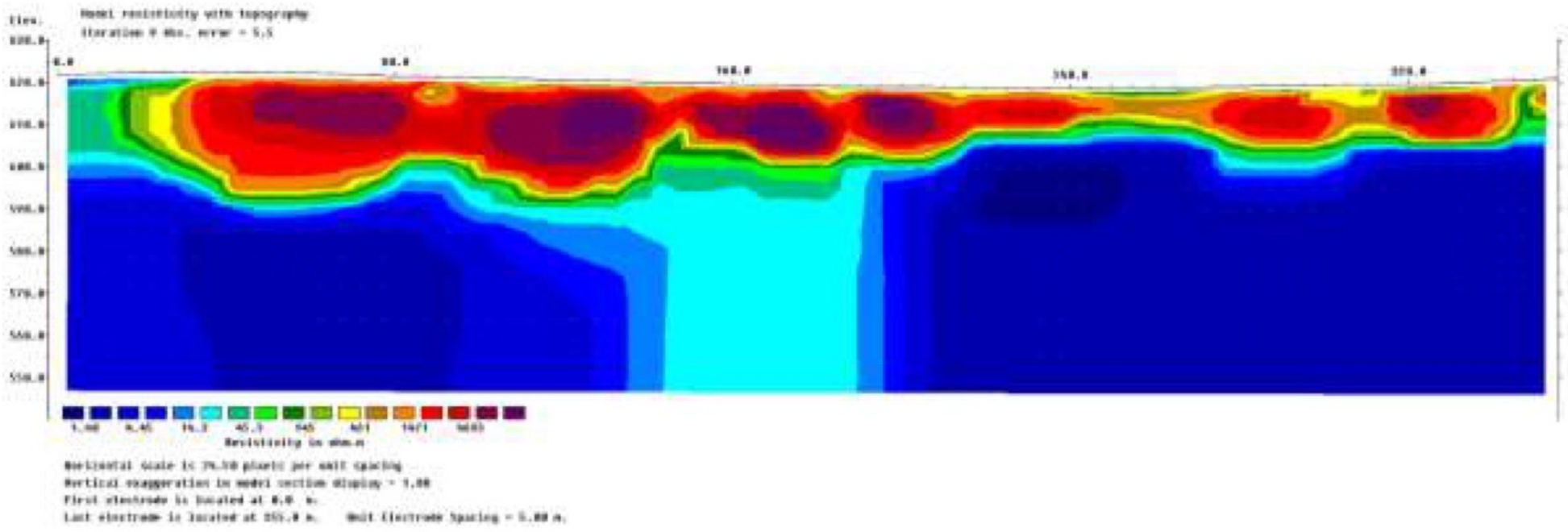



**Figure 5.15** 2D- electrical resistivity imaging map for Line-3

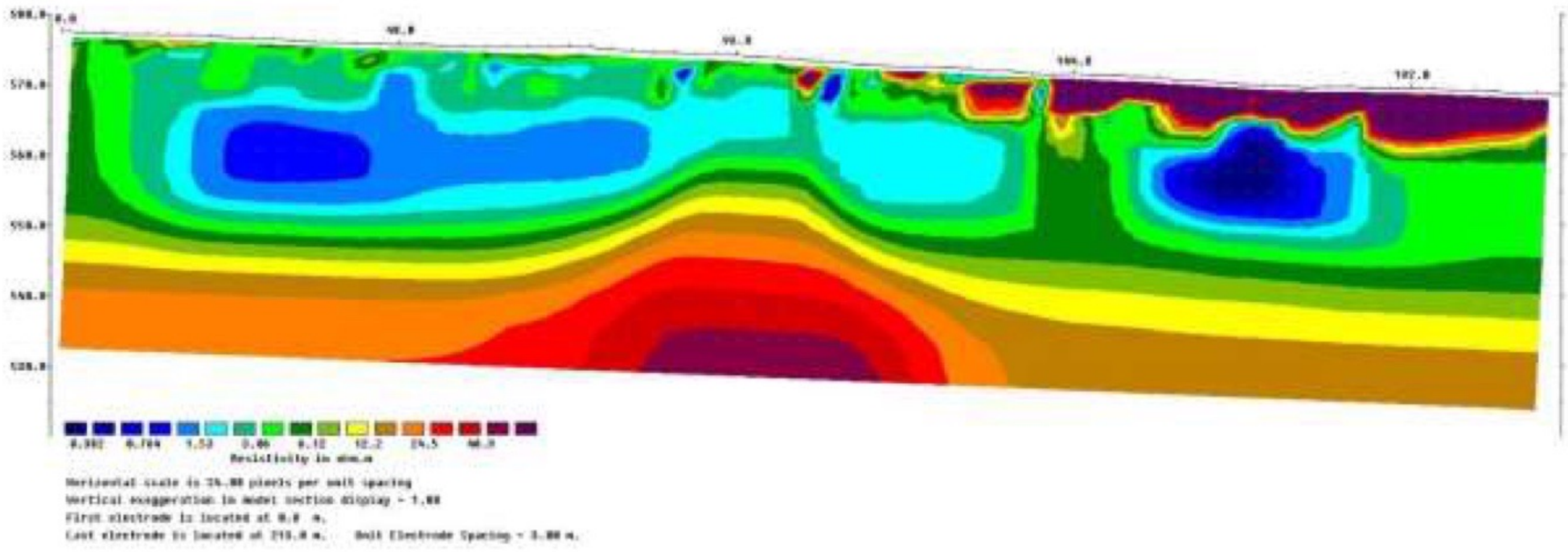



**Figure 5.16** 2D- electrical resistivity imaging map for Line-4

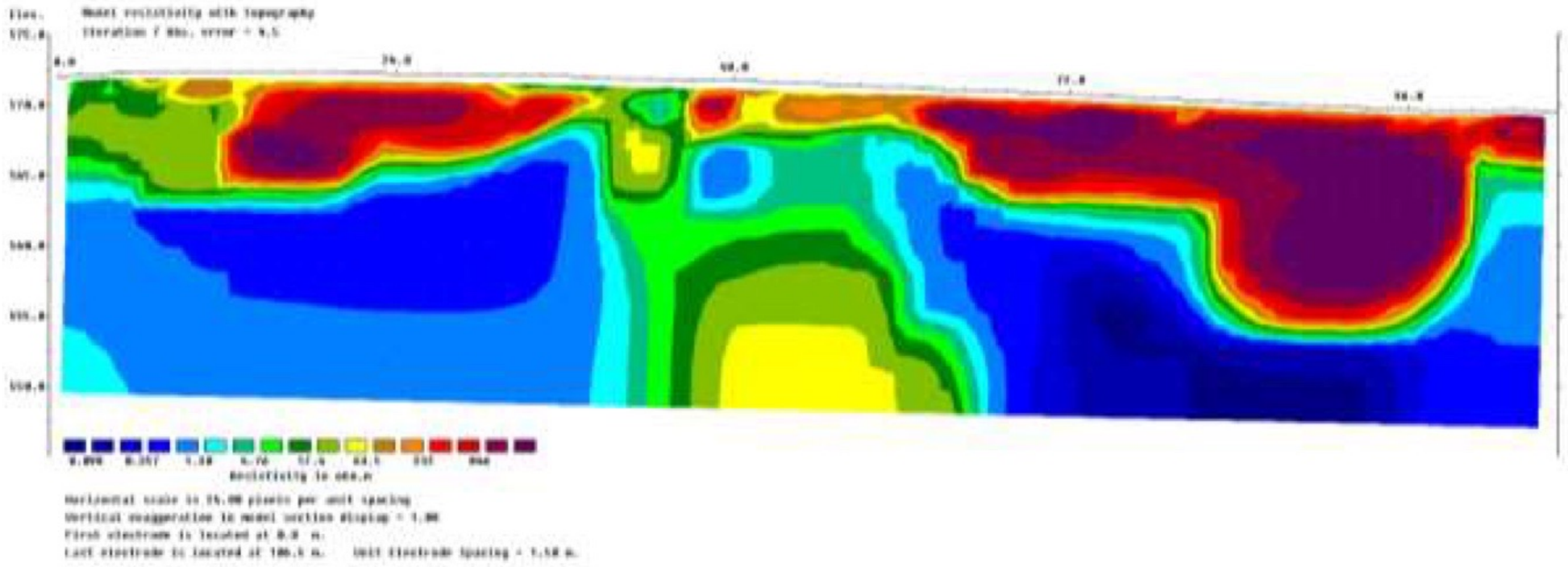


**Figure 5.17** 2D- electrical resistivity imaging map for Line-6

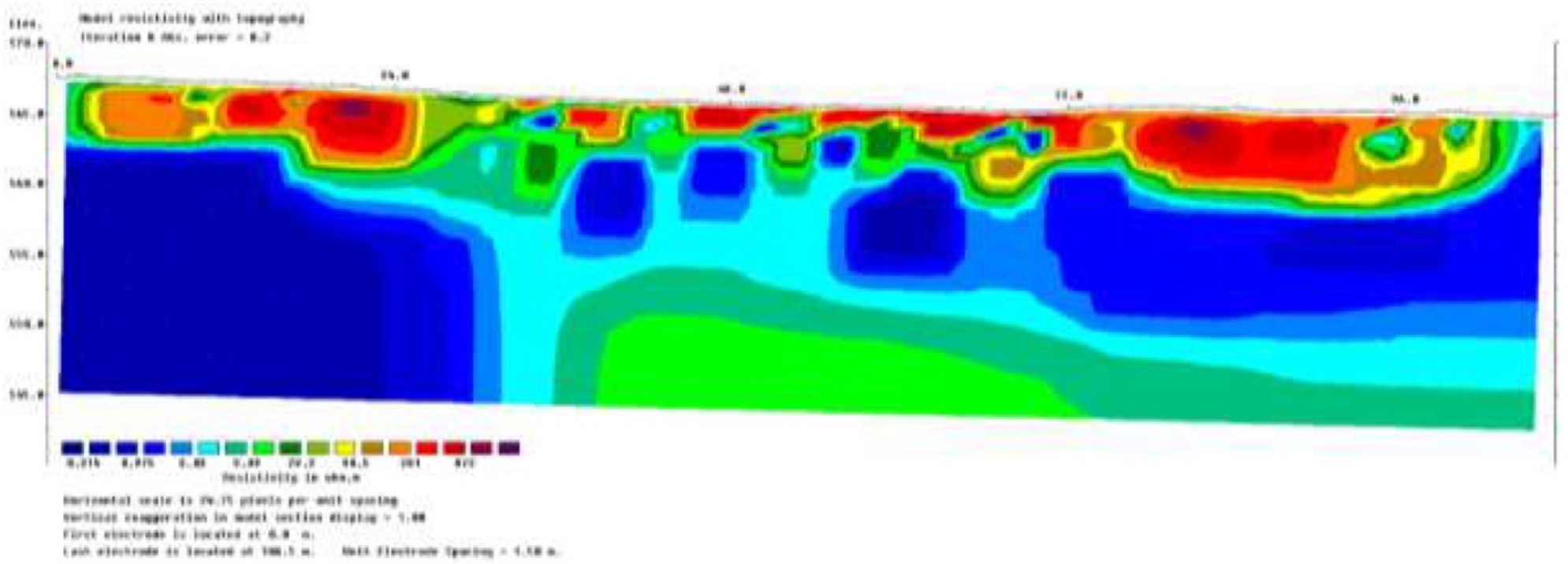


**Figure 5.18** 2D- electrical resistivity imaging map for Line-7

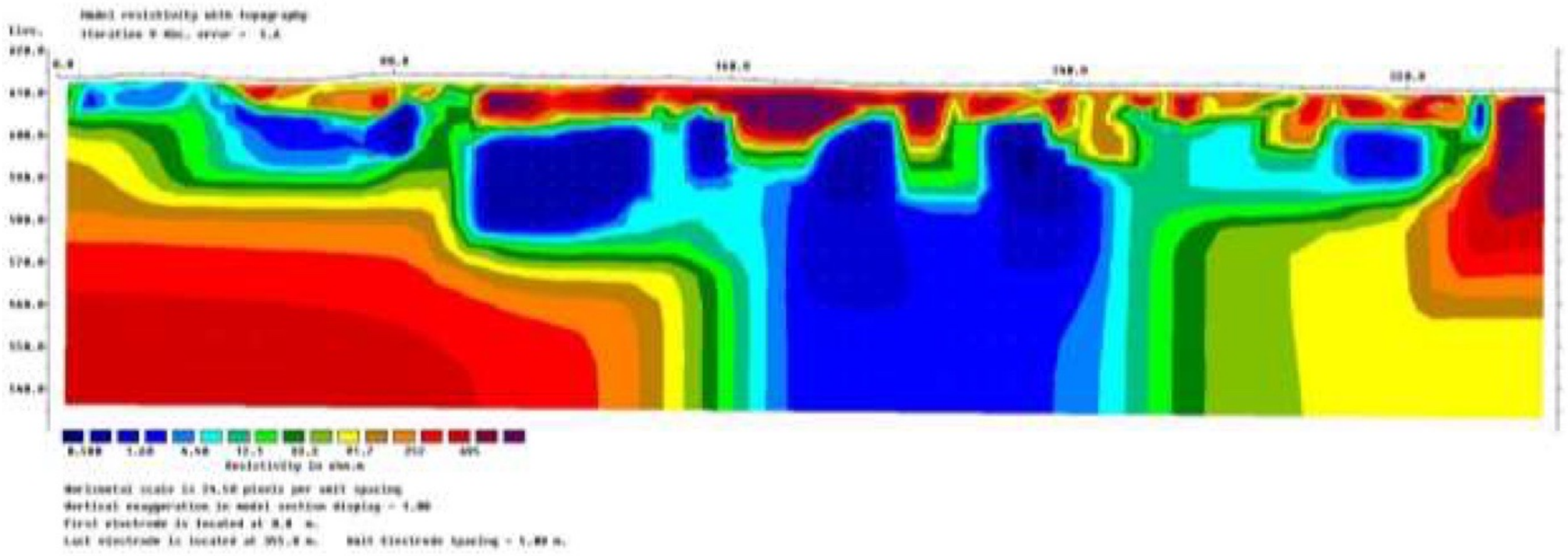


**Figure 5.19** 2D- electrical resistivity imaging map for Line-8

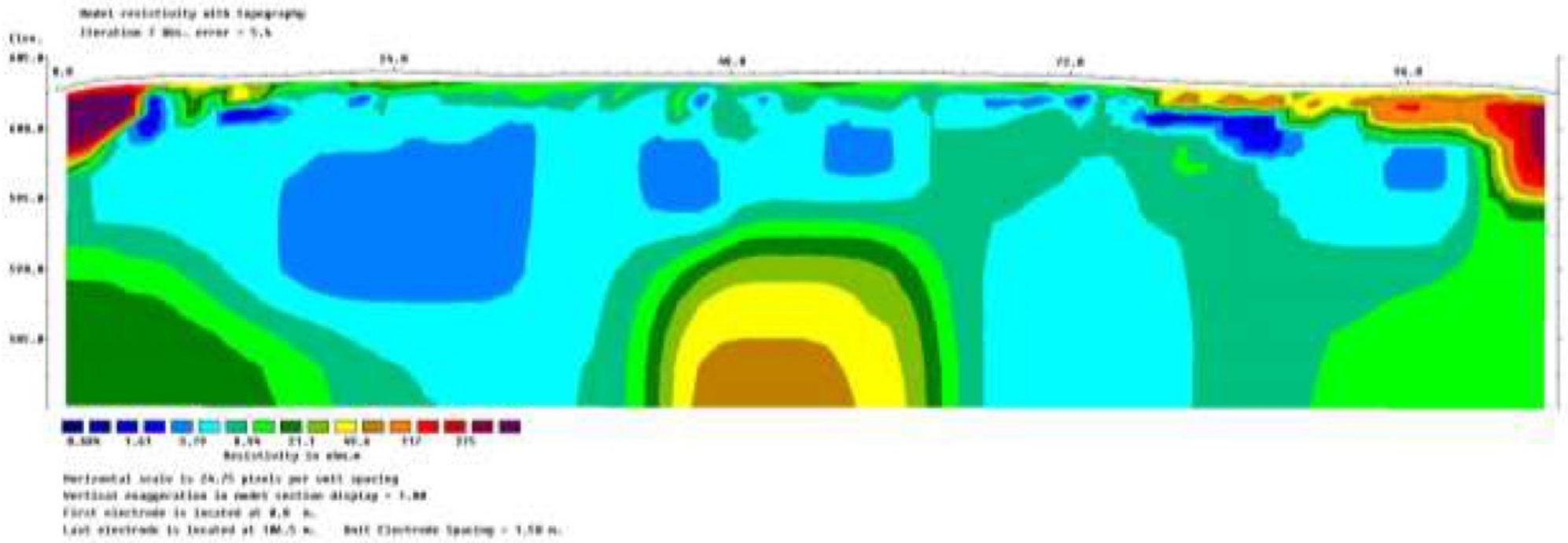


**Figure 5.20** 2D- electrical resistivity imaging map for Line-9

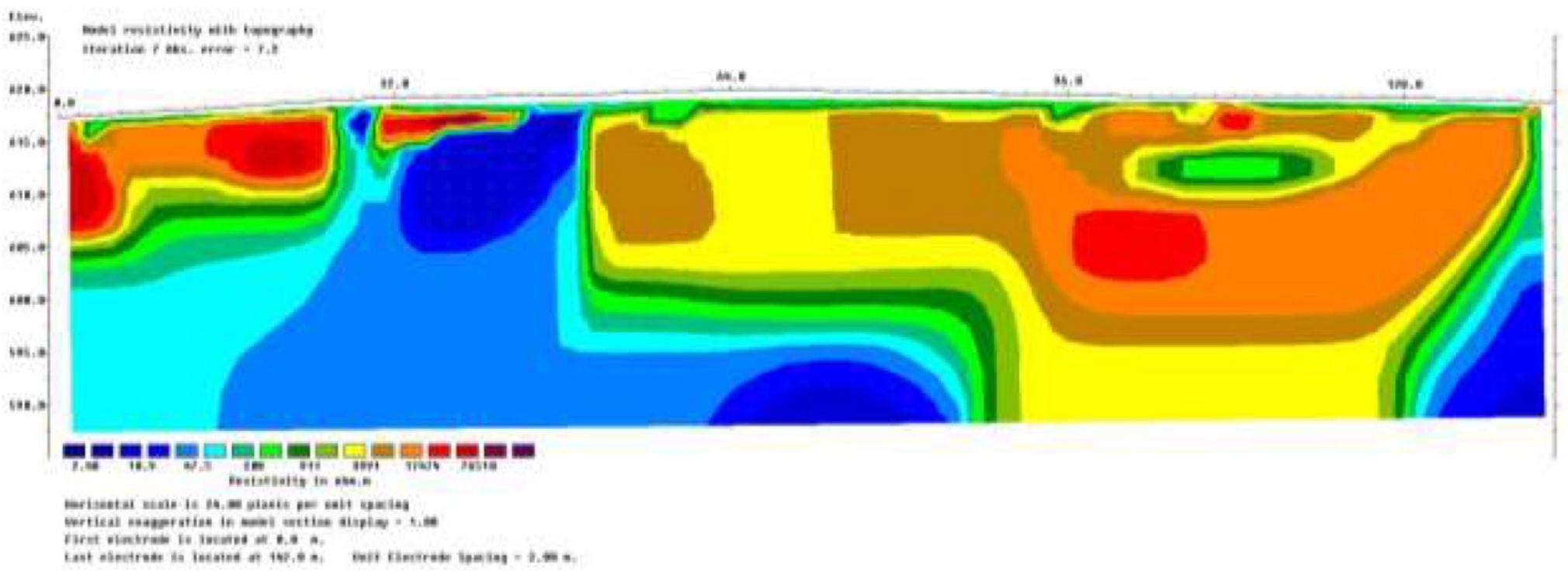


**Figure 5.21** 2D- electrical resistivity imaging map for Line-10

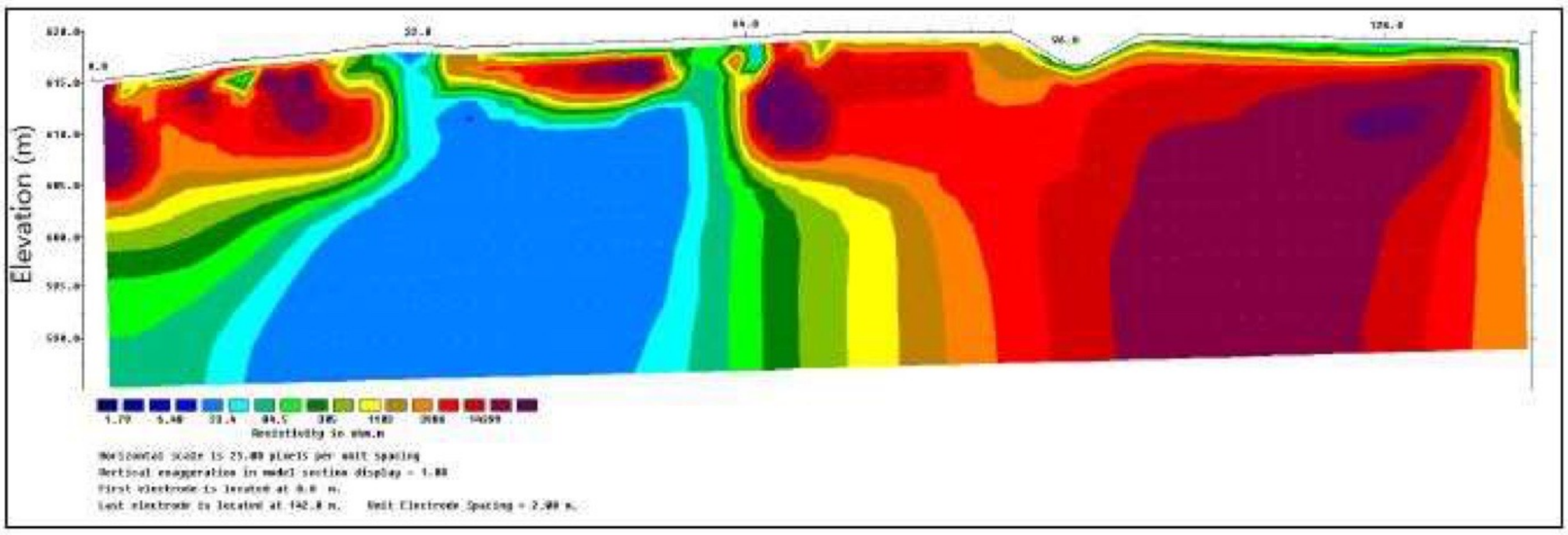



**Figure 5.22** 2D- electrical resistivity imaging map for Line-11

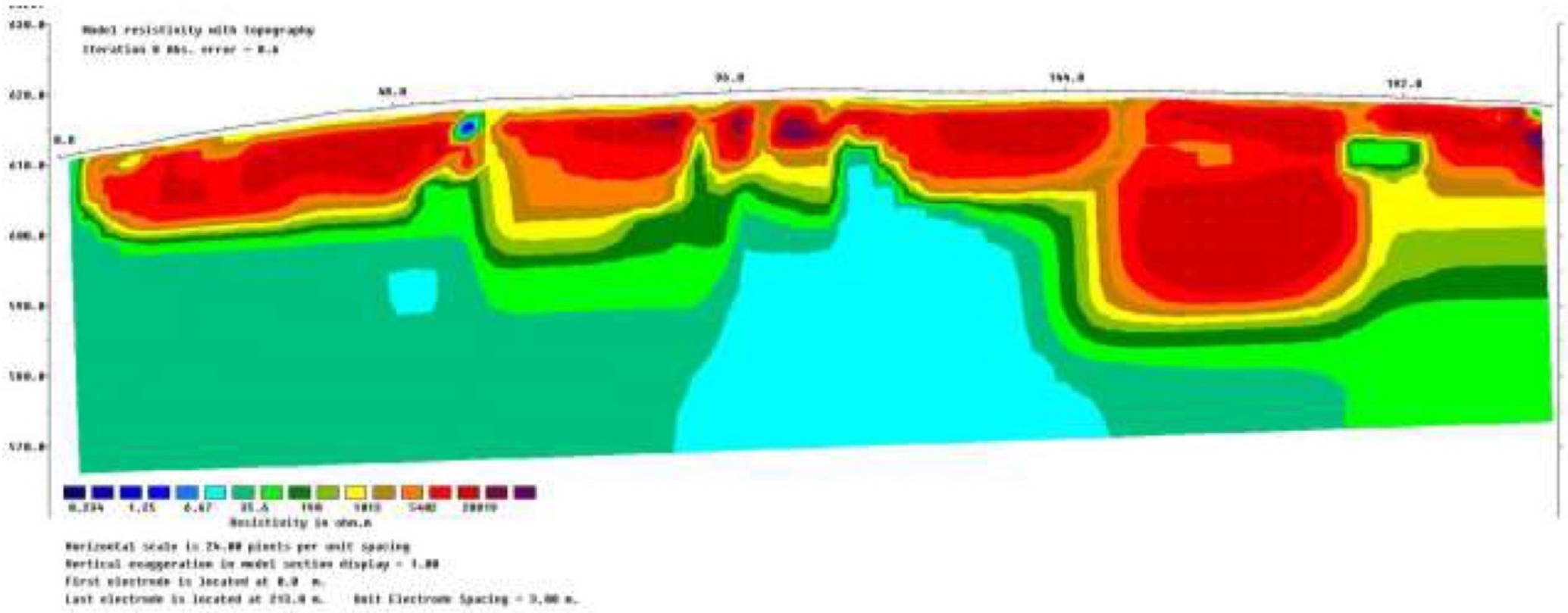



**Figure 5.23** 2D- electrical resistivity imaging map for Line-12

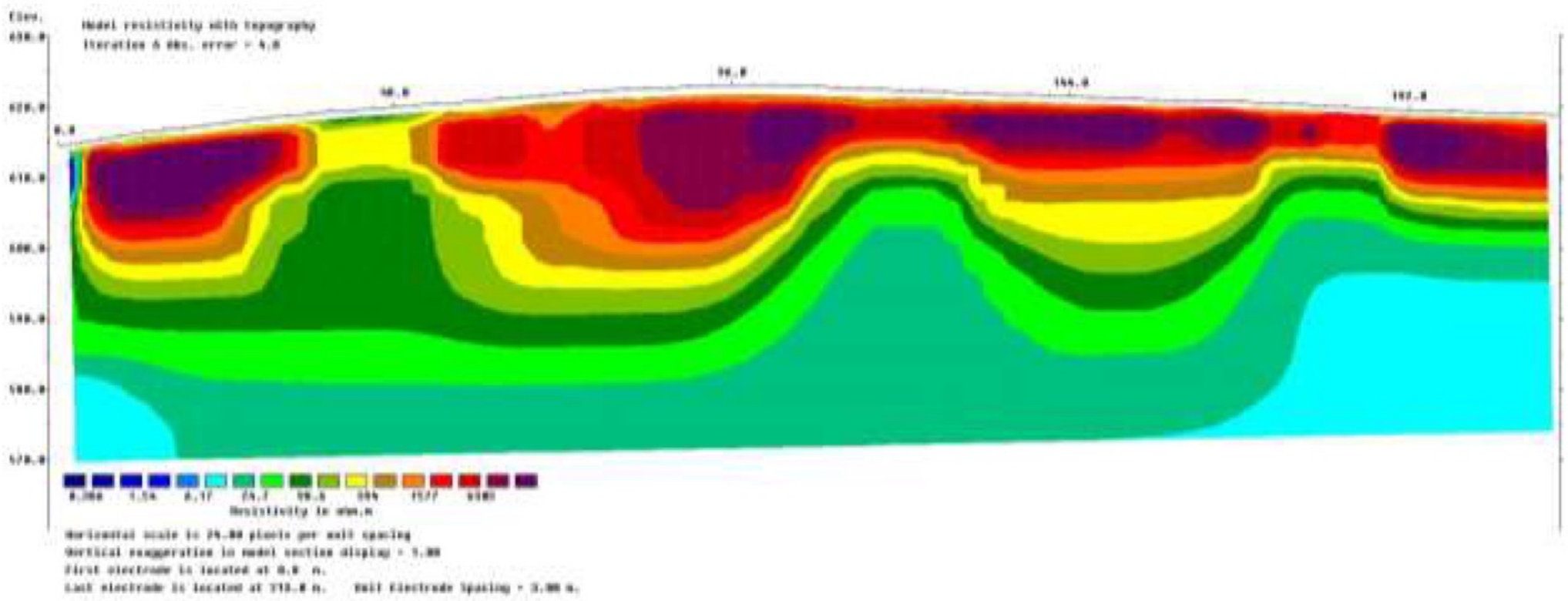



**Figure 5.24** 2D- electrical resistivity imaging map for Line-13

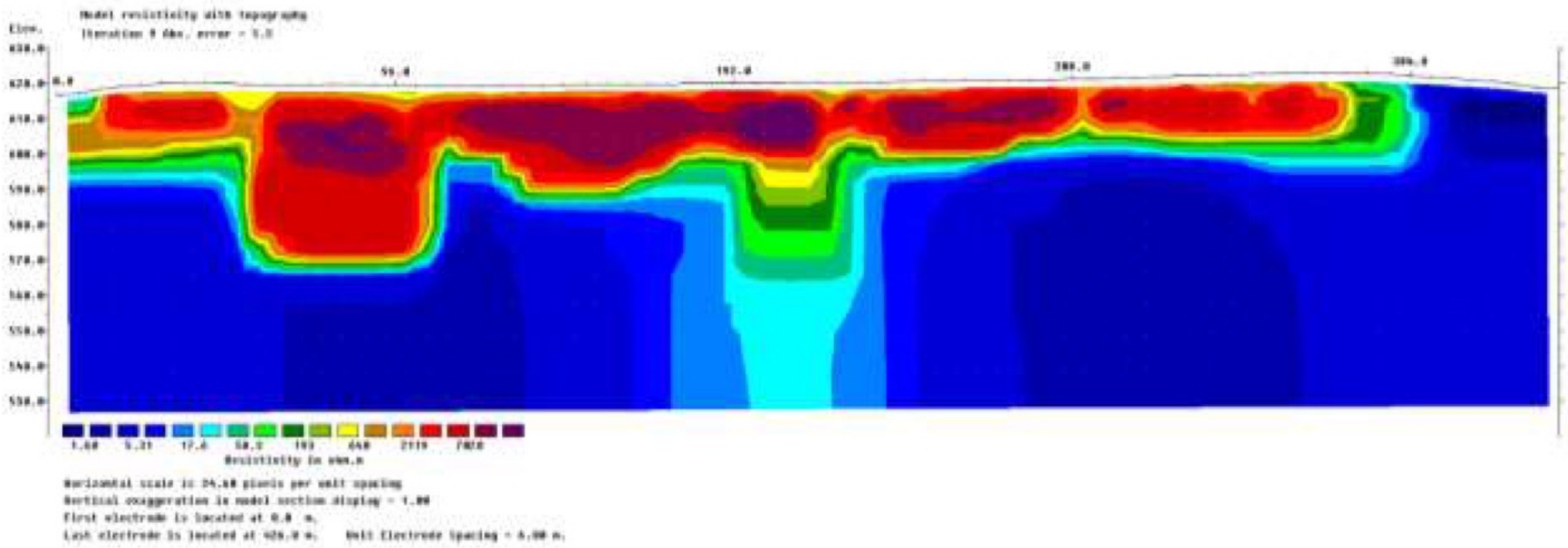



**Figure 5.25** 2D- electrical resistivity imaging map for Line-14

Based on the 2D ERT imaging results presented in Figures 5.13 to 5.25, it can be observed that the MSW at most of the locations of JLH possesses low electrical resistivity, which is indicative of the presence of saturated MSW with different salts and dissolved compounds. Moreover, Figures 5.12, 5.13, 5.15, 5.17 to 5.21 depict that the JLH consists of several isolated locations with extremely low electrical resistivity. Such isolated low-electrical resistivity locations could be due to the presence of saturated MSW, which is prone to decompose in due course, or conductive materials such as metals. This state of MSW will also be a root cause for the generation of combustible gases such as methane.

## 6. Details of the MSW sampling and on-site segregation

Before initiating sample collection, the soil cover, followed by geotextile, was removed carefully to avoid damage to the landfill cover system. Subsequently, a flight auger of ≈165 mm diameter attached to a drilling machine was inserted in the specific borehole location (refer to

Plate ***6.1***a). Samples were collected from different depths, until the hard strata or the presence of liquid interface is encountered. Details of the borehole location, termination depth, and the number of samples collected are mentioned in Table 6.1. A total of 16 boreholes were executed to retrieve 150 samples. The samples thus obtained were removed manually from the auger (refer to

Plate ***6.1***b-d) and sieved through a 10 mm sieve (refer to

Plate ***6.2***a). Subsequently, the coarse- and fine- fractions were weighed and the data is tabulated in Table 6.2. These fractions were packed in airtight press-lock bags to prevent moisture loss, if any, (refer to

Plate ***6.2***b and c). Subsequently, the airtight bags were packed and transported to IIT Bombay for further testing/analyses (refer to

Plate ***6.2***d and f). Later, the boreholes were sealed by the landfill operator (refer to Plate 6.3).

Incidentally, during the sampling, a few of the boreholes released foam/bubbles/liquid (refer to Plate 6.4a to c), which are indicative of the presence of undecomposed MSW.

(a)

(b)

(c)

(d)

**Plate 6.1** Images depicting the flight auger and the sample collection procedure

**Table 6.1** Details of the boreholes and number of samples collected

| BH | Location | Termination Depth (ft) | Depth till Sample Collected (ft) | Termination depth (m) | Nos. of Samples Retrieved |
|---|---|---|---|---|---|
| BH-1 | Near Line 13 End | 85.50 | 80 | 26.06 | 8 |
| BH-2 | Near Line 14 End | 105.50 | 100 | 32.16 | 10 |
| BH-3 | Near Line 1 End | 88.25 | 80 | 26.90 | 8 |
| BH-4 | Near Line 2 End | 124.50 | 120 | 37.95 | 12 |
| BH-5 | Near Line 13 Start | 104.50 | 100 | 31.85 | 10 |
| BH-6 | Near Line 12 Start | 126.25 | 120 | 38.48 | 12 |
| BH-7 | Near Line 10 Start | 127.50 | 120 | 38.86 | 12 |
| BH-8 | Near Line 14 Start | 15.75 | 15 | 4.80 | 3 |
| BH-9 | Near Line 3 Start | 15.50 | 15 | 4.72 | 3 |
| BH-10 | Near Line 2 Start / Centre | 139.00 | 139 | 42.37 | 14 |
| BH-11 | Near Line 1 Start | 138.50 | 130 | 42.21 | 13 |
| BH-12 | Near Line 10 End / Line 8 Centre | 139.00 | 139 | 42.37 | 14 |
| BH-13 | Near Line 9 Centre | 112.25 | 120 | 34.21 | 13 |
| BH-14 | Near Line 9 End | 19.25 | 15 | 5.87 | 3 |
| BH-15 | Near Line 4 Centre | 111.50 | 110 | 33.99 | 12 |
| BH-16 | Near Line 4 End | 23.50 | 20 | 7.16 | 3 |
| | | | **Total depth** | **449.96** | **150** |

(a)

(b)

(c)

(d)



(e)



(f)

**Plate 6.2** Images depicting the on-site segregation, weighing and packing of the samples being witnessed by the GHMC

**Table 6.2** Details of the coarse- and fine- samples obtained from the in-situ segregation

| Sample No. | Depth (m) | Weight of sample (kg) | | | Percentage weight | |
|---|---|---|---|---|---|---|
| | | Total | >10mm | <10mm | >10 mm | <10 mm |
| **Borehole-01** | | | | | | |
| 1 | 3 | 4.64 | 3.89 | 0.75 | 83.84 | 16.16 |
| 2 | 6 | 4.86 | 4.02 | 0.84 | 82.72 | 17.28 |
| 3 | 9 | 4.06 | 3.60 | 0.46 | 88.67 | 11.33 |
| 4 | 12 | 7.28 | 6.30 | 0.98 | 86.54 | 13.46 |
| 5 | 15 | 4.28 | 3.52 | 0.76 | 82.24 | 17.76 |
| 6 | 18 | 6.24 | 5.02 | 1.22 | 80.45 | 19.55 |
| 7 | 21 | 3.88 | 2.99 | 0.89 | 77.06 | 22.94 |
| 8 | 24 | 6.80 | 5.35 | 1.45 | 78.68 | 21.32 |
| **Borehole-02** | | | | | | |
| 9 | 3 | 8 | 6.89 | 1.11 | 86.13 | 13.88 |
| 10 | 6 | 8.96 | 7.62 | 1.34 | 85.04 | 14.96 |
| 11 | 9 | 6.22 | 5.4 | 0.82 | 86.82 | 13.18 |
| 12 | 12 | 6.2 | 5.36 | 0.84 | 86.45 | 13.55 |
| 13 | 15 | 6.56 | 5.58 | 0.98 | 85.06 | 14.94 |
| 14 | 18 | 6.72 | 6.05 | 0.67 | 90.03 | 9.97 |
| 15 | 21 | 6.82 | 5.55 | 1.27 | 81.38 | 18.62 |
| 16 | 24 | 6.4 | 4.95 | 1.45 | 77.34 | 22.66 |
| 17 | 27 | 6.31 | 4.68 | 1.63 | 74.17 | 25.83 |
| 18 | 30 | 4.88 | 3.79 | 1.09 | 77.66 | 22.34 |
| **Borehole-03** | | | | | | |
| 19 | 3 | 6.18 | 5.35 | 0.83 | 86.57 | 13.43 |
| 20 | 6 | 5.95 | 4.88 | 1.07 | 82.02 | 17.98 |
| 21 | 9 | 3.16 | 2.55 | 0.61 | 80.70 | 19.30 |
| 22 | 12 | 3.68 | 2.98 | 0.7 | 80.98 | 19.02 |
| 23 | 15 | 4.82 | 3.85 | 0.97 | 79.88 | 20.12 |
| 24 | 18 | 5.13 | 4.05 | 1.08 | 78.95 | 21.05 |
| 25 | 21 | 3.95 | 3.09 | 0.86 | 78.23 | 21.77 |
| 26 | 24 | 3.96 | 3.05 | 0.91 | 77.02 | 22.98 |
| **Borehole-04** | | | | | | |
| 27 | 3 | 3.1 | 2.75 | 0.35 | 88.71 | 11.29 |
| 28 | 6 | 3.05 | 2.56 | 0.49 | 83.93 | 16.07 |
| 29 | 9 | 5.31 | 4.51 | 0.8 | 84.93 | 15.07 |
| 30 | 12 | 5.22 | 4.39 | 0.83 | 84.10 | 15.90 |
| 31 | 15 | 3.82 | 3.25 | 0.57 | 85.08 | 14.92 |
| 32 | 18 | 4.48 | 3.69 | 0.79 | 82.37 | 17.63 |
| 33 | 21 | 5.04 | 4.05 | 0.99 | 80.36 | 19.64 |
| 34 | 24 | 6.02 | 4.96 | 1.06 | 82.39 | 17.61 |
| 35 | 27 | 5.25 | 4.22 | 1.03 | 80.38 | 19.62 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 36 | 30 | 4.32 | 3.52 | 0.8 | 81.48 | 18.52 |
| 37 | 33 | 4.25 | 3.32 | 0.93 | 78.12 | 21.88 |
| 38 | 36 | 5.92 | 4.55 | 1.37 | 76.86 | 23.14 |
| **Borehole-05** | | | | | | |
| 39 | 3 | 6.11 | 5.15 | 0.96 | 84.29 | 15.71 |
| 40 | 6 | 5.75 | 4.78 | 0.97 | 83.13 | 16.87 |
| 41 | 9 | 3.25 | 2.68 | 0.57 | 82.46 | 17.54 |
| 42 | 12 | 3.78 | 3.05 | 0.73 | 80.69 | 19.31 |
| 43 | 15 | 4.25 | 3.35 | 0.9 | 78.82 | 21.18 |
| 44 | 18 | 5.03 | 3.96 | 1.07 | 78.73 | 21.27 |
| 45 | 21 | 5.02 | 4.01 | 1.01 | 79.88 | 20.12 |
| 46 | 24 | 4.15 | 3.29 | 0.86 | 79.28 | 20.72 |
| 47 | 27 | 4.6 | 3.58 | 1.02 | 77.83 | 22.17 |
| 48 | 30 | 5.78 | 4.48 | 1.3 | 77.51 | 22.49 |
| **Borehole-06** | | | | | | |
| 49 | 3 | 5.88 | 4.98 | 0.9 | 84.69 | 15.31 |
| 50 | 6 | 3.09 | 2.58 | 0.51 | 83.50 | 16.50 |
| 51 | 9 | 3.11 | 2.56 | 0.55 | 82.32 | 17.68 |
| 52 | 12 | 4.88 | 3.98 | 0.9 | 81.56 | 18.44 |
| 53 | 15 | 5.08 | 4.25 | 0.83 | 83.66 | 16.34 |
| 54 | 18 | 3.96 | 3.23 | 0.73 | 81.57 | 18.43 |
| 55 | 21 | 5.07 | 4.09 | 0.98 | 80.67 | 19.33 |
| 56 | 24 | 4.89 | 3.88 | 1.01 | 79.35 | 20.65 |
| 57 | 27 | 5.42 | 4.29 | 1.13 | 79.15 | 20.85 |
| 58 | 30 | 5.02 | 4.05 | 0.97 | 80.68 | 19.32 |
| 59 | 33 | 3.65 | 2.88 | 0.77 | 78.90 | 21.10 |
| 60 | 36 | 4.36 | 3.41 | 0.95 | 78.21 | 21.79 |
| **Borehole-07** | | | | | | |
| 61 | 3 | 4.25 | 3.69 | 0.56 | 86.82 | 13.18 |
| 62 | 6 | 5.12 | 4.38 | 0.74 | 85.55 | 14.45 |
| 63 | 9 | 5.88 | 5.04 | 0.84 | 85.71 | 14.29 |
| 64 | 12 | 5.16 | 4.36 | 0.8 | 84.50 | 15.50 |
| 65 | 15 | 4.55 | 3.79 | 0.76 | 83.30 | 16.70 |
| 66 | 18 | 3.89 | 3.25 | 0.64 | 83.55 | 16.45 |
| 67 | 21 | 5.88 | 4.85 | 1.03 | 82.48 | 17.52 |
| 68 | 24 | 4.96 | 4.01 | 0.95 | 80.85 | 19.15 |
| 69 | 27 | 4.02 | 3.25 | 0.77 | 80.85 | 19.15 |
| 70 | 30 | 5.95 | 4.68 | 1.27 | 78.66 | 21.34 |
| 71 | 33 | 5.68 | 4.49 | 1.19 | 79.05 | 20.95 |
| 72 | 36 | 4.25 | 3.35 | 0.9 | 78.82 | 21.18 |
| **Borehole-08** | | | | | | |
| 73 | 1.5 | 3.52 | 2.17 | 1.35 | 61.65 | 38.35 |
| 74 | 3 | 5.18 | 1.25 | 3.93 | 24.13 | 75.87 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 75 | 4.5 | 4.30 | 0.80 | 3.50 | 18.60 | 81.40 |
| **Borehole-09** | | | | | | |
| 76 | 5 | 5.27 | 2.16 | 3.11 | 40.99 | 59.01 |
| 77 | 10 | 6.56 | 2.16 | 4.40 | 32.93 | 67.07 |
| 78 | 15 | 7.25 | 2.80 | 4.45 | 38.62 | 61.38 |
| **Borehole-10** | | | | | | |
| 79 | 3 | 7.24 | 6.25 | 0.99 | 86.33 | 13.67 |
| 80 | 6 | 3.38 | 2.89 | 0.49 | 85.50 | 14.50 |
| 81 | 9 | 3.30 | 2.75 | 0.55 | 83.33 | 16.67 |
| 82 | 12 | 2.82 | 2.38 | 0.44 | 84.40 | 15.60 |
| 83 | 15 | 2.65 | 2.25 | 0.40 | 84.91 | 15.09 |
| 84 | 18 | 4.32 | 3.89 | 0.43 | 90.05 | 9.95 |
| 85 | 21 | 3.32 | 2.78 | 0.54 | 83.73 | 16.27 |
| 86 | 24 | 4.44 | 3.76 | 0.68 | 84.68 | 15.32 |
| 87 | 27 | 5.62 | 4.62 | 1.00 | 82.21 | 17.79 |
| 88 | 30 | 7.15 | 5.79 | 1.36 | 80.98 | 19.02 |
| 89 | 33 | 7.05 | 5.58 | 1.47 | 79.15 | 20.85 |
| 90 | 36 | 5.92 | 4.65 | 1.27 | 78.55 | 21.45 |
| 91 | 39 | 6.44 | 4.99 | 1.45 | 77.48 | 22.52 |
| 92 | 41.7 | 2.65 | 2.05 | 0.60 | 77.36 | 22.64 |
| **Borehole-11** | | | | | | |
| 93 | 3 | 4.42 | 3.80 | 0.62 | 85.97 | 14.03 |
| 94 | 6 | 5.65 | 4.75 | 0.90 | 84.07 | 15.93 |
| 95 | 9 | 5.80 | 4.88 | 0.92 | 84.14 | 15.86 |
| 96 | 12 | 4.82 | 3.95 | 0.87 | 81.95 | 18.05 |
| 97 | 15 | 6.02 | 4.96 | 1.06 | 82.39 | 17.61 |
| 98 | 18 | 5.62 | 4.88 | 0.74 | 86.83 | 13.17 |
| 99 | 21 | 4.42 | 3.91 | 0.51 | 88.46 | 11.54 |
| 100 | 24 | 5.98 | 4.90 | 1.08 | 81.94 | 18.06 |
| 101 | 27 | 4.85 | 3.85 | 1.00 | 79.38 | 20.62 |
| 102 | 30 | 5.60 | 4.68 | 0.92 | 83.57 | 16.43 |
| 103 | 33 | 6.44 | 5.05 | 1.39 | 78.42 | 21.58 |
| 104 | 36 | 4.42 | 3.39 | 1.03 | 76.70 | 23.30 |
| 105 | 39 | 5.86 | 4.36 | 1.50 | 74.40 | 25.60 |
| **Borehole-12** | | | | | | |
| 106 | 3 | 6.26 | 5.41 | 0.85 | 86.42 | 13.58 |
| 107 | 6 | 6.36 | 5.25 | 1.11 | 82.55 | 17.45 |
| 108 | 9 | 6.65 | 5.65 | 1.00 | 84.96 | 15.04 |
| 109 | 12 | 5.85 | 4.98 | 0.87 | 85.13 | 14.87 |
| 110 | 15 | 5.96 | 5.08 | 0.88 | 85.23 | 14.77 |
| 111 | 18 | 4.48 | 3.95 | 0.53 | 88.17 | 11.83 |
| 112 | 21 | 4.78 | 3.99 | 0.79 | 83.47 | 16.53 |
| 113 | 24 | 6.62 | 5.54 | 1.08 | 83.69 | 16.31 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 114 | 27 | 4.45 | 3.79 | 0.66 | 85.17 | 14.83 |
| 115 | 30 | 6.80 | 5.32 | 1.48 | 78.24 | 21.76 |
| 116 | 33 | 5.30 | 4.25 | 1.05 | 80.19 | 19.81 |
| 117 | 36 | 7.98 | 6.25 | 1.73 | 78.32 | 21.68 |
| 118 | 39 | 6.41 | 5.22 | 1.19 | 81.44 | 18.56 |
| 119 | 41.7 | 6.84 | 5.44 | 1.40 | 79.53 | 20.47 |
| **Borehole-13** | | | | | | |
| 120 | 3 | 5.68 | 5.04 | 0.64 | 88.73 | 11.27 |
| 121 | 6 | 5.25 | 4.36 | 0.89 | 83.05 | 16.95 |
| 122 | 9 | 4.35 | 3.79 | 0.56 | 87.13 | 12.87 |
| 123 | 12 | 3.88 | 3.25 | 0.63 | 83.76 | 16.24 |
| 124 | 15 | 5.25 | 4.65 | 0.60 | 88.57 | 11.43 |
| 125 | 18 | 6.25 | 5.58 | 0.67 | 89.28 | 10.72 |
| 126 | 21 | 6.62 | 5.65 | 0.97 | 85.35 | 14.65 |
| 127 | 24 | 7.02 | 5.78 | 1.24 | 82.34 | 17.66 |
| 128 | 27 | 5.22 | 4.22 | 1.00 | 80.84 | 19.16 |
| 129 | 30 | 3.89 | 3.18 | 0.71 | 81.75 | 18.25 |
| 130 | 31.5 | 5.11 | 4.15 | 0.96 | 81.21 | 18.79 |
| 131 | 33 | 4.78 | 3.85 | 0.93 | 80.54 | 19.46 |
| 132 | 33.6 | 5.88 | 4.65 | 1.23 | 79.08 | 20.92 |
| **Borehole-14** | | | | | | |
| 133 | 1.5 | 9.02 | 2.81 | 6.21 | 31.15 | 68.85 |
| 134 | 3 | 6.34 | 2.78 | 3.56 | 43.85 | 56.15 |
| 135 | 4.5 | 7.96 | 3.96 | 4.00 | 49.75 | 50.25 |
| **Borehole-15** | | | | | | |
| 136 | 3 | 4.11 | 3.69 | 0.42 | 89.78 | 10.22 |
| 137 | 6 | 5.11 | 4.38 | 0.73 | 85.71 | 14.29 |
| 138 | 9 | 5.62 | 5.04 | 0.58 | 89.68 | 10.32 |
| 139 | 12 | 3.65 | 3.15 | 0.50 | 86.30 | 13.70 |
| 140 | 15 | 4.18 | 3.59 | 0.59 | 85.89 | 14.11 |
| 141 | 18 | 5.01 | 4.19 | 0.82 | 83.63 | 16.37 |
| 142 | 21 | 4.29 | 3.72 | 0.57 | 86.71 | 13.29 |
| 143 | 24 | 6.11 | 5.02 | 1.09 | 82.16 | 17.84 |
| 144 | 27 | 3.65 | 3.02 | 0.63 | 82.74 | 17.26 |
| 145 | 30 | 5.42 | 4.38 | 1.04 | 80.81 | 19.19 |
| 146 | 33 | 4.45 | 3.55 | 0.90 | 79.78 | 20.22 |
| 147 | 33.6 | 3.98 | 3.09 | 0.89 | 77.64 | 22.36 |
| **Borehole-16** | | | | | | |
| 148 | 10 | 3.05 | 2.75 | 0.30 | 90.16 | 9.84 |
| 149 | 15 | 3.12 | 2.75 | 0.37 | 88.14 | 11.86 |
| 150 | 20 | 4.35 | 3.85 | 0.50 | 88.51 | 11.49 |

(a) (b)

**Plate 6.3** The photographs depicting the borehole and its closure

(a) (b)

(c)

**Plate 6.4** The photographs depicting the leachate and bubble formation and bursting by landfill gas emission the release of foam/bubbles/liquid from a typical borehole

## 7. Processing and characterization of the DMSW @ IIT Bombay Laboratory

The coarse fraction, i.e., >10 mm obtained from the site, was further segregated into plastics, textiles, residues (such as fine dirt and mixed waste) and stones, and the weight of each of these fractions was recorded. For this purpose, 1/3$^{rd}$ of the total samples available from each borehole were selected randomly. The coarse-fraction is particularly useful for subsequent estimation of calorific values. The photographs depicting the laboratory segregation process are mentioned in Plate 7.1. Subsequently, each fraction's total weight and percentage are mentioned in Table 7.1. From Table 7.1, it can be observed that a significant fraction of the coarse fraction is plastics, followed by residues and stones. However, it can be observed that combining all together (i.e., coarse- and fine- fractions), fine fractions and residues will be a large fraction that is prone to decomposition. Hence, subsequent characterization of these fractions is a must.

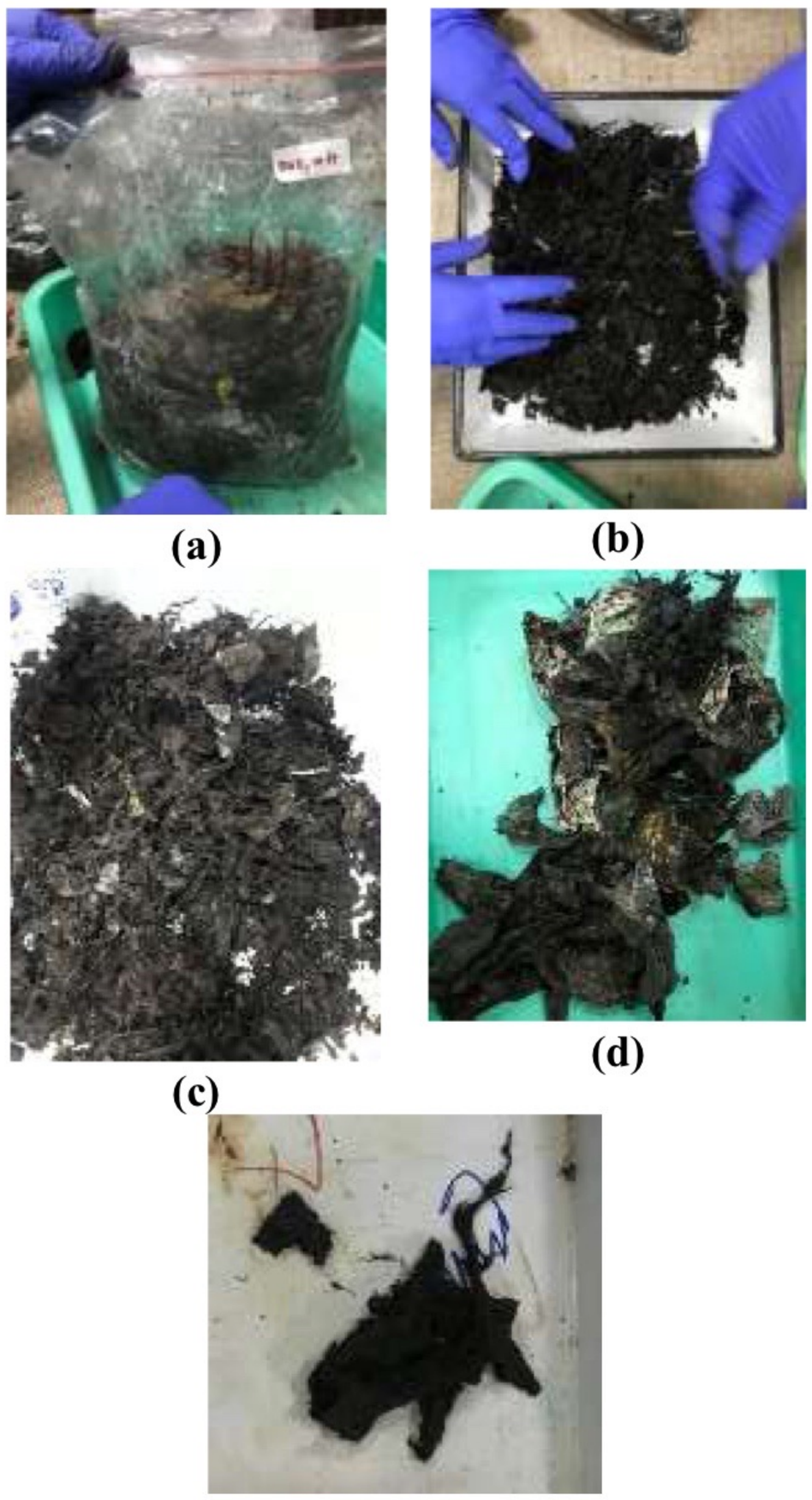


**Plate 7.1** Images depicting the laboratory segregation process of the coarse-fractions

**Table 7.1** Results obtained for the coarse-fractions of the MSW

| BH | Depth (m) | Weight (g) | | | | | Percentage weight | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Plastics | Textile | Residues | Stones | Total | Plastics | Textile | Residues | Stones |
| BH-01 | 12 | 234 | 157 | 772 | 0 | 1163 | 20.12 | 13.50 | 66.38 | 0.00 |
| | 15 | 308 | 163 | 890 | 0 | 1361 | 22.63 | 11.98 | 65.39 | 0.00 |
| | 24 | 445 | 177 | 1243 | 0 | 1865 | 23.86 | 9.49 | 66.65 | 0.00 |
| | **Avg** | **329** | **166** | **968** | **0** | **1463** | **22.20** | **11.66** | **66.14** | **0.00** |
| BH-02 | 3 | 158 | 100 | 679 | 0 | 937 | 16.86 | 10.67 | 72.47 | 0.00 |
| | 6 | 263 | 202 | 858 | 0 | 1323 | 19.88 | 15.27 | 64.85 | 0.00 |
| | 9 | 437 | 104 | 463 | 0 | 1004 | 43.53 | 10.36 | 46.12 | 0.00 |
| | 12 | 411 | 104 | 333 | 0 | 848 | 48.47 | 12.26 | 39.27 | 0.00 |
| | **Avg** | **317** | **128** | **583** | **0** | **1028** | **32.18** | **12.14** | **55.68** | **0.00** |
| BH-03 | 3 | 284 | 32 | 283 | 32 | 631 | 45.01 | 5.07 | 44.85 | 5.07 |
| | 21 | 364 | 108 | 30 | 0 | 502 | 72.51 | 21.51 | 5.98 | 0.00 |
| | 24 | 274 | 221 | 115 | 0 | 610 | 44.92 | 36.23 | 18.85 | 0.00 |
| | **Avg** | **307** | **120** | **143** | **11** | **581** | **54.15** | **20.94** | **23.23** | **1.69** |
| BH-04 | 15 | 259 | 99 | 298 | 7 | 663 | 39.06 | 14.93 | 44.95 | 1.06 |
| | 27 | 333 | 79 | 6 | 0 | 418 | 79.67 | 18.90 | 1.44 | 0.00 |
| | 30 | 226 | 98 | 490 | 79 | 893 | 25.31 | 10.97 | 54.87 | 8.85 |
| | 36 | 194 | 385 | 87 | 0 | 666 | 29.13 | 57.81 | 13.06 | 0.00 |
| | **Avg** | **253** | **165** | **220** | **22** | **660** | **43.29** | **25.65** | **28.58** | **2.48** |
| BH-05 | 15 | 245 | 96 | 322 | 0 | 663 | 36.95 | 14.48 | 48.57 | 0.00 |
| | 27 | 270 | 243 | 315 | 0 | 828 | 32.61 | 29.35 | 38.04 | 0.00 |
| | 30 | 292 | 57 | 58 | 0 | 407 | 71.74 | 14.00 | 14.25 | 0.00 |
| | 33 | 361 | 0 | 29 | 0 | 390 | 92.56 | 0.00 | 7.44 | 0.00 |
| | **Avg** | **292** | **99** | **181** | **0** | **572** | **58.47** | **14.46** | **27.07** | **0.00** |
| BH-06 | 6 | 320 | 20 | 623 | 4 | 967 | 33.09 | 2.07 | 64.43 | 0.41 |
| | 9 | 244 | 30 | 667 | 149 | 1090 | 22.39 | 2.75 | 61.19 | 13.67 |
| | 18 | 659 | 34 | 56 | 0 | 749 | 87.98 | 4.54 | 7.48 | 0.00 |
| | 36 | 460 | 0 | 56 | 8 | 524 | 87.79 | 0.00 | 10.69 | 1.53 |
| | **Avg** | **421** | **21** | **351** | **40** | **833** | **57.81** | **2.34** | **35.95** | **3.90** |
| BH-07 | 3 | 227 | 126 | 190 | 0 | 543 | 41.80 | 23.20 | 34.99 | 0.00 |
| | 12 | 362 | 37 | 822 | 52 | 1273 | 28.44 | 2.91 | 64.57 | 4.08 |
| | 18 | 329 | 84 | 723 | 141 | 1277 | 25.76 | 6.58 | 56.62 | 11.04 |
| | 27 | 606 | 87 | 152 | 0 | 845 | 71.72 | 10.30 | 17.99 | 0.00 |
| | **Avg** | **381** | **84** | **472** | **48** | **985** | **41.93** | **10.75** | **43.54** | **3.78** |
| BH-08 | 15 | 22 | 7 | 315 | 431 | 775 | 2.84 | 0.90 | 40.65 | 55.61 |
| BH-10 | 3 | 231 | 194 | 467 | 16 | 908 | 25.44 | 21.37 | 51.43 | 1.76 |
| | 6 | 24 | 816 | 23 | 0 | 863 | 2.78 | 94.55 | 2.67 | 0.00 |
| | 9 | 273 | 29 | 190 | 25 | 517 | 52.80 | 5.61 | 36.75 | 4.84 |
| | 15 | 178 | 53 | 264 | 41 | 536 | 33.21 | 9.89 | 49.25 | 7.65 |
| | 18 | 214 | 66 | 130 | 0 | 410 | 52.20 | 16.10 | 31.71 | 0.00 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Avg** | **184** | **232** | **215** | **16** | **647** | **33.29** | **29.50** | **34.36** | **2.85** |
| BH-11 | 15 | 204 | 21 | 533 | 85 | 843 | 24.20 | 2.49 | 63.23 | 10.08 |
| | 18 | 167 | 189 | 475 | 0 | 831 | 20.10 | 22.74 | 57.16 | 0.00 |
| | 33 | 211 | 49 | 595 | 0 | 855 | 24.68 | 5.73 | 69.59 | 0.00 |
| | 36 | 232 | 80 | 715 | 0 | 1027 | 22.59 | 7.79 | 69.62 | 0.00 |
| | **Avg** | **204** | **85** | **580** | **21** | **889** | **22.89** | **9.69** | **64.90** | **2.52** |
| BH-12 | 9 | 316 | 158 | 347 | 0 | 821 | 38.49 | 19.24 | 42.27 | 0.00 |
| | 15 | 340 | 59 | 169 | 0 | 568 | 59.86 | 10.39 | 29.75 | 0.00 |
| | 18 | 188 | 293 | 73 | 6 | 560 | 33.57 | 52.32 | 13.04 | 1.07 |
| | 24 | 189 | 212 | 354 | 0 | 755 | 25.03 | 28.08 | 46.89 | 0.00 |
| | 42 | 395 | 182 | 147 | 0 | 724 | 54.56 | 25.14 | 20.30 | 0.00 |
| | **Avg** | **286** | **181** | **218** | **1** | **686** | **42.30** | **27.03** | **30.45** | **0.21** |
| BH-13 | 6 | 208 | 12 | 462 | 56 | 738 | 28.18 | 1.63 | 62.60 | 7.59 |
| | 21 | 427 | 61 | 111 | 0 | 599 | 71.29 | 10.18 | 18.53 | 0.00 |
| | 30 | 309 | 241 | 99 | 0 | 649 | 47.61 | 37.13 | 15.25 | 0.00 |
| | 39 | 483 | 110 | 223 | 0 | 816 | 59.19 | 13.48 | 27.33 | 0.00 |
| | **Avg** | **357** | **106** | **224** | **14** | **701** | **51.57** | **15.61** | **30.93** | **1.90** |
| BH-14 | 6 | 270 | 92 | 255 | 3 | 620 | 43.55 | 14.84 | 41.13 | 0.48 |
| | 9 | 342 | 50 | 296 | 0 | 688 | 49.71 | 7.27 | 43.02 | 0.00 |
| | 21 | 433 | 64 | 111 | 0 | 608 | 71.22 | 10.53 | 18.26 | 0.00 |
| | **Avg** | **348** | **69** | **221** | **1** | **639** | **54.82** | **10.88** | **34.14** | **0.16** |
| BH-15 | 12 | 164 | 432 | 137 | 29 | 762 | 21.52 | 56.69 | 17.98 | 3.81 |
| | 33 | 401 | 100 | 90 | 4 | 595 | 67.39 | 16.81 | 15.13 | 0.67 |
| | **Avg** | **283** | **266** | **114** | **17** | **679** | **44.46** | **36.75** | **16.55** | **2.24** |
| BH-16 | 6 | 298 | 26 | 273 | 32 | 629 | 47.38 | 4.13 | 43.40 | 5.09 |
| | 9 | 330 | 56 | 31 | 0 | 417 | 79.14 | 13.43 | 7.43 | 0.00 |
| | **Avg** | **314** | **41** | **152** | **16** | **523** | **63.26** | **8.78** | **25.42** | **2.54** |
| **Avg** | | | | | | | **42.74** | **16.68** | **37.80** | **2.78** |

## *7.1 Characteristics of the fine-fractions*

### *7.1.1 Moisture Content*

Moisture content was determined by keeping the sample in an oven at 110±5°C and its weight loss was recorded intermittently. This procedure was followed until no further weight loss was observed as per the guidelines reported in the literature (ASTM International, 2020; Goli et al., 2022). The results obtained for different samples are listed in Table 7.2 (and in Tables A1 to A16).

**Table 7.2** The moisture content of the fine-fractions

| BH | Moisture content (%) | | |
|---|---|---|---|
| | Avg (±SD) | Maximum | Minimum |
| BH-01 | 73.6±38.7 | 107.6±111.4 | 48.7±10.7 |
| BH-02 | 62.4±28.3 | 75.7±22.2 | 43.4±7.3 |
| BH-03 | 40.5±7.4 | 49.6±3.3 | 33.2±2 |
| BH-04 | 50.4±12.3 | 72.6±2.6 | 34.7±2.2 |
| BH-05 | 33.8±11.4 | 54.7±1.2 | 19.1±0.9 |
| BH-06 | 30.7±12.1 | 55±1.2 | 20.6±1.1 |
| BH-07 | 47.0±12.8 | 63.5±9.0 | 23.5±0.1 |
| BH-08 | 10.50±5.80 | 15.6±1.20 | 4.30±0.30 |
| BH-09 | 4.6±0.6 | 5.1±0.4 | 4.2±0.4 |
| BH-10 | 42.5±11.5 | 60.9±3.6 | 29.4±3.5 |
| BH-11 | 43.9±4.9 | 51.2±2.3 | 39.0±0.6 |
| BH-12 | 50.5±7.5 | 63.1±6.3 | 41.6±8.7 |
| BH-13 | 54.9±12.4 | 67.9±5.2 | 43.5±2.6 |
| BH-14 | 20.6±9.3 | 25.8±0.9 | 7.4±9.6 |
| BH-15 | 31.5±6.1 | 24.4±1.6 | 39.3±3.8 |
| BH-16 | 31.2±10.2 | 42.0±1.6 | 21.7±9.4 |

From Table 7.2, it can be observed that the average moisture content of the fine-fractions varies between ≈ 4 and 74%, which is pretty high. In fact, the maximum moisture content of some of the samples is noticed to vary between 54 % to 108 %, which can be attributed to the presence of a very high amount of organic matter. It should be noted that the samples with such high moisture content will be prone to subsequent decomposition (Patil et al., 2017).

### *7.1.2 Organic Matter*

The organic matter (OM) present in fine fractions was determined by resorting to the loss-on-ignition (LOI) test, as suggested by Goli et al. (2022). For this purpose, approx. 25 g of the oven-dried fine fraction was taken in a ceramic crucible and placed in a muffle. The muffle temperature was increased gradually to 440°C and maintained until no further change in the weight of the residue was observed. The results obtained from moisture content determination for all samples are mentioned in Table 7.3. Further, detailed experimental results were mentioned in Tables B1 to B16.

**Table 7.3** Borehole-wise variation in the organic matter of fine fractions

| Borehole No | Organic matter (%) | | |
|---|---|---|---|
| | Avg (±SD) | Max | Min |
| BH-01 | 23.49±5.51 | 33.27±9.47 | 18.10±1.38 |
| BH-02 | 25.28±4.63 | 31.13±0.62 | 19.64±0.71 |
| BH-03 | 16.29±2.84 | 11.29±1.65 | 18.80±1.83 |
| BH-04 | 20.53±2.96 | 17.55±1.49 | 25.54±3.28 |
| BH-05 | 15.05±6.27 | 23.06±4.63 | 6.26±0.64 |
| BH-06 | 12.49±4.08 | 20.65±1.50 | 8.08±1.83 |
| BH-07 | 17.82±4.28 | 22.78±2.29 | 12.22±1.27 |
| BH-08 | 4.46±0.81 | 5.45±0.17 | 3.89±0.18 |
| BH-09 | 3.17±0.53 | 3.21±0.34 | 3.13±0.77 |
| BH-10 | 16.83±7.27 | 36.46±4.51 | 9.74±0.48 |
| BH-11 | 16.94±4.03 | 24.49±4.70 | 12.26±0.51 |
| BH-12 | 17.31±3.08 | 20.32±1.15 | 14.04±2.56 |
| BH-13 | 20.74±3.99 | 30.10±1.99 | 16.42±0.96 |
| BH-14 | 8.22±3.61 | 11.26±1.98 | 1.63±0.23 |
| BH-15 | 12.90±3.02 | 17.31±1.38 | 10.07±0.80 |
| BH-16 | 14.58±2.12 | 15.94±1.02 | 12.88±2.23 |

Table 7.2 shows that the organic matter (OM) in fine fractions varied from 1.63±0.23 and 36.46±4.51%, with an average value of ≈20%. Such higher OM suggests that the DMSW is prone to further decomposition when exposed to an external environment. Moreover, the values suggest that the fine fraction is unsuitable for their utilization as structural fill material applications (Goli et al., 2022).

### *7.1.3 Specific Gravity*

The specific gravity of the oven-dried fine fraction of the DMSW was measured by employing a helium gas pycnometer, as per the ASTM standard (ASTM D 5550, 2006). Approximately 20 g of the oven-dried sample was transferred into a pycnometer cell and He gas was purged to measure the volume of the solids. The average specific gravity of the fine fraction collected from each borehole is listed in Table 7.4, while the results for each sample are given in Tables C1 to C10.

**Table 7.4** Borehole-wise variation in the specific gravity of fine fractions

| Borehole No | Specific gravity | | |
|---|---|---|---|
| | Average (±SD) | Max | Min |
| BH-01 | 2.26±0.03 | 2.36±0.02 | 2.15±0.04 |
| BH-02 | 2.18±0.02 | 2.38±0.02 | 1.92±0.01 |
| BH-03 | 2.23±0.01 | 2.34±0.01 | 2.07±0.01 |
| BH-04 | 2.21±0.01 | 2.30±0.00 | 2.05±0.01 |
| BH-05 | 2.31±0.02 | 2.47±0.02 | 2.13±0.04 |
| BH-06 | 2.36±0.01 | 2.47±0.01 | 2.17±0.04 |
| BH-07 | 2.28±0.01 | 2.41±0.02 | 2.17±0.02 |
| BH-08 | 2.61±0.02 | 2.65±0.02 | 2.58±0.02 |
| BH-09 | 2.67±0.01 | 2.69±0.01 | 2.66±0.01 |
| BH-10 | 2.32±0.01 | 2.47±0.00 | 1.92±0.04 |
| BH-11 | 2.30±0.01 | 2.37±0.00 | 2.18±0.01 |
| BH-12 | 2.23±0.02 | 2.30±0.01 | 2.17±0.02 |
| BH-13 | 2.26±0.01 | 2.31±0.02 | 2.19±0.01 |
| BH-14 | 2.48±0.01 | 2.63±0.00 | 2.40±0.01 |
| BH-15 | 2.48±0.00 | 2.46±0.00 | 2.38±0.00 |
| BH-16 | 2.33±0.00 | 2.39±0.01 | 2.29±0.01 |

It can be observed that the overall average specific gravity of the fine fraction is 2.30±0.13, which is much lower as compared to the sands, silty clays, and moorum that are being used for structural fill applications. As such, the utilization of fine fractions as structural fill for the low-lying areas is not recommended. The reason being this material will not be getting properly compacted and will always be prone to long-term degradation.

### *7.1.4 Analysis of Leachates*

The characteristics of leachates would help in evaluating the environmental suitability of the fine-fractions for different applications. In this context, the leaching characteristics were established by adopting the methodology developed by Goli et al. (2022). In this context, 10 g of sample was mixed with 200 mL of deionized water to attain a liquid-to-solid (*L/S*) ratio of 20 and stirred for 24 h on a magnetic stirrer. The supernatant was filtered through Whatman No. 42 ashless paper and the filtrate was tested for parameters like pH, electrical conductivity (EC), total dissolved solids (TDS) and salinity. Subsequently, the samples were analyzed for hardness, chlorides and other elements to test their concentrations. The leachate analysis was performed on 34 representative samples and the results are listed in Tables 7.5 and Table ***7.6***.

**Table 7.5** The values of pH, EC, TDS, Salinity, Hardness and Chlorides for leachates of the representative samples from different bore-holes

| BH | Depth (m) | Parameter | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | pH | EC (ms/cm) | TDS (mg/L) | Salinity (mg/L) | Hardness (mg/L) | Chlorides (mg/L) | TOC (mg/L) | TN (mg/L) |
| BH-01 | 12 | 7.56 | 1.754 | 968.5 | 983.1 | 400 | 496.51 | 144.58 | 38.97 |
| BH-01 | 24 | 7.24 | 1.607 | 886.6 | 895.7 | 426.67 | 426.67 | 120.80 | 34.19 |
| BH-02 | 15 | 7.30 | 1.261 | 795.9 | 695.4 | 413.33 | 331.97 | 107.45 | 29.96 |
| BH-02 | 30 | 7.18 | 1.731 | 955.0 | 969.6 | 466.67 | 436.67 | 127.21 | 40.13 |
| BH-03 | 12 | 7.26 | 1.142 | 630.9 | 627.8 | 600 | 280 | 92.32 | 36.87 |
| BH-03 | 24 | 7.28 | 1.349 | 744.9 | 746.5 | 426.67 | 256.67 | 92.92 | 35.99 |
| BH-04 | 12 | 7.22 | 1.118 | 617.1 | 613.1 | 506.67 | 396.70 | 83.63 | 32.93 |
| BH-04 | 24 | 7.27 | 1.288 | 711.4 | 711.8 | 446.67 | 313.33 | 134.45 | 40.80 |
| BH-04 | 36 | 7.33 | 1.239 | 683.6 | 683.2 | 400 | 346.67 | 116.25 | 33.92 |
| BH-05 | 15 | 7.34 | 1.121 | 617.5 | 612.6 | 540 | 290 | 91.39 | 30.42 |
| BH-05 | 30 | 7.50 | 0.933 | 515.4 | 509 | 346.67 | 296.67 | 79.92 | 28.89 |
| BH-06 | 12 | 7.18 | 0.799 | 441.2 | 432.7 | 446.67 | 353.33 | 68.55 | 25.74 |
| BH-06 | 24 | 7.08 | 1.507 | 832.7 | 838.5 | 486.67 | 363.33 | 92.22 | 37.14 |
| BH-07 | 12 | 7.11 | 1.424 | 786 | 790.1 | 460 | 263.33 | 81.38 | 37.10 |
| BH-07 | 24 | 7.14 | 1.021 | 563.7 | 558.7 | 340 | 280 | 104.84 | 28.93 |
| BH-07 | 36 | 7.37 | 1.278 | 705.6 | 705.7 | 366.67 | 210 | 79.30 | 22.25 |
| BH-08 | 06 | 7.38 | 0.610 | 337.2 | 328.4 | 466.67 | 140 | 38.19 | 27.76 |
| BH-09 | 06 | 7.44 | 0.457 | 252.5 | 243.9 | 186.67 | 90 | 37.87 | 31.08 |
| BH-10 | 15 | 7.37 | 0.972 | 563.3 | 530.4 | 480 | 180 | 76.91 | 39.89 |
| BH-10 | 30 | 7.46 | 1.012 | 558.9 | 553.4 | 353.33 | 226.67 | 83.07 | 39.26 |
| BH-10 | 42 | 7.33 | 1.592 | 879.1 | 888.2 | 466.67 | 430 | 120.83 | 43.86 |
| BH-11 | 12 | 7.68 | 1.198 | 661.5 | 660.4 | 486.67 | 280 | 81.10 | 35.54 |
| BH-11 | 24 | 7.36 | 1.720 | 645.4 | 644.2 | 480 | 267.67 | 54.32 | 30.69 |
| BH-11 | 39 | 7.29 | 1.284 | 707.5 | 707.1 | 433.33 | 356.67 | 54.01 | 27.16 |
| BH-12 | 15 | 6.98 | 1.293 | 714.4 | 715.3 | 313.33 | 396.67 | 85.65 | 29.16 |
| BH-12 | 30 | 7.23 | 1.300 | 717.7 | 718.6 | 460 | 436.67 | 90.28 | 29.06 |
| BH-12 | 42 | 7.25 | 1.426 | 787.8 | 792.5 | 393.33 | 530 | 121.70 | 39.17 |
| BH-13 | 12 | 7.38 | 0.900 | 496.8 | 489.6 | 226.67 | 410 | 69.25 | 30.46 |
| BH-13 | 24 | 7.42 | 1.366 | 753.5 | 755.1 | 513.33 | 413.33 | 93.72 | 31.49 |
| BH-13 | 39 | 7.3 | 1.376 | 759.2 | 762.9 | 426.67 | 373.33 | 94.37 | 31.86 |
| BH-14 | 09 | 7.6 | 0.636 | 351.1 | 342.7 | 160 | 167.67 | 36.81 | 29.71 |
| BH-15 | 09 | 7.29 | 0.809 | 446.4 | 438.9 | 260 | 230 | 53.08 | 28.88 |
| BH-16 | 06 | 7.36 | 1.110 | 612.6 | 609.6 | 406.67 | 260 | 100.29 | 46.38 |

**Table 7.6** The concentration of leachable elements from the fine-fractions

| BH | Depth (m) | Leachable elements concentration (in mg/L) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Al | Ba | Ca | Cr | Cu | Fe | K | Mg | Mn | Na | Ni | Zn | S |
| BH-01 | 12 | 0.08 | 0.01 | 16.74 | BDL | 0.16 | 0.24 | 101.29 | 6.79 | 0.03 | 320.25 | 0.04 | 0.09 | 21.68 |
| BH-01 | 24 | 0.02 | 0.03 | 44.08 | BDL | 0.07 | 0.12 | 45.69 | 8.08 | 0.07 | 78.24 | 0.05 | 0.07 | 16.28 |
| BH-02 | 15 | BDL | 0.04 | 25.89 | BDL | 0.03 | 0.04 | 15.41 | 4.61 | BDL | 28.38 | BDL | 0.04 | 12.98 |
| BH-02 | 30 | BDL | 0.01 | 11.53 | BDL | 0.15 | 0.17 | 73.92 | 4.74 | BDL | 108.93 | 0.02 | 0.07 | 15.43 |
| BH-03 | 12 | 0.02 | 0.02 | 30.02 | 0.01 | 0.33 | 0.22 | 234.88 | 9.65 | 0.05 | 204.98 | 0.05 | 0.21 | 29.20 |
| BH-03 | 24 | 0.05 | 0.02 | 23.59 | 0.01 | 0.12 | 0.34 | 130.92 | 9.38 | BDL | 298.98 | 0.06 | 0.13 | 34.22 |
| BH-04 | 12 | 0.01 | 0.03 | 29.99 | 0.01 | 0.13 | 0.23 | 116.84 | 10.01 | BDL | 222.14 | 0.04 | 0.09 | 37.73 |
| BH-04 | 24 | 0.12 | 0.02 | 18.45 | BDL | 0.08 | 0.08 | 37.57 | 3.62 | BDL | 64.26 | 0.02 | 0.04 | 15.80 |
| BH-04 | 36 | 0.02 | 0.05 | 63.62 | BDL | 0.04 | 0.08 | 69.41 | 10.96 | 0.01 | 110.59 | 0.04 | 0.07 | 37.43 |
| BH-05 | 15 | 0.01 | 0.02 | 32.58 | BDL | 0.13 | 0.15 | 86.44 | 9.63 | 0.03 | 207.34 | 0.04 | 0.12 | 33.61 |
| BH-05 | 30 | 0.04 | 0.02 | 25.53 | 0.01 | 0.12 | 0.30 | 115.58 | 7.69 | 0.02 | 301.89 | 0.04 | 0.12 | 25.99 |
| BH-06 | 12 | 0.07 | 0.02 | 22.46 | BDL | 0.13 | 0.24 | 69.54 | 7.07 | 0.04 | 118.81 | 0.03 | 0.09 | 17.86 |
| BH-06 | 24 | 0.03 | 0.03 | 36.29 | BDL | 0.08 | 0.09 | 64.25 | 7.89 | BDL | 101.40 | 0.03 | 0.10 | 19.77 |
| BH-07 | 12 | 0.05 | 0.02 | 31.61 | 0.01 | 0.24 | 0.34 | 240.16 | 10.64 | BDL | 225.09 | 0.05 | 0.12 | 33.71 |
| BH-07 | 24 | 0.06 | 0.02 | 36.70 | BDL | 0.06 | 0.09 | 84.07 | 11.70 | 0.05 | 125.90 | 0.03 | 0.10 | 38.28 |
| BH-07 | 36 | 0.08 | 0.01 | 17.73 | BDL | 0.25 | 0.29 | 88.03 | 5.28 | BDL | 130.96 | 0.04 | 0.08 | 24.18 |
| BH-08 | 06 | 0.06 | 0.02 | 24.06 | 0.01 | 0.12 | 0.37 | 117.23 | 7.56 | 0.03 | 153.11 | 0.04 | 0.12 | 14.78 |
| BH-09 | 06 | 0.07 | 0.03 | 36.01 | 0.01 | 0.18 | 0.35 | 107.11 | 10.33 | 0.03 | 178.62 | 0.05 | 0.13 | 29.21 |
| BH-10 | 15 | 0.04 | 0.03 | 55.16 | BDL | 0.22 | 0.17 | 109.47 | 8.67 | 0.02 | 199.06 | 0.04 | 0.09 | 40.08 |
| BH-10 | 30 | 0.10 | 0.01 | 19.22 | BDL | 0.14 | 0.21 | 53.00 | 5.19 | 0.03 | 94.766 | 0.03 | 0.08 | 18.80 |
| BH-10 | 42 | 0.03 | 0.04 | 39.93 | BDL | 0.04 | 0.07 | 89.45 | 11.89 | BDL | 247.20 | 0.03 | 0.05 | 34.41 |
| BH-11 | 12 | 0.03 | 0.03 | 25.55 | BDL | 0.10 | 0.14 | 61.60 | 8.09 | 0.02 | 113.85 | 0.03 | 0.12 | 18.94 |
| BH-11 | 24 | 0.04 | 0.02 | 18.48 | BDL | 0.13 | 0.24 | 124.15 | 5.88 | 0.02 | 222.82 | 0.04 | 0.11 | 14.22 |
| BH-11 | 39 | 0.03 | 0.02 | 37.28 | 0.01 | 0.15 | 0.30 | 155.45 | 10.74 | BDL | 224.47 | 0.05 | 0.21 | 34.09 |
| BH-12 | 15 | 0.03 | 0.02 | 37.68 | BDL | 0.17 | 0.28 | 110.55 | 11.10 | BDL | 218.72 | 0.06 | 0.16 | 21.06 |
| BH-12 | 30 | 0.09 | 0.02 | 21.13 | BDL | 0.17 | 0.45 | 110.77 | 6.87 | BDL | 275.71 | 0.04 | 0.32 | 22.86 |
| BH-12 | 42 | 0.03 | 0.03 | 40.33 | BDL | 0.10 | 0.16 | 92.18 | 9.08 | 0.04 | 282.03 | 0.04 | 0.14 | 31.92 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-13 | 12 | 0.02 | 0.02 | 36.04 | 0.01 | 0.13 | 0.22 | 114.72 | 11.87 | 0.02 | 229.52 | 0.04 | 0.13 | 31.05 |
| BH-13 | 24 | 0.02 | 0.03 | 43.54 | BDL | 0.08 | 0.18 | 83.37 | 9.82 | 0.01 | 242.62 | 0.04 | 0.09 | 24.14 |
| BH-13 | 39 | 0.04 | BDL | 20.61 | BDL | 0.06 | 0.21 | 97.20 | 7.50 | BDL | 271.77 | 0.04 | 0.07 | 27.53 |
| BH-14 | 09 | 0.05 | 0.02 | 24.36 | BDL | 0.28 | 0.35 | 111.48 | 7.84 | 0.04 | 232.84 | 0.05 | 0.08 | 22.79 |
| BH-15 | 09 | 0.05 | 0.02 | 24.68 | BDL | 0.28 | 0.35 | 112.12 | 7.80 | 0.04 | 194.93 | 0.05 | 0.08 | 22.76 |
| BH-16 | 06 | 0.03 | 0.02 | 18.20 | 0.01 | 0.16 | 0.16 | 77.34 | 7.71 | 0.04 | 317.39 | 0.04 | 0.09 | 17.37 |

Note:

- BDL represents *below detection limit* (i.e., 0.01 mg/L)
- Concentrations of Ag, Co, Cd, Hg, Pb, Ti and Mo in all samples is BDL

From these results, it can be observed that the concentrations of the leachable heavy metals are within the permissible limits as far as their disposal in land surface waters is concerned. However, the concentrations of metals like Na, K and Cl are high, indicating that the fine-fractions are contaminated with salts. Moreover, the higher concentration of S in all the samples can be attributed to the presence of decomposable organic matter in these fractions, which corroborates the findings from the organic matter determination test. Similarly, the TOC and TN concentrations also indicate the presence of leachable organic matter, which has a potential for further biological degradation due to microbial activities. Based on the characteristics of the leachate obtained from these fractions and the foam/bubble formation, it can also be opined that the leachate present in the JLH is yet to decompose. Hence, treating the leachates obtained from landfills using an appropriate treatment technique becomes mandatory.

### *7.2 The calorific value of the coarse-fractions*

The calorific value of the coarse-fractions was obtained using a portable bomb calorimeter. For this purpose, 2 g of the oven-dried sample was shredded to a size of <10 mm and placed in the sample holder. Subsequently, the experiment was performed following the guidelines proposed in the literature (Goli et al., 2022). Approximately 75 randomly collected samples were tested to get a representative calorific value and ash content and the results are presented in Table 7.7.

**Table 7.7** The calorific value and ash content of the coarse-fractions

| BH | Depth (m) | Ash content (%) | Calorific Value (kCal/kg) |
|---|---|---|---|
| BH-01 | 03 | 37.77 | 2888.33 |
| | 09 | 37.59 | 1833.61 |
| | 12 | 54.03 | 3692.96 |
| | 15 | 28.90 | 1812.09 |
| | 18 | 41.09 | 2774.04 |
| | 21 | 36.32 | 1299.90 |
| BH-02 | 03 | 57.93 | 1554.83 |
| | 06 | 32.70 | 2145.12 |
| | 09 | 41.07 | 2462.62 |
| | 12 | 42.05 | 2554.88 |
| | 15 | 53.18 | 5828.55 |
| | 18 | 40.02 | 3280.21 |
| | 24 | 24.67 | 3653.43 |
| | 27 | 38.27 | 756.91 |
| | 30 | 41.54 | 1056.45 |

| | | | |
|---|---|---|---|
| BH-03 | 03 | 29.29 | 3198.43 |
| | 06 | 43.27 | 1292.39 |
| | 09 | 11.25 | 4579.96 |
| | 12 | 45.80 | 3344.65 |
| | 15 | 31.94 | 3528.52 |
| | 18 | 35.17 | 3184.88 |
| | 21 | 33.72 | 3288.56 |
| | 24 | 28.28 | 3328.54 |
| BH-05 | 03 | 45.69 | 2704.60 |
| | 06 | 29.62 | 3707.45 |
| | 09 | 36.79 | 1954.29 |
| | 12 | 40.52 | 4083.77 |
| | 15 | 33.83 | 1457.86 |
| | 18 | 38.67 | 4743.62 |
| | 21 | 57.29 | 2253.79 |
| | 27 | 47.26 | 4974.84 |
| | 30 | 44.33 | 3361.18 |
| | 33 | 53.35 | 2209.93 |
| BH-08 | 1.5 | 69.81 | 3989.55 |
| | 3.0 | 55.33 | 2142.39 |
| | 4.5 | 50.72 | 3796.90 |
| BH-09 | 1.5 | 38.91 | 3092.25 |
| | 4.5 | 27.24 | 2393.13 |
| BH-10 | 03 | 28.77 | 1147.96 |
| | 06 | 42.12 | 934.39 |
| | 09 | 44.06 | 3411.75 |
| | 12 | 28.13 | 2701.66 |
| | 15 | 30.41 | 3144.37 |
| | 18 | 38.79 | 5300.08 |
| | 21 | 35.24 | 2948.88 |
| | 24 | 11.86 | 1363.64 |
| | 27 | 25.27 | 3391.50 |
| | 30 | 37.15 | 3250.11 |
| | 33 | 42.18 | 1163.73 |
| | 36 | 43.07 | 2947.22 |
| | 39 | 53.36 | 2651.48 |
| | 41.7 | 44.46 | 2039.41 |
| BH-12 | 03 | 33.49 | 3034.28 |
| | 09 | 47.78 | 3574.57 |
| | 15 | 40.63 | 3994.90 |
| | 18 | 37.35 | 3386.92 |
| | 21 | 23.21 | 4291.47 |

| | | | |
|---|---|---|---|
| | 24 | 42.78 | 4024.64 |
| | 27 | 33.39 | 1126.19 |
| | 30 | 48.88 | 2491.54 |
| | 33 | 38.00 | 2600.81 |
| | 36 | 45.45 | 2998.08 |
| | 39 | 45.95 | 2489.12 |
| | 41.70 | 39.28 | 3168.18 |
| BH-13 | 03 | 30.26 | 4747.82 |
| | 06 | 39.12 | 1039.74 |
| | 09 | 26.18 | 1484.19 |
| | 15 | 23.37 | 3165.62 |
| | 18 | 13.39 | 3982.31 |
| | 21 | 11.62 | 4479.63 |
| | 24 | 42.79 | 5556.29 |
| | 27 | 54.31 | 3184.01 |
| | 30 | 21.80 | 3697.30 |
| | 31.5 | 31.68 | 3361.36 |
| | 33 | 50.42 | 2182.17 |
| | 33.6 | 50.97 | 4838.59 |

The data presented in Table 7.7 indicates that the calorific value of the coarse-fractions varies between 934 to 5556 kCal/kg and for most of the samples, this value is >1500 kCal/kg, which indicates their suitability as a refuse-derived fuel. However, it's noteworthy that the ash content of these samples is >20%, which is a big concern as per the guidelines laid down by the Ministry of Urban Affairs (2018).

## 8. Conclusions and the way forward

- MASW results indicate the presence of saturated and loosely compacted MSW up to greater depths, which confirms the presence of yet to stabilize MSW.
- ERT results indicate the presence of low-resistivity pockets in the MSW, which can be attributed to the presence of saturated or moist MSW (read the yet-to-decompose waste).
- The segregation of DMSW samples indicates the dominance of plastics and fine-fractions (<10 mm) of the waste matrix up to ≈40 % (each) by weight.
- The organic matter (up to 35%) and moisture content (>100%) of the fine-fractions are very high, which indicates their susceptibility to get decomposed in the long run.
- The specific gravity of the fine fractions is around 2.30, which makes it an unpreferred, if not unsuitable, material for infrastructural development (viz., making foundation pads, reclamation, etc.).
- The emission of foam/gas/leachate from the JLH indicates the ongoing decomposition of the MSW. **Hence, the biomining of JLH at this point in time is not recommended.**
- Though the calorific value of most of the samples of the coarse-fractions is >1500 kCal/kg, their ash content is also about 60%. Such a situation makes these fractions **unsuitable for their application as refuse-derived fuel**.
- Higher $Na^+$ concentration in fine-fractions would form sodic soil when used as a soil amending agent for agricultural applications.
- Higher TOC, TN and S concentrations in leachate generated from the fine-fractions indicate their potential for subsequent degradation. Hence, it becomes mandatory to **treat the leachates generated in the JLH** appropriately.
- Based on the present state of the decomposed MSW and foam observed during borehole drilling, it can be concluded that the waste is **yet to decompose**. **Hence, the JLH is not ready for biomining.**

*Disclaimer*

*Results from these investigations are not valid forever, and hence cannot be employed to determine the time for initiation of biomining at the JLH. Periodic sampling followed by extensive testing should be performed to ascertain the threadiness of the JLH for biomining.*

## Appendix A

**Table A.1** Moisture content analysis results for Borehole-01

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 23.01 | 28.50 | 26.39 | 62.5 | 58.8±8.8 |
| | 1B | 24.73 | 30.38 | 28.53 | 48.8 | |
| | 1C | 22.70 | 26.66 | 25.10 | 65.1 | |
| 6 | 2A | 22.88 | 28.98 | 25.97 | 97.5 | 89.8±11.4 |
| | 2B | 23.86 | 29.32 | 26.95 | 76.7 | |
| | 2C | 22.68 | 26.38 | 24.57 | 95.3 | |
| 9 | 3A | 20.99 | 28.31 | 25.42 | 65.3 | 64.7±14.5 |
| | 3B | 35.23 | 40.19 | 38.00 | 78.8 | |
| | 3C | 19.95 | 24.87 | 23.23 | 49.9 | |
| 12 | 4A | 22.53 | 26.71 | 24.97 | 71.3 | 72.0±12.5 |
| | 4B | 22.18 | 25.44 | 24.22 | 59.9 | |
| | 4C | 22.72 | 26.92 | 24.99 | 84.8 | |
| 15 | 5A | 21.64 | 25.66 | 23.82 | 84.4 | 85.9±6.3 |
| | 5B | 24.80 | 29.70 | 27.34 | 92.8 | |
| | 5C | 24.63 | 26.83 | 25.85 | 80.5 | |
| 18 | 6A | 21.73 | 26.94 | 25.55 | 36.4 | 48.7±10.7 |
| | 6B | 22.44 | 26.40 | 24.99 | 55.3 | |
| | 6C | 25.90 | 29.87 | 28.47 | 54.4 | |
| 21 | 7A | 21.99 | 27.66 | 25.36 | 68.3 | 61.2±11.7 |
| | 7B | 21.88 | 26.00 | 24.67 | 47.7 | |
| | 7C | 22.41 | 25.73 | 24.39 | 67.6 | |
| 24 | 8A | 22.93 | 27.77 | 26.36 | 41.0 | 107.6±111.4 |
| | 8B | 21.49 | 26.62 | 25.01 | 45.7 | |
| | 8C | 22.97 | 29.48 | 24.91 | 236.3 | |
| | | | | **Avg (±SD)** | **73.6±38.7** | |

**Table A.2** Moisture content analysis results for Borehole-02

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 22.75 | 28.08 | 26.32 | 49.5 | 57.0±10.9 |
| | 1B | 22.60 | 30.24 | 27.63 | 52.1 | |
| | 1C | 22.27 | 28.08 | 25.70 | 69.5 | |
| 6 | 2A | 34.76 | 42.58 | 37.68 | 167.2 | 74.5±84.2 |
| | 2B | 33.25 | 39.87 | 39.69 | 2.8 | |
| | 2C | 35.29 | 44.82 | 41.50 | 53.5 | |
| 9 | 3A | 35.35 | 56.75 | 51.99 | 28.7 | 53.4±24.0 |
| | 3B | 37.08 | 62.36 | 53.40 | 54.9 | |
| | 3C | 34.16 | 61.30 | 49.53 | 76.6 | |
| 12 | 4A | 36.09 | 57.41 | 48.91 | 66.3 | 73.8±10.2 |
| | 4B | 36.59 | 59.36 | 48.87 | 85.4 | |
| | 4C | 22.98 | 35.27 | 30.23 | 69.7 | |
| 15 | 5A | 23.85 | 37.29 | 32.79 | 50.3 | 52.6±2.5 |
| | 5B | 23.32 | 40.84 | 34.60 | 55.3 | |
| | 5C | 20.46 | 36.47 | 30.97 | 52.2 | |
| 18 | 6A | 22.62 | 37.26 | 30.22 | 92.7 | 75.7±22.2 |
| | 6B | 22.11 | 39.53 | 33.68 | 50.5 | |
| | 6C | 23.62 | 40.12 | 32.59 | 83.9 | |
| 21 | 7A | 27.31 | 44.12 | 35.16 | 114.3 | 73.4±35.6 |
| | 7B | 16.07 | 26.33 | 22.92 | 49.7 | |
| | 7C | 16.75 | 33.51 | 27.47 | 56.2 | |
| 24 | 8A | 22.47 | 41.63 | 36.64 | 35.2 | 43.4±7.3 |
| | 8B | 22.73 | 41.30 | 35.50 | 45.4 | |
| | 8C | 22.56 | 47.08 | 38.97 | 49.4 | |
| 27 | 9A | 22.34 | 37.85 | 31.95 | 61.4 | 63.5±9.1 |
| | 9B | 21.02 | 33.43 | 28.18 | 73.4 | |
| | 9C | 24.83 | 42.31 | 36.06 | 55.7 | |
| 30 | 10A | 16.89 | 36.27 | 29.61 | 52.4 | 56.5±4.7 |
| | 10B | 23.03 | 42.73 | 35.69 | 55.6 | |
| | 10C | 20.52 | 35.55 | 29.82 | 61.7 | |
| | | | | **Avg (±SD)** | **62.4±28.3** | |

**Table A.3** Moisture content analysis results for Borehole-03

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 21.75 | 35.08 | 30.65 | 49.7 | 49.1±2.1 |
| | 1B | 24.79 | 38.93 | 34.42 | 46.8 | |
| | 1C | 23.89 | 36.42 | 32.20 | 50.8 | |
| 6 | 2A | 19.97 | 32.04 | 28.07 | 49.1 | 45.8±3.0 |
| | 2B | 21.51 | 35.99 | 31.64 | 43.0 | |
| | 2C | 22.21 | 35.87 | 31.59 | 45.5 | |
| 9 | 3A | 22.91 | 38.08 | 34.74 | 28.2 | 32.1±4.8 |
| | 3B | 22.72 | 32.72 | 29.99 | 37.4 | |
| | 3C | 22.03 | 34.96 | 31.94 | 30.6 | |
| 12 | 4A | 22.95 | 39.30 | 34.88 | 37.0 | 37.2±1.6 |
| | 4B | 22.71 | 35.07 | 31.82 | 35.7 | |
| | 4C | 22.44 | 33.90 | 30.69 | 38.9 | |
| 15 | 5A | 21.01 | 38.93 | 33.91 | 38.9 | 41.5±2.3 |
| | 5B | 23.03 | 40.16 | 34.99 | 43.2 | |
| | 5C | 24.75 | 40.38 | 35.72 | 42.5 | |
| 18 | 6A | 21.66 | 41.15 | 36.35 | 32.6 | 33.2±2.0 |
| | 6B | 22.99 | 39.98 | 35.90 | 31.6 | |
| | 6C | 22.46 | 40.74 | 35.95 | 35.5 | |
| 21 | 7A | 22.74 | 37.35 | 32.86 | 44.4 | 35.5±7.7 |
| | 7B | 22.55 | 41.92 | 37.36 | 30.7 | |
| | 7C | 25.92 | 42.24 | 38.33 | 31.5 | |
| 24 | 8A | 24.65 | 45.31 | 38.16 | 52.9 | 49.6±3.3 |
| | 8B | 21.91 | 37.42 | 32.29 | 49.3 | |
| | 8C | 35.25 | 58.45 | 51.09 | 46.4 | |
| | | | | **Avg (±SD)** | **40.5±7.4** | |

**Table A.4** Moisture content analysis results for Borehole-04

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 23.62 | 42.48 | 38.46 | 27.1 | 27.7±0.5 |
| | 1B | 22.76 | 39.44 | 35.80 | 27.9 | |
| | 1C | 22.98 | 38.17 | 34.85 | 28.0 | |
| 6 | 2A | 20.46 | 37.22 | 32.29 | 41.7 | 39.9±1.6 |
| | 2B | 27.31 | 45.15 | 40.19 | 38.5 | |
| | 2C | 16.78 | 35.71 | 30.35 | 39.5 | |
| 9 | 3A | 22.10 | 39.56 | 35.27 | 32.6 | 34.7±2.2 |
| | 3B | 22.59 | 40.11 | 35.61 | 34.6 | |
| | 3C | 23.84 | 40.85 | 36.26 | 36.9 | |
| 12 | 4A | 37.09 | 64.48 | 56.36 | 42.1 | 43.3±1.1 |
| | 4B | 35.29 | 71.27 | 60.24 | 44.2 | |
| | 4C | 36.09 | 63.85 | 55.42 | 43.6 | |
| 15 | 5A | 34.16 | 66.94 | 55.14 | 56.3 | 56.8±5.5 |
| | 5B | 33.27 | 64.61 | 52.55 | 62.5 | |
| | 5C | 36.60 | 69.77 | 58.49 | 51.5 | |
| 18 | 6A | 34.76 | 65.86 | 54.91 | 54.3 | 52.0±2.0 |
| | 6B | 35.35 | 73.00 | 60.37 | 50.5 | |
| | 6C | 16.09 | 28.72 | 24.44 | 51.3 | |
| 21 | 7A | 23.35 | 42.28 | 35.98 | 49.9 | 54.1±3.6 |
| | 7B | 22.30 | 41.74 | 34.77 | 55.9 | |
| | 7C | 22.64 | 40.07 | 33.77 | 56.6 | |
| 24 | 8A | 21.76 | 38.63 | 33.09 | 48.8 | 48.9±1.8 |
| | 8B | 24.82 | 44.24 | 37.70 | 50.8 | |
| | 8C | 23.92 | 48.55 | 40.65 | 47.3 | |
| 27 | 9A | 21.53 | 41.90 | 35.03 | 50.9 | 54.4±5.1 |
| | 9B | 23.04 | 42.56 | 35.87 | 52.2 | |
| | 9C | 21.95 | 42.31 | 34.65 | 60.3 | |
| 30 | 10A | 24.68 | 49.60 | 40.71 | 55.5 | 60.0±4.5 |
| | 10B | 22.08 | 42.42 | 34.44 | 64.5 | |
| | 10C | 23.37 | 49.06 | 39.43 | 60.0 | |
| 33 | 11A | 23.88 | 45.71 | 36.59 | 71.7 | 72.6±2.6 |
| | 11B | 22.51 | 50.59 | 38.97 | 70.6 | |
| | 11C | 22.81 | 51.78 | 39.31 | 75.6 | |
| 36 | 12A | 27.34 | 50.11 | 41.33 | 62.8 | 60.0±2.4 |
| | 12B | 25.95 | 46.73 | 39.08 | 58.3 | |
| | 12C | 23.07 | 52.56 | 41.62 | 58.9 | |
| | | | | **Avg (±SD)** | **50.4±12.3** | |

**Table A.5** Moisture content analysis results for Borehole-05

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 22.71 | 39.56 | 33.64 | 54.1 | 54.7±1.2 |
| | 1B | 21.01 | 38.62 | 32.29 | 56.1 | |
| | 1C | 22.21 | 40.40 | 34.03 | 53.8 | |
| 6 | 2A | 24.76 | 46.00 | 39.00 | 47.9 | 46.4±2.5 |
| | 2B | 23.91 | 40.38 | 35.38 | 43.6 | |
| | 2C | 22.72 | 42.68 | 36.22 | 47.8 | |
| 9 | 3A | 21.51 | 38.75 | 33.95 | 38.6 | 38.5±3.2 |
| | 3B | 24.65 | 45.14 | 39.80 | 35.2 | |
| | 3C | 23.03 | 41.35 | 35.97 | 41.6 | |
| 12 | 4A | 22.92 | 39.89 | 35.47 | 35.2 | 38.2±3.7 |
| | 4B | 22.04 | 38.97 | 34.08 | 40.6 | |
| | 4C | 22.94 | 42.09 | 36.75 | 38.7 | |
| 15 | 5A | 25.92 | 43.32 | 38.19 | 41.8 | 39.5±2.6 |
| | 5B | 19.97 | 39.56 | 34.31 | 36.6 | |
| | 5C | 22.54 | 38.56 | 33.98 | 40.1 | |
| 18 | 6A | 22.44 | 49.01 | 44.03 | 23.1 | 24.1±1.4 |
| | 6B | 21.91 | 43.04 | 38.72 | 25.7 | |
| | 6C | 22.99 | 49.06 | 44.08 | 23.6 | |
| 21 | 7A | 22.44 | 48.62 | 44.59 | 18.2 | 19.1±0.9 |
| | 7B | 21.69 | 54.95 | 49.59 | 19.2 | |
| | 7C | 21.75 | 50.21 | 45.48 | 19.9 | |
| 24 | 9A | 22.46 | 46.91 | 42.24 | 23.6 | 21.8±2.5 |
| | 9B | 24.79 | 49.05 | 45.18 | 18.9 | |
| | 9C | 35.25 | 69.05 | 62.78 | 22.8 | |
| 27 | 10A | 36.17 | 84.42 | 72.45 | 33.0 | 29.6±7.4 |
| | 10B | 35.31 | 82.59 | 74.36 | 21.1 | |
| | 10C | 35.35 | 85.64 | 72.70 | 34.6 | |
| 30 | 11A | 36.67 | 79.40 | 70.79 | 25.3 | 26.0±0.8 |
| | 11B | 34.80 | 79.29 | 69.89 | 26.8 | |
| | 11C | 37.14 | 81.61 | 72.48 | 25.9 | |
| | | | | **Avg (±SD)** | **33.8±11.4** | |

**Table A.6** Moisture content analysis results for Borehole-06

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 22.78 | 48.04 | 40.40 | 43.3 | 41.2±2.0 |
| | 1B | 27.32 | 47.22 | 41.59 | 39.4 | |
| | 1C | 23.63 | 46.74 | 40.04 | 40.8 | |
| 6 | 2A | 34.18 | 73.99 | 64.92 | 29.5 | 26.5±2.9 |
| | 2B | 35.31 | 75.45 | 67.74 | 23.8 | |
| | 2C | 37.10 | 75.70 | 67.72 | 26.1 | |
| 9 | 3A | 23.00 | 49.37 | 43.95 | 25.9 | 24.7±1.2 |
| | 3B | 20.48 | 43.92 | 39.28 | 24.7 | |
| | 3C | 22.65 | 48.72 | 43.75 | 23.6 | |
| 12 | 4A | 35.37 | 83.99 | 75.53 | 21.1 | 21.1±0.2 |
| | 4B | 33.29 | 78.75 | 70.91 | 20.8 | |
| | 4C | 34.78 | 82.16 | 73.83 | 21.3 | |
| 15 | 5A | 22.12 | 46.67 | 42.44 | 20.8 | 20.7±0.4 |
| | 5B | 23.34 | 51.88 | 47.07 | 20.3 | |
| | 5C | 22.31 | 46.82 | 42.57 | 21.0 | |
| 18 | 6A | 36.11 | 82.60 | 74.32 | 21.7 | 21.6±0.0 |
| | 6B | 36.62 | 85.59 | 76.89 | 21.6 | |
| | 6C | 16.10 | 35.70 | 32.21 | 21.7 | |
| 21 | 7A | 16.81 | 44.65 | 39.88 | 20.6 | 20.6±1.1 |
| | 7B | 23.85 | 54.12 | 49.20 | 19.4 | |
| | 7C | 22.62 | 47.07 | 42.73 | 21.6 | |
| 24 | 8A | 33.33 | 66.72 | 54.79 | 55.6 | 55.0±1.2 |
| | 8B | 35.41 | 78.58 | 63.51 | 53.6 | |
| | 8C | 34.21 | 79.52 | 63.31 | 55.7 | |
| 27 | 9A | 21.69 | 49.83 | 43.24 | 30.6 | 30.4±1.4 |
| | 9B | 22.14 | 46.70 | 41.18 | 29.0 | |
| | 9C | 22.72 | 42.66 | 37.86 | 31.7 | |
| 30 | 10A | 22.23 | 45.35 | 41.66 | 19.0 | 20.8±5.4 |
| | 10B | 16.15 | 31.42 | 29.26 | 16.5 | |
| | 10C | 22.65 | 45.24 | 40.47 | 26.8 | |
| 33 | 11A | 20.00 | 45.51 | 38.43 | 38.4 | 43.8±4.9 |
| | 11B | 23.67 | 45.43 | 38.69 | 44.9 | |
| | 11C | 22.67 | 47.28 | 39.29 | 48.1 | |
| 36 | 12A | 22.69 | 54.11 | 43.63 | 50.1 | 48.2±1.8 |
| | 12B | 22.99 | 49.30 | 40.95 | 46.5 | |
| | 12C | 22.67 | 39.29 | 33.89 | 48.1 | |
| | | | | **Avg (±SD)** | **31.2±12.3** | |

**Table A.7** Moisture content analysis results for Borehole-07

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 22.78 | 37.38 | 31.77 | 62.4 | 59.2±3.0 |
| | 1B | 22.99 | 40.24 | 33.85 | 58.9 | |
| | 1C | 24.65 | 41.21 | 35.24 | 56.3 | |
| 6 | 2A | 19.97 | 34.25 | 28.71 | 63.4 | 56.3±7.0 |
| | 2B | 24.76 | 41.70 | 35.59 | 56.3 | |
| | 2C | 20.99 | 43.78 | 36.25 | 49.3 | |
| 9 | 3A | 22.54 | 41.08 | 34.79 | 51.3 | 48.4±2.6 |
| | 3B | 24.79 | 41.99 | 36.49 | 47.0 | |
| | 3C | 21.76 | 41.08 | 34.93 | 46.7 | |
| 12 | 4A | 21.51 | 37.83 | 31.80 | 58.5 | 51.9±5.9 |
| | 4B | 22.93 | 40.93 | 34.95 | 49.7 | |
| | 4C | 22.20 | 37.74 | 32.74 | 47.4 | |
| 15 | 5A | 21.67 | 43.93 | 36.72 | 47.9 | 45.6±2.0 |
| | 5B | 22.05 | 37.64 | 32.84 | 44.5 | |
| | 5C | 22.44 | 44.17 | 37.48 | 44.5 | |
| 18 | 6A | 23.05 | 43.45 | 39.59 | 23.5 | 23.5±0.1 |
| | 6B | 23.90 | 40.11 | 37.01 | 23.7 | |
| | 6C | 21.92 | 42.90 | 38.91 | 23.4 | |
| 21 | 7A | 22.71 | 40.97 | 35.81 | 39.4 | 41.2±2.6 |
| | 7B | 22.70 | 45.20 | 38.78 | 40.0 | |
| | 7C | 25.93 | 47.77 | 41.07 | 44.2 | |
| 24 | 8A | 22.94 | 46.05 | 37.01 | 64.2 | 58.7±5.8 |
| | 8B | 22.46 | 39.77 | 33.33 | 59.3 | |
| | 8C | 35.25 | 70.35 | 58.26 | 52.6 | |
| 27 | 9A | 25.95 | 53.94 | 46.44 | 36.6 | 36.4±0.6 |
| | 9B | 23.93 | 49.80 | 42.99 | 35.8 | |
| | 9C | 21.01 | 45.79 | 39.11 | 36.9 | |
| 30 | 10A | 22.74 | 43.38 | 35.16 | 66.1 | 63.5±9.0 |
| | 10B | 22.51 | 44.56 | 36.88 | 53.5 | |
| | 10C | 24.69 | 46.41 | 37.39 | 70.9 | |
| 33 | 11A | 23.07 | 51.34 | 45.11 | 28.3 | 28.2±1.9 |
| | 11B | 23.39 | 44.50 | 39.63 | 30.0 | |
| | 11C | 22.81 | 44.62 | 40.08 | 26.3 | |
| 36 | 12A | 22.48 | 45.34 | 37.12 | 56.2 | 51.3±5.4 |
| | 12B | 22.73 | 48.22 | 40.25 | 45.5 | |
| | 12C | 24.84 | 46.54 | 39.09 | 52.2 | |
| | | | | **Avg (±SD)** | **47.0±12.8** | |

**Table A.8** Moisture content analysis results for Borehole-08

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 1.5 | 1A | 23.86 | 30.54 | 29.63 | 15.8 | 11.5±6.0 |
| | 1B | 22.77 | 46.31 | 45.26 | 4.7 | |
| | 1C | 22.63 | 34.07 | 32.65 | 14.2 | |
| 3 | 2A | 34.19 | 49.28 | 47.16 | 16.3 | 15.6±1.2 |
| | 2B | 35.32 | 46.04 | 44.55 | 16.2 | |
| | 2C | 35.26 | 47.93 | 46.36 | 14.2 | |
| 4.5 | 3A | 22.06 | 35.13 | 34.63 | 4.0 | 4.3±0.3 |
| | 3B | 22.99 | 34.07 | 33.58 | 4.6 | |
| | 3C | 21.67 | 30.67 | 30.29 | 4.3 | |
| | | | | **Avg (±SD)** | **10.5±5.8** | |

**Table A.9** Moisture content analysis results for Borehole-09

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 1.5 | 1A | 23.02 | 45.84 | 44.84 | 4.6 | 4.2±0.4 |
| | 1B | 20.50 | 30.48 | 30.08 | 4.2 | |
| | 1C | 34.78 | 47.90 | 47.42 | 3.8 | |
| 4.5 | 2A | 23.65 | 31.93 | 31.50 | 5.5 | 5.1±0.4 |
| | 2B | 22.32 | 30.77 | 30.39 | 4.7 | |
| | 2C | 23.35 | 36.92 | 36.27 | 5.0 | |
| | | | | **Avg (±SD)** | **4.6±0.6** | |

**Table A.10** Moisture content analysis results for Borehole-10

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 22.74 | 27.39 | 25.58 | 64.1 | 60.9±3.6 |
| | 1B | 24.66 | 31.71 | 29.15 | 57.0 | |
| | 1C | 37.12 | 44.00 | 41.37 | 61.7 | |
| 6 | 2A | 21.76 | 30.38 | 28.23 | 33.2 | 43.7±9.1 |
| | 2B | 22.97 | 30.36 | 27.89 | 50.2 | |
| | 2C | 23.01 | 29.11 | 27.15 | 47.5 | |
| 9 | 3A | 22.20 | 29.04 | 27.22 | 36.4 | 41.7±5.1 |
| | 3B | 22.44 | 40.07 | 34.47 | 46.5 | |
| | 3C | 23.91 | 38.65 | 34.28 | 42.1 | |
| 12 | 4A | 22.67 | 43.88 | 38.35 | 35.2 | 36.0±1.9 |
| | 4B | 22.12 | 43.24 | 37.81 | 34.6 | |
| | 4C | 19.98 | 42.30 | 36.14 | 38.1 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 15 | 5A | 22.55 | 48.68 | 42.61 | 30.3 | 29.5±0.6 |
| | 5B | 24.79 | 51.79 | 45.71 | 29.0 | |
| | 5C | 23.06 | 47.53 | 41.98 | 29.3 | |
| 18 | 6A | 21.01 | 39.65 | 34.95 | 33.7 | 33.1±0.9 |
| | 6B | 27.33 | 46.18 | 41.46 | 33.4 | |
| | 6C | 25.93 | 45.33 | 40.63 | 32.0 | |
| 21 | 7A | 22.48 | 45.56 | 38.47 | 44.3 | 42.3±4.8 |
| | 7B | 21.92 | 45.59 | 39.21 | 36.9 | |
| | 7C | 16.84 | 32.75 | 27.75 | 45.8 | |
| 24 | 8A | 21.52 | 44.11 | 38.63 | 32.1 | 29.6±3.3 |
| | 8B | 22.71 | 45.80 | 40.33 | 31.0 | |
| | 8C | 24.78 | 53.66 | 47.74 | 25.8 | |
| 27 | 9A | 16.13 | 34.65 | 28.19 | 53.5 | 45.7±10.3 |
| | 9B | 36.64 | 56.30 | 49.78 | 49.6 | |
| | 9C | 33.32 | 55.61 | 49.95 | 34.1 | |
| 30 | 10A | 36.14 | 62.46 | 56.74 | 27.8 | 29.4±3.5 |
| | 10B | 35.38 | 64.01 | 56.84 | 33.4 | |
| | 10C | 22.71 | 45.31 | 40.52 | 26.9 | |
| 33 | 11A | 22.34 | 43.35 | 35.99 | 53.9 | 41.9±12.7 |
| | 11B | 14.84 | 40.40 | 34.72 | 28.5 | |
| | 11C | 24.68 | 44.25 | 38.34 | 43.3 | |
| 36 | 12A | 23.08 | 48.21 | 40.26 | 46.3 | 59.5±11.5 |
| | 12B | 20.55 | 33.51 | 28.41 | 64.9 | |
| | 12C | 22.52 | 40.56 | 33.30 | 67.4 | |
| 39 | 13A | 22.82 | 43.89 | 36.67 | 52.1 | 50.0±5.2 |
| | 13B | 23.39 | 42.32 | 35.70 | 53.8 | |
| | 13C | 22.09 | 41.12 | 35.30 | 44.0 | |
| 41.7 | 14A | 21.02 | 40.67 | 34.19 | 49.1 | 51.1±11.7 |
| | 14B | 23.88 | 41.32 | 35.32 | 52.5 | |
| | 14C | 21.54 | 41.33 | 34.59 | 51.6 | |
| | | | | **Avg (±SD)** | **42.5±11.5** | |

**Table A.11** Moisture content analysis results for Borehole-11

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 22.34 | 46.22 | 39.56 | 38.7 | 40.5±2.1 |
| | 1B | 23.37 | 48.29 | 40.82 | 42.8 | |
| | 1C | 22.72 | 39.23 | 34.50 | 40.1 | |
| 6 | 2A | 23.08 | 48.80 | 41.47 | 39.9 | 39.0±0.8 |
| | 2B | 20.51 | 39.62 | 34.28 | 38.8 | |
| | 2C | 25.93 | 46.29 | 40.64 | 38.4 | |
| 9 | 3A | 23.92 | 41.87 | 36.14 | 46.8 | 46.2±1.0 |
| | 3B | 21.03 | 40.49 | 34.30 | 46.6 | |
| | 3C | 22.23 | 43.45 | 36.87 | 45.0 | |
| 12 | 4A | 21.95 | 40.23 | 34.32 | 47.8 | 46.8±2.1 |
| | 4B | 22.07 | 42.11 | 35.95 | 44.3 | |
| | 4C | 16.89 | 33.89 | 28.37 | 48.1 | |
| 15 | 5A | 22.13 | 47.43 | 39.60 | 44.8 | 39.2±5.0 |
| | 5B | 21.76 | 45.70 | 39.50 | 34.9 | |
| | 5C | 24.80 | 48.37 | 41.88 | 38.0 | |
| 18 | 6A | 22.47 | 40.01 | 35.10 | 38.9 | 39.0±0.6 |
| | 6B | 23.68 | 46.39 | 40.07 | 38.5 | |
| | 6C | 22.65 | 43.73 | 37.75 | 39.7 | |
| 21 | 7A | 20.00 | 41.45 | 35.49 | 38.4 | 39.7±1.8 |
| | 7B | 23.02 | 41.89 | 36.33 | 41.8 | |
| | 7C | 24.81 | 43.32 | 38.12 | 39.0 | |
| 24 | 8A | 23.67 | 44.46 | 38.07 | 44.4 | 43.7±0.9 |
| | 8B | 21.55 | 42.15 | 35.98 | 42.7 | |
| | 8C | 22.34 | 45.35 | 38.33 | 43.9 | |
| 27 | 9A | 37.14 | 65.43 | 55.82 | 51.4 | 50.6±4.5 |
| | 9B | 34.31 | 63.15 | 54.09 | 45.8 | |
| | 9C | 35.41 | 67.61 | 56.23 | 54.6 | |
| 30 | 10A | 34.81 | 65.65 | 55.35 | 50.1 | 48.2±1.9 |
| | 10B | 35.32 | 60.47 | 52.31 | 48.0 | |
| | 10C | 36.49 | 71.76 | 60.59 | 46.3 | |
| 33 | 11A | 22.09 | 43.82 | 37.21 | 43.7 | 42.3±1.7 |
| | 11B | 23.04 | 46.52 | 39.50 | 42.6 | |
| | 11C | 20.01 | 38.04 | 32.84 | 40.5 | |
| 36 | 12A | 21.76 | 39.92 | 34.69 | 40.4 | 44.6±5.7 |
| | 12B | 22.95 | 46.92 | 38.81 | 51.1 | |
| | 12C | 35.35 | 63.81 | 55.35 | 42.3 | |
| 39 | 13A | 36.18 | 70.78 | 59.09 | 51.0 | 51.2±2.3 |
| | 13B | 25.39 | 45.93 | 39.17 | 49.0 | |
| | 13C | 36.67 | 77.32 | 63.15 | 53.6 | |
| | | | | **Avg (±SD)** | **43.9±4.9** | |

**Table A.12** Moisture content analysis results for Borehole-12

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 22.72 | 40.65 | 35.01 | 45.9 | 49.5±4.0 |
| | 1B | 23.00 | 39.88 | 34.35 | 48.8 | |
| | 1C | 21.68 | 38.91 | 32.89 | 53.7 | |
| 6 | 2A | 23.76 | 38.70 | 33.49 | 53.5 | 50.5±2.6 |
| | 2B | 24.81 | 40.46 | 35.33 | 48.7 | |
| | 2C | 22.23 | 45.17 | 37.60 | 49.3 | |
| 9 | 3A | 21.02 | 41.49 | 34.38 | 53.2 | 50.6±2.3 |
| | 3B | 21.53 | 42.09 | 35.31 | 49.2 | |
| | 3C | 19.98 | 42.50 | 35.06 | 49.3 | |
| 12 | 4A | 22.49 | 43.63 | 37.15 | 44.2 | 44.8±1.6 |
| | 4B | 24.66 | 46.75 | 39.72 | 46.7 | |
| | 4C | 22.34 | 43.22 | 36.88 | 43.6 | |
| 15 | 5A | 22.13 | 42.40 | 35.97 | 46.5 | 48.3±4.2 |
| | 5B | 23.07 | 44.99 | 37.39 | 53.0 | |
| | 5C | 23.66 | 51.47 | 42.80 | 45.3 | |
| 18 | 6A | 22.94 | 46.41 | 39.20 | 44.4 | 51.5±6.4 |
| | 6B | 21.76 | 41.72 | 34.79 | 53.2 | |
| | 6C | 22.72 | 42.85 | 35.55 | 56.9 | |
| 21 | 7A | 22.81 | 42.86 | 36.22 | 49.5 | 47.4±2.1 |
| | 7B | 23.87 | 47.18 | 39.92 | 45.2 | |
| | 7C | 16.14 | 29.74 | 25.36 | 47.5 | |
| 24 | 8A | 34.20 | 70.72 | 59.59 | 43.8 | 43.4±1.2 |
| | 8B | 35.34 | 69.07 | 58.71 | 44.3 | |
| | 8C | 36.68 | 79.15 | 66.60 | 42.0 | |
| 27 | 9A | 23.93 | 46.47 | 39.05 | 49.1 | 51.4±2.5 |
| | 9B | 23.67 | 45.97 | 38.44 | 50.9 | |
| | 9C | 25.95 | 50.85 | 42.11 | 54.0 | |
| 30 | 10A | 22.99 | 45.56 | 37.47 | 55.8 | 63.1±6.3 |
| | 10B | 22.73 | 46.77 | 37.24 | 65.7 | |
| | 10C | 22.69 | 46.59 | 36.95 | 67.6 | |
| 33 | 11A | 21.76 | 41.75 | 34.39 | 58.3 | 62.0±5.5 |
| | 11B | 22.73 | 40.67 | 33.39 | 68.3 | |
| | 11C | 22.56 | 44.46 | 36.31 | 59.3 | |
| 36 | 12A | 27.34 | 44.80 | 38.01 | 63.7 | 59.2±4.6 |
| | 12B | 21.68 | 47.84 | 38.62 | 54.5 | |
| | 12C | 20.00 | 38.43 | 31.57 | 59.4 | |
| 39 | 13A | 35.32 | 68.30 | 58.98 | 39.4 | 41.6±8.7 |
| | 13B | 37.14 | 70.69 | 62.15 | 34.1 | |
| | 13C | 34.80 | 73.89 | 60.65 | 51.2 | |
| 41.7 | 14A | 33.33 | 75.21 | 62.25 | 44.8 | 44.6±0.9 |
| | 14B | 35.35 | 72.61 | 60.99 | 45.4 | |
| | 14C | 35.41 | 73.78 | 62.14 | 43.5 | |
| | | | | **Avg (±SD)** | **50.5±7.5** | |

**Table A.13** Moisture content analysis results for Borehole-13

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 23.00 | 44.74 | 37.98 | 45.1 | 44.0±1.0 |
| | 1B | 23.35 | 48.16 | 40.69 | 43.0 | |
| | 1C | 22.55 | 44.24 | 37.62 | 44.0 | |
| 6 | 2A | 25.93 | 46.31 | 39.57 | 49.5 | 45.6±3.4 |
| | 2B | 22.68 | 45.41 | 38.52 | 43.5 | |
| | 2C | 22.64 | 45.16 | 38.30 | 43.8 | |
| 9 | 3A | 20.51 | 41.11 | 34.91 | 43.0 | 43.5±2.6 |
| | 3B | 24.73 | 44.57 | 38.31 | 46.3 | |
| | 3C | 22.07 | 46.16 | 39.13 | 41.2 | |
| 12 | 4A | 21.93 | 43.54 | 36.75 | 45.8 | 45.5±1.6 |
| | 4B | 22.46 | 39.85 | 34.56 | 43.8 | |
| | 4C | 23.03 | 43.27 | 36.81 | 46.9 | |
| 15 | 5A | 16.85 | 38.47 | 32.06 | 42.2 | 45.0±2.8 |
| | 5B | 27.33 | 47.18 | 40.75 | 47.9 | |
| | 5C | 23.91 | 43.46 | 37.42 | 44.8 | |
| 18 | 6A | 33.32 | 78.35 | 63.91 | 47.2 | 47.5±1.0 |
| | 6B | 37.12 | 80.07 | 66.02 | 48.6 | |
| | 6C | 35.29 | 81.71 | 66.94 | 46.7 | |
| 21 | 7A | 35.39 | 74.99 | 63.13 | 42.7 | 46.1±3.1 |
| | 7B | 35.79 | 71.83 | 60.39 | 46.5 | |
| | 7C | 36.16 | 76.79 | 63.45 | 48.9 | |
| 24 | 8A | 22.99 | 44.41 | 35.33 | 73.7 | 67.9±5.2 |
| | 8B | 16.93 | 43.99 | 33.21 | 66.2 | |
| | 8C | 22.15 | 38.82 | 32.33 | 63.7 | |
| 27 | 9A | 22.57 | 43.69 | 35.51 | 63.1 | 64.0±1.0 |
| | 9B | 23.02 | 43.96 | 35.79 | 63.9 | |
| | 9C | 23.54 | 57.68 | 44.22 | 65.1 | |
| 30 | 10A | 23.88 | 56.88 | 44.66 | 58.8 | 56.2±5.7 |
| | 10B | 27.34 | 60.69 | 49.63 | 49.6 | |
| | 10C | 20.54 | 44.50 | 35.51 | 60.1 | |
| 31.5 | 11A | 22.65 | 49.39 | 39.89 | 55.1 | 55.6±2.4 |
| | 11B | 34.20 | 75.96 | 60.58 | 58.3 | |
| | 11C | 35.84 | 67.59 | 56.52 | 53.5 | |
| 33 | 12A | 21.94 | 38.07 | 30.69 | 84.4 | 80.0±4.8 |
| | 12B | 22.82 | 41.73 | 33.28 | 80.8 | |
| | 12C | 24.81 | 61.91 | 46.03 | 74.9 | |
| 33.6 | 13A | 16.15 | 38.96 | 29.15 | 75.4 | 72.3±2.8 |
| | 13B | 21.68 | 50.30 | 38.53 | 69.9 | |
| | 13C | 22.24 | 53.75 | 40.61 | 71.6 | |
| | | | | **Avg (±SD)** | **54.9±12.4** | |

**Table A.14** Moisture content analysis results for Borehole-14

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 1.5 | 1A | 34.19 | 93.09 | 88.01 | 9.4 | 22.6±12.8 |
| | 1B | 35.39 | 99.19 | 82.64 | 35.0 | |
| | 1C | 33.32 | 88.88 | 78.37 | 23.3 | |
| 3 | 2A | 37.13 | 91.48 | 79.99 | 26.8 | 25.8±0.9 |
| | 2B | 36.18 | 94.94 | 83.00 | 25.5 | |
| | 2C | 34.80 | 94.76 | 82.72 | 25.1 | |
| 4.5 | 3A | 35.40 | 87.20 | 77.99 | 21.6 | 21.7±0.4 |
| | 3B | 36.68 | 93.11 | 83.17 | 21.4 | |
| | 3C | 35.29 | 92.80 | 82.38 | 22.1 | |
| 6 | 4A | 21.69 | 49.80 | 44.18 | 25.0 | 25.6±0.8 |
| | 4B | 23.87 | 49.20 | 43.90 | 26.5 | |
| | 4C | 22.68 | 48.14 | 42.99 | 25.3 | |
| 9 | 5A | 27.34 | 57.13 | 56.68 | 1.5 | 7.4±9.6 |
| | 5B | 22.98 | 48.07 | 44.16 | 18.5 | |
| | 5C | 22.77 | 61.59 | 60.77 | 2.2 | |
| | | | | **Avg (±SD)** | **20.6±9.3** | |

**Table A.15** Moisture content analysis results for Borehole-15

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 36.49 | 90.92 | 80.05 | 25.0 | 24.4±1.6 |
| | 1B | 35.84 | 84.40 | 74.49 | 25.6 | |
| | 1C | 34.31 | 89.28 | 79.12 | 22.7 | |
| 6 | 2A | 25.39 | 54.47 | 48.69 | 24.8 | 27.3±2.5 |
| | 2B | 22.83 | 52.18 | 45.91 | 27.1 | |
| | 2C | 20.63 | 46.91 | 40.86 | 29.9 | |
| 9 | 3A | 23.54 | 52.12 | 45.10 | 32.5 | 30.5±1.8 |
| | 3B | 22.95 | 49.64 | 43.52 | 29.8 | |
| | 3C | 22.77 | 52.99 | 46.19 | 29.1 | |
| 12 | 4A | 21.94 | 46.67 | 40.45 | 33.6 | 36.2±2.2 |
| | 4B | 22.48 | 46.98 | 40.33 | 37.3 | |
| | 4C | 22.08 | 44.27 | 38.19 | 37.7 | |
| 15 | 5A | 23.02 | 47.02 | 40.70 | 35.7 | 39.3±3.8 |
| | 5B | 16.92 | 41.96 | 34.94 | 38.9 | |
| | 5C | 23.03 | 45.18 | 38.48 | 43.4 | |
| | | | | **Avg (±SD)** | **31.5±6.1** | |

**Table A.16** Moisture content analysis results for Borehole-16

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Moisture content (%) | Avg. (±SD) Moisture content (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 22.50 | 48.28 | 43.60 | 22.2 | 21.7±9.4 |
| | 1B | 23.04 | 50.46 | 47.51 | 12.1 | |
| | 1C | 22.95 | 47.18 | 41.45 | 30.9 | |
| 4.5 | 2A | 21.54 | 40.29 | 34.73 | 42.1 | 42.0±1.6 |
| | 2B | 22.56 | 46.48 | 39.23 | 43.5 | |
| | 2C | 22.81 | 48.94 | 41.43 | 40.4 | |
| 6 | 3A | 22.74 | 46.04 | 41.10 | 26.9 | 29.9±3.2 |
| | 3B | 24.67 | 49.79 | 43.53 | 33.2 | |
| | 3C | 16.15 | 32.97 | 29.12 | 29.7 | |
| | | | | **Avg (±SD)** | **31.2±10.2** | |

## Appendix B

**Table B.1** Organic matter results for Borehole-01

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 93.86 | 97.84 | 97.08 | 19.04 | 21.52±2.92 |
| | 1B | 105.87 | 108.98 | 108.21 | 24.74 | |
| | 1C | 101.33 | 105.48 | 104.62 | 20.79 | |
| 6 | 2A | 93.96 | 97.13 | 96.43 | 22.22 | 22.15±1.02 |
| | 2B | 101.33 | 105.60 | 104.70 | 21.09 | |
| | 2C | 105.86 | 108.22 | 107.67 | 23.13 | |
| 9 | 3A | 96.32 | 100.25 | 99.52 | 18.46 | 18.10±1.38 |
| | 3B | 102.42 | 105.47 | 104.88 | 19.28 | |
| | 3C | 109.74 | 113.36 | 112.76 | 16.58 | |
| 12 | 4A | 102.42 | 105.37 | 104.72 | 21.92 | 22.05±2.61 |
| | 4B | 96.33 | 99.87 | 99.00 | 24.72 | |
| | 4C | 109.74 | 114.12 | 113.26 | 19.51 | |
| 15 | 5A | 96.32 | 100.03 | 99.10 | 25.12 | 25.17±1.45 |
| | 5B | 102.42 | 106.19 | 105.19 | 26.65 | |
| | 5C | 109.74 | 113.32 | 112.47 | 23.75 | |
| 18 | 6A | 101.33 | 104.68 | 103.68 | 29.81 | 33.27±9.47 |
| | 6B | 93.96 | 96.42 | 95.34 | 43.98 | |
| | 6C | 105.87 | 111.13 | 109.76 | 26.02 | |
| 21 | 7A | 102.43 | 106.60 | 105.78 | 19.77 | 22.14±5.71 |
| | 7B | 96.32 | 100.12 | 99.44 | 18.00 | |
| | 7C | 109.74 | 111.91 | 111.29 | 28.65 | |
| 24 | 8A | 101.33 | 104.69 | 103.85 | 24.97 | 23.57±1.26 |
| | 8B | 105.87 | 108.72 | 108.06 | 23.20 | |
| | 8C | 93.97 | 98.50 | 97.48 | 22.54 | |
| | | | | **Avg (±SD)** | **23.49±5.51** | |

**Table B.2** Organic matter results for Borehole-02

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 93.96 | 96.40 | 95.93 | 19.35 | 19.64±0.71 |
| | 1B | 101.33 | 103.48 | 103.07 | 19.11 | |
| | 1C | 105.87 | 107.99 | 107.56 | 20.45 | |
| 6 | 2A | 102.43 | 105.33 | 104.74 | 20.20 | 21.05±2.14 |
| | 2B | 96.33 | 98.98 | 98.47 | 19.46 | |
| | 2C | 109.75 | 112.50 | 111.85 | 23.48 | |
| 9 | 3A | 93.97 | 97.03 | 96.22 | 26.30 | 28.13±4.04 |
| | 3B | 101.33 | 104.00 | 103.13 | 32.76 | |
| | 3C | 105.87 | 108.87 | 108.11 | 25.33 | |
| 12 | 4A | 109.74 | 113.03 | 112.09 | 28.54 | 26.881.98 |
| | 4B | 96.33 | 99.41 | 98.65 | 24.68 | |
| | 4C | 102.43 | 105.99 | 105.01 | 27.42 | |
| 15 | 5A | 101.33 | 105.21 | 104.44 | 19.71 | 22.92±4.84 |
| | 5B | 105.86 | 109.67 | 108.88 | 20.56 | |
| | 5C | 93.96 | 97.23 | 96.30 | 28.49 | |
| 18 | 6A | 105.86 | 108.63 | 107.85 | 28.15 | 30.75±2.25 |
| | 6B | 93.96 | 96.57 | 95.74 | 32.02 | |
| | 6C | 101.33 | 104.39 | 103.40 | 32.07 | |
| 21 | 7A | 93.96 | 97.37 | 96.56 | 23.92 | 25.68±2.55 |
| | 7B | 101.33 | 104.06 | 103.28 | 28.61 | |
| | 7C | 105.88 | 107.97 | 107.46 | 24.51 | |
| 24 | 8A | 101.33 | 104.17 | 103.57 | 21.10 | 19.87±1.45 |
| | 8B | 105.87 | 109.40 | 108.69 | 20.23 | |
| | 8C | 93.97 | 97.64 | 96.97 | 18.27 | |
| 27 | 9A | 102.42 | 105.37 | 104.64 | 24.62 | 26.80±2.20 |
| | 9B | 96.33 | 99.83 | 98.89 | 26.77 | |
| | 9C | 109.75 | 112.38 | 111.61 | 29.01 | |
| 30 | 10A | 105.87 | 109.33 | 108.23 | 31.84 | 31.13±0.62 |
| | 10B | 101.33 | 103.85 | 103.08 | 30.69 | |
| | 10C | 93.96 | 97.53 | 96.43 | 30.87 | |
| | | | | **Avg (±SD)** | **25.28±4.63** | |

**Table B.3** Organic matter results for Borehole-03

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 93.97 | 97.74 | 97.03 | 18.64 | 17.31±1.16 |
| | 1B | 101.34 | 105.12 | 104.49 | 16.50 | |
| | 1C | 105.87 | 109.62 | 108.99 | 16.80 | |
| 6 | 2A | 109.75 | 113.55 | 112.84 | 18.57 | 19.10±0.89 |
| | 2B | 102.43 | 106.60 | 105.83 | 18.60 | |
| | 2C | 96.36 | 100.19 | 99.42 | 20.13 | |
| 9 | 3A | 93.97 | 98.05 | 97.44 | 14.76 | 14.88±1.66 |
| | 3B | 105.87 | 109.16 | 108.72 | 13.29 | |
| | 3C | 101.34 | 105.15 | 104.51 | 16.60 | |
| 12 | 4A | 109.75 | 113.51 | 112.85 | 17.54 | 18.81±1.83 |
| | 4B | 102.43 | 105.64 | 104.97 | 20.90 | |
| | 4C | 96.32 | 99.72 | 99.11 | 17.97 | |
| 15 | 5A | 102.43 | 105.99 | 105.39 | 16.88 | 17.12±0.87 |
| | 5B | 109.75 | 113.43 | 112.83 | 16.40 | |
| | 5C | 96.33 | 100.60 | 99.83 | 18.08 | |
| 18 | 6A | 101.34 | 105.26 | 104.75 | 13.14 | 11.30±1.65 |
| | 6B | 105.87 | 111.06 | 110.50 | 10.81 | |
| | 6C | 93.97 | 98.70 | 98.23 | 9.94 | |
| 21 | 7A | 102.43 | 106.42 | 105.93 | 12.33 | 13.96±1.41 |
| | 7B | 109.75 | 113.93 | 113.32 | 14.72 | |
| | 7C | 96.33 | 100.27 | 99.69 | 14.84 | |
| 24 | 8A | 105.87 | 109.44 | 108.83 | 17.06 | 17.81±1.71 |
| | 8B | 101.34 | 105.75 | 105.02 | 16.60 | |
| | 8C | 93.97 | 98.71 | 97.78 | 19.77 | |
| | | | | **Avg (±SD)** | **16.29±2.84** | |

**Table B.4** Organic matter results for Borehole-04

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 105.87 | 109.28 | 108.68 | 17.68 | 17.55±1.49 |
| | 1B | 93.96 | 96.84 | 96.38 | 16.00 | |
| | 1C | 101.33 | 104.49 | 103.89 | 18.97 | |
| 6 | 2A | 102.42 | 105.94 | 105.20 | 21.04 | 20.94±0.62 |
| | 2B | 109.74 | 112.63 | 112.01 | 21.51 | |
| | 2C | 96.32 | 100.19 | 99.41 | 20.28 | |
| 9 | 3A | 93.96 | 97.21 | 96.58 | 19.51 | 19.23±1.94 |
| | 3B | 101.33 | 104.23 | 103.73 | 17.16 | |
| | 3C | 105.87 | 109.49 | 108.73 | 21.01 | |
| 12 | 4A | 102.43 | 106.21 | 105.53 | 17.88 | 18.98±0.95 |
| | 4B | 96.33 | 100.15 | 99.40 | 19.58 | |
| | 4C | 109.74 | 113.83 | 113.03 | 19.49 | |
| 15 | 5A | 109.75 | 112.99 | 112.18 | 25.15 | 22.34±2.52 |
| | 5B | 96.33 | 100.05 | 99.25 | 21.62 | |
| | 5C | 102.43 | 106.71 | 105.84 | 20.27 | |
| 18 | 6A | 102.42 | 105.25 | 104.64 | 21.80 | 25.54±3.28 |
| | 6B | 96.32 | 99.52 | 98.66 | 26.89 | |
| | 6C | 109.75 | 112.90 | 112.02 | 27.93 | |
| 21 | 7A | 105.87 | 109.28 | 108.55 | 21.60 | 22.52±2.37 |
| | 7B | 93.97 | 97.59 | 96.67 | 25.21 | |
| | 7C | 101.34 | 105.93 | 104.98 | 20.74 | |
| 24 | 8A | 105.87 | 109.60 | 108.92 | 18.06 | 17.66±2.06 |
| | 8B | 93.97 | 97.38 | 96.72 | 19.49 | |
| | 8C | 101.33 | 106.96 | 106.09 | 15.43 | |
| 27 | 9A | 96.33 | 100.18 | 99.35 | 21.55 | 20.01±1.94 |
| | 9B | 102.43 | 107.31 | 106.44 | 17.82 | |
| | 9C | 109.75 | 113.40 | 112.64 | 20.65 | |
| 30 | 10A | 93.96 | 99.35 | 98.52 | 15.34 | 20.06±4.24 |
| | 10B | 105.87 | 109.00 | 108.27 | 23.57 | |
| | 10C | 101.33 | 105.69 | 104.76 | 21.27 | |
| 33 | 11A | 102.43 | 106.68 | 105.88 | 18.82 | 20.59±2.05 |
| | 11B | 96.33 | 100.79 | 99.77 | 22.83 | |
| | 11C | 109.75 | 114.80 | 113.78 | 20.12 | |
| 36 | 12A | 102.42 | 106.81 | 105.72 | 24.81 | 20.88±3.44 |
| | 12B | 109.75 | 114.39 | 113.53 | 18.47 | |
| | 12C | 96.31 | 100.14 | 99.40 | 19.36 | |
| | | | | **Avg (±SD)** | **20.53±2.96** | |

**Table B.5** Organic matter results for Borehole-05

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 102.42 | 104.88 | 104.26 | 25.12 | 22.53±2.31 |
| | 1B | 96.32 | 99.57 | 98.86 | 21.79 | |
| | 1C | 109.74 | 113.26 | 112.53 | 20.68 | |
| 6 | 2A | 109.74 | 112.71 | 112.09 | 20.73 | 23.07±4.63 |
| | 2B | 96.32 | 100.29 | 99.49 | 20.08 | |
| | 2C | 102.43 | 105.94 | 104.94 | 28.40 | |
| 9 | 3A | 105.87 | 108.68 | 108.02 | 23.36 | 20.83±2.64 |
| | 3B | 93.96 | 96.28 | 95.79 | 21.03 | |
| | 3C | 101.33 | 105.41 | 104.68 | 18.09 | |
| 12 | 4A | 96.32 | 99.71 | 99.11 | 17.78 | 18.58±1.39 |
| | 4B | 102.42 | 105.71 | 105.05 | 20.19 | |
| | 4C | 109.74 | 113.18 | 112.57 | 17.77 | |
| 15 | 5A | 93.97 | 97.09 | 96.54 | 17.52 | 18.52±0.86 |
| | 5B | 101.33 | 104.17 | 103.63 | 18.98 | |
| | 5C | 105.87 | 109.92 | 109.15 | 19.05 | |
| 18 | 6A | 93.96 | 98.62 | 98.11 | 10.83 | 10.72±0.67 |
| | 6B | 101.33 | 105.68 | 105.24 | 10.00 | |
| | 6C | 105.87 | 110.70 | 110.15 | 11.32 | |
| 21 | 7A | 96.32 | 100.78 | 100.49 | 6.46 | 6.26±0.64 |
| | 7B | 102.42 | 107.61 | 107.26 | 6.77 | |
| | 7C | 109.74 | 114.78 | 114.50 | 5.53 | |
| 24 | 9A | 102.43 | 107.93 | 107.44 | 8.97 | 9.15±0.21 |
| | 9B | 96.33 | 102.45 | 101.88 | 9.39 | |
| | 9C | 109.74 | 115.35 | 114.84 | 9.10 | |
| 27 | 10A | 102.42 | 106.66 | 106.32 | 7.94 | 9.46±1.89 |
| | 10B | 96.31 | 102.03 | 101.37 | 11.58 | |
| | 10C | 109.75 | 117.03 | 116.38 | 8.87 | |
| 30 | 11A | 93.96 | 99.70 | 99.04 | 11.40 | 11.43±0.02 |
| | 11B | 101.33 | 106.77 | 106.14 | 11.44 | |
| | 11C | 105.87 | 110.54 | 110.00 | 11.45 | |
| | | | | **Avg (±SD)** | **15.05±6.27** | |

**Table B.6** Organic matter results for Borehole-06

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 109.74 | 113.86 | 113.14 | 17.46 | 16.34±1.15 |
| | 1B | 102.43 | 106.48 | 105.87 | 15.16 | |
| | 1C | 96.33 | 100.57 | 99.87 | 16.39 | |
| 6 | 2A | 101.33 | 106.63 | 106.01 | 11.77 | 10.58±1.80 |
| | 2B | 93.96 | 98.47 | 98.09 | 8.51 | |
| | 2C | 105.86 | 110.43 | 109.91 | 11.47 | |
| 9 | 3A | 109.74 | 114.95 | 114.38 | 10.86 | 10.68±0.72 |
| | 3B | 96.32 | 99.95 | 99.59 | 9.89 | |
| | 3C | 102.42 | 107.67 | 107.08 | 11.30 | |
| 12 | 4A | 93.96 | 100.08 | 99.48 | 9.73 | 8.08±1.83 |
| | 4B | 101.33 | 105.62 | 105.36 | 6.11 | |
| | 4C | 105.86 | 112.63 | 112.06 | 8.41 | |
| 15 | 5A | 96.32 | 100.36 | 99.97 | 9.60 | 8.79±0.74 |
| | 5B | 102.42 | 107.65 | 107.20 | 8.62 | |
| | 5C | 109.74 | 115.84 | 115.34 | 8.15 | |
| 18 | 6A | 105.86 | 111.19 | 110.67 | 9.77 | 9.67±0.16 |
| | 6B | 101.33 | 105.69 | 105.27 | 9.75 | |
| | 6C | 93.96 | 101.19 | 100.50 | 9.49 | |
| 21 | 7A | 102.42 | 108.26 | 107.69 | 9.74 | 9.65±1.15 |
| | 7B | 109.74 | 116.02 | 115.49 | 8.45 | |
| | 7C | 96.32 | 102.09 | 101.47 | 10.75 | |
| 24 | 8A | 105.86 | 109.64 | 108.91 | 19.30 | 20.65±1.50 |
| | 8B | 93.96 | 98.64 | 97.59 | 22.26 | |
| | 8C | 101.33 | 105.31 | 104.49 | 20.39 | |
| 27 | 9A | 109.74 | 113.90 | 113.53 | 8.94 | 11.24±2.02 |
| | 9B | 102.43 | 105.92 | 105.50 | 12.04 | |
| | 9C | 96.33 | 101.46 | 100.81 | 12.75 | |
| 30 | 10A | 101.33 | 105.24 | 104.78 | 11.72 | 11.95±0.35 |
| | 10B | 93.96 | 97.13 | 96.73 | 12.36 | |
| | 10C | 105.86 | 109.31 | 108.91 | 11.77 | |
| 33 | 11A | 109.75 | 116.12 | 115.33 | 12.44 | 15.77±4.78 |
| | 11B | 96.33 | 98.76 | 98.24 | 21.25 | |
| | 11C | 102.43 | 107.42 | 106.74 | 13.63 | |
| 36 | 12A | 101.33 | 105.73 | 105.08 | 14.81 | 16.48±1.82 |
| | 12B | 105.87 | 109.56 | 108.96 | 16.22 | |
| | 12C | 93.97 | 96.67 | 96.17 | 18.42 | |
| | | | | **Avg (±SD)** | **12.49±4.08** | |

**Table B.7** Organic matter results for Borehole-07

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 105.86 | 108.79 | 108.04 | 25.40 | 22.78±2.29 |
| | 1B | 93.96 | 96.86 | 96.25 | 21.15 | |
| | 1C | 101.33 | 104.28 | 103.64 | 21.79 | |
| 6 | 2A | 96.33 | 99.29 | 98.64 | 21.92 | 22.19±3.42 |
| | 2B | 102.42 | 105.91 | 105.25 | 18.90 | |
| | 2C | 109.74 | 112.16 | 111.53 | 25.73 | |
| 9 | 3A | 105.86 | 109.26 | 108.73 | 15.49 | 17.66±2.15 |
| | 3B | 101.33 | 105.25 | 104.56 | 17.69 | |
| | 3C | 93.96 | 96.88 | 96.30 | 19.79 | |
| 12 | 4A | 102.42 | 104.60 | 104.00 | 27.44 | 22.22±4.55 |
| | 4B | 109.74 | 112.17 | 111.68 | 20.15 | |
| | 4C | 96.32 | 99.59 | 98.96 | 19.08 | |
| 15 | 5A | 93.96 | 97.63 | 97.08 | 14.88 | 18.63±3.81 |
| | 5B | 105.86 | 109.44 | 108.64 | 22.50 | |
| | 5C | 101.33 | 104.83 | 104.18 | 18.50 | |
| 18 | 6A | 109.74 | 114.11 | 113.44 | 15.40 | 14.51±0.92 |
| | 6B | 96.33 | 98.48 | 98.19 | 13.56 | |
| | 6C | 102.43 | 106.59 | 105.98 | 14.59 | |
| 21 | 7A | 105.86 | 109.29 | 108.66 | 18.35 | 16.65±1.49 |
| | 7B | 93.96 | 97.56 | 97.00 | 15.55 | |
| | 7C | 101.33 | 104.56 | 104.04 | 16.07 | |
| 24 | 8A | 102.42 | 107.57 | 106.81 | 14.84 | 17.24±2.81 |
| | 8B | 96.32 | 99.94 | 99.21 | 20.33 | |
| | 8C | 109.74 | 114.03 | 113.32 | 16.55 | |
| 27 | 9A | 102.43 | 107.34 | 106.76 | 11.73 | 12.56±1.27 |
| | 9B | 96.33 | 100.75 | 100.23 | 11.92 | |
| | 9C | 109.74 | 113.52 | 112.99 | 14.02 | |
| 30 | 10A | 105.87 | 108.86 | 108.20 | 21.92 | 21.91±2.92 |
| | 10B | 93.96 | 97.09 | 96.49 | 18.99 | |
| | 10C | 101.33 | 104.12 | 103.43 | 24.83 | |
| 33 | 11A | 102.42 | 107.96 | 107.38 | 10.60 | 12.22±1.86 |
| | 11B | 96.33 | 99.20 | 98.86 | 11.83 | |
| | 11C | 109.74 | 113.26 | 112.76 | 14.25 | |
| 36 | 12A | 93.96 | 97.52 | 96.96 | 15.74 | 15.33±1.36 |
| | 12B | 105.86 | 110.18 | 109.58 | 13.81 | |
| | 12C | 101.33 | 107.54 | 106.52 | 16.44 | |
| | | | | **Avg (±SD)** | **17.83±4.28** | |

**Table B.8** Organic matter results for Borehole-08

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 1.5 | 1A | 93.96 | 98.60 | 98.43 | 3.68 | 3.89±0.18 |
| | 1B | 105.87 | 111.12 | 110.91 | 3.96 | |
| | 1C | 101.33 | 105.24 | 105.08 | 4.02 | |
| 3 | 2A | 105.86 | 108.95 | 108.78 | 5.34 | 5.45±0.17 |
| | 2B | 101.33 | 106.68 | 106.38 | 5.64 | |
| | 2C | 93.97 | 99.32 | 99.03 | 5.36 | |
| 4.5 | 3A | 102.42 | 107.27 | 107.06 | 4.34 | 4.03±0.57 |
| | 3B | 96.32 | 100.06 | 99.89 | 4.39 | |
| | 3C | 109.74 | 113.54 | 113.41 | 3.37 | |
| | | | | **Avg (±SD)** | **4.46±0.81** | |

**Table B.9** Organic matter results for Borehole-09

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 1.5 | 1A | 109.74 | 114.27 | 114.16 | 2.58 | 3.13±0.77 |
| | 1B | 102.42 | 107.12 | 106.99 | 2.81 | |
| | 1C | 96.32 | 100.14 | 99.99 | 4.01 | |
| 4.5 | 2A | 102.43 | 106.45 | 106.31 | 3.53 | 3.21±0.35 |
| | 2B | 109.75 | 114.85 | 114.70 | 2.84 | |
| | 2C | 96.32 | 101.50 | 101.33 | 3.25 | |
| | | | | **Avg (±SD)** | **3.17±0.53** | |

**Table B.10** Organic matter results for Borehole-10

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 105.87 | 109.46 | 108.28 | 32.85 | 36.46±4.51 |
| | 1B | 101.33 | 106.06 | 104.41 | 35.02 | |
| | 1C | 93.97 | 95.72 | 94.99 | 41.52 | |
| 6 | 2A | 102.42 | 105.32 | 104.85 | 16.10 | 16.06±2.48 |
| | 2B | 96.33 | 100.58 | 99.80 | 18.53 | |
| | 2C | 109.74 | 114.61 | 113.95 | 13.57 | |
| 9 | 3A | 102.43 | 106.82 | 106.19 | 14.33 | 15.67±1.48 |
| | 3B | 96.33 | 100.70 | 100.03 | 15.42 | |
| | 3C | 109.75 | 114.10 | 113.35 | 17.26 | |
| 12 | 4A | 96.32 | 100.00 | 99.47 | 14.60 | 13.99±1.70 |
| | 4B | 102.44 | 107.76 | 106.94 | 15.30 | |
| | 4C | 109.75 | 113.39 | 112.95 | 12.07 | |
| 15 | 5A | 105.87 | 110.19 | 109.79 | 9.34 | 9.74±0.48 |
| | 5B | 93.96 | 99.40 | 98.88 | 9.61 | |
| | 5C | 101.33 | 105.28 | 104.88 | 10.28 | |
| 18 | 6A | 102.42 | 106.59 | 106.00 | 14.08 | 14.58±1.12 |
| | 6B | 96.32 | 100.50 | 99.92 | 13.80 | |
| | 6C | 109.74 | 113.62 | 113.01 | 15.86 | |
| 21 | 7A | 93.97 | 98.00 | 97.45 | 13.66 | 14.88±1.19 |
| | 7B | 101.33 | 106.07 | 105.36 | 14.94 | |
| | 7C | 105.87 | 110.68 | 109.91 | 16.03 | |
| 24 | 8A | 93.96 | 98.41 | 97.94 | 10.56 | 10.05±1.05 |
| | 8B | 101.33 | 104.78 | 104.41 | 10.74 | |
| | 8C | 105.87 | 110.92 | 110.47 | 8.84 | |
| 27 | 9A | 101.33 | 106.03 | 105.36 | 14.43 | 14.08±0.68 |
| | 9B | 93.97 | 98.21 | 97.59 | 14.52 | |
| | 9C | 105.87 | 109.95 | 109.41 | 13.30 | |
| 30 | 10A | 96.32 | 102.56 | 101.85 | 11.33 | 10.51±0.71 |
| | 10B | 109.75 | 113.92 | 113.50 | 10.04 | |
| | 10C | 102.42 | 106.95 | 106.49 | 10.16 | |
| 33 | 11A | 96.33 | 99.96 | 99.12 | 23.15 | 23.04±1.21 |
| | 11B | 102.43 | 105.86 | 105.03 | 24.19 | |
| | 11C | 109.74 | 113.34 | 112.55 | 21.79 | |
| 36 | 12A | 105.86 | 109.20 | 108.27 | 27.98 | 26.17±3.43 |
| | 12B | 101.33 | 105.53 | 104.60 | 22.21 | |
| | 12C | 93.96 | 97.93 | 96.81 | 28.31 | |
| 39 | 13A | 102.43 | 106.85 | 106.21 | 14.34 | 16.09±1.52 |
| | 13B | 109.74 | 113.27 | 112.68 | 16.78 | |
| | 13C | 96.33 | 99.81 | 99.21 | 17.15 | |
| 41.7 | 14A | 105.87 | 109.18 | 108.83 | 10.68 | 14.35±3.53 |
| | 14B | 101.33 | 105.60 | 104.98 | 14.65 | |
| | 14C | 93.97 | 98.19 | 97.44 | 17.71 | |
| | | | | **Avg (±SD)** | **16.83±7.28** | |

**Table B.11** Organic matter results for Borehole-11

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 93.96 | 97.93 | 97.29 | 16.13 | 17.33±2.32 |
| | 1B | 101.33 | 104.19 | 103.62 | 20.01 | |
| | 1C | 105.87 | 111.14 | 110.30 | 15.86 | |
| 6 | 2A | 96.32 | 99.62 | 98.97 | 19.68 | 17.87±1.88 |
| | 2B | 102.42 | 107.19 | 106.33 | 17.99 | |
| | 2C | 109.74 | 113.93 | 113.27 | 15.92 | |
| 9 | 3A | 93.96 | 99.14 | 98.34 | 15.43 | 17.07±3.23 |
| | 3B | 105.86 | 110.40 | 109.46 | 20.79 | |
| | 3C | 101.33 | 106.37 | 105.61 | 15.00 | |
| 12 | 4A | 109.74 | 112.33 | 111.68 | 25.44 | 24.49±4.70 |
| | 4B | 102.43 | 104.99 | 104.25 | 28.64 | |
| | 4C | 96.33 | 100.83 | 99.96 | 19.40 | |
| 15 | 5A | 109.74 | 112.91 | 112.29 | 19.39 | 16.75±2.89 |
| | 5B | 102.43 | 107.47 | 106.60 | 17.21 | |
| | 5C | 96.33 | 100.32 | 99.78 | 13.65 | |
| 18 | 6A | 105.87 | 111.30 | 110.54 | 14.10 | 13.74±0.83 |
| | 6B | 93.96 | 99.07 | 98.41 | 12.80 | |
| | 6C | 101.33 | 105.91 | 105.25 | 14.33 | |
| 21 | 7A | 96.32 | 100.17 | 99.68 | 12.80 | 16.23±3.67 |
| | 7B | 109.74 | 114.98 | 113.93 | 20.10 | |
| | 7C | 102.43 | 108.06 | 107.17 | 15.78 | |
| 24 | 8A | 105.87 | 110.07 | 109.43 | 15.14 | 14.02±1.21 |
| | 8B | 101.33 | 105.47 | 104.95 | 12.73 | |
| | 8C | 93.97 | 97.77 | 97.23 | 14.20 | |
| 27 | 9A | 93.97 | 99.56 | 98.45 | 19.81 | 21.39±1.39 |
| | 9B | 101.33 | 105.83 | 104.85 | 21.93 | |
| | 9C | 105.87 | 111.52 | 110.25 | 22.43 | |
| 30 | 10A | 102.43 | 107.99 | 107.06 | 16.70 | 15.58±0.99 |
| | 10B | 96.33 | 103.25 | 102.20 | 15.21 | |
| | 10C | 109.74 | 113.59 | 113.02 | 14.84 | |
| 33 | 11A | 105.86 | 109.86 | 109.31 | 13.76 | 14.19±1.59 |
| | 11B | 93.96 | 97.86 | 97.24 | 15.95 | |
| | 11C | 101.33 | 106.73 | 106.03 | 12.86 | |
| 36 | 12A | 102.43 | 105.91 | 105.08 | 23.88 | 19.33±6.00 |
| | 12B | 96.32 | 101.40 | 100.76 | 12.53 | |
| | 12C | 109.74 | 113.39 | 112.61 | 21.58 | |
| 39 | 13A | 102.43 | 106.86 | 106.32 | 12.03 | 12.26±0.51 |
| | 13B | 96.33 | 100.42 | 99.93 | 11.90 | |
| | 13C | 109.75 | 114.66 | 114.03 | 12.85 | |
| | | | | **Avg (±SD)** | **16.94±4.03** | |

**Table B.12** Organic matter results for Borehole-12

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 101.33 | 105.07 | 104.27 | 21.55 | 20.32±1.15 |
| | 1B | 93.96 | 97.04 | 96.42 | 20.14 | |
| | 1C | 105.87 | 110.11 | 109.29 | 19.27 | |
| 6 | 2A | 105.87 | 110.44 | 109.65 | 17.25 | 19.05±3.05 |
| | 2B | 101.33 | 105.00 | 104.36 | 17.33 | |
| | 2C | 93.96 | 96.64 | 96.03 | 22.57 | |
| 9 | 3A | 96.33 | 99.07 | 98.60 | 17.36 | 18.17±2.12 |
| | 3B | 102.42 | 104.86 | 104.36 | 20.57 | |
| | 3C | 109.74 | 112.93 | 112.41 | 16.57 | |
| 12 | 4A | 109.75 | 113.32 | 112.83 | 13.74 | 15.20±2.33 |
| | 4B | 102.43 | 106.03 | 105.52 | 13.96 | |
| | 4C | 96.33 | 100.57 | 99.81 | 17.88 | |
| 15 | 5A | 96.32 | 100.41 | 99.77 | 15.70 | 15.96±1.39 |
| | 5B | 102.42 | 107.53 | 106.78 | 14.73 | |
| | 5C | 109.75 | 113.47 | 112.82 | 17.47 | |
| 18 | 6A | 105.87 | 107.99 | 107.51 | 22.91 | 20.19±3.43 |
| | 6B | 101.32 | 104.91 | 104.14 | 21.34 | |
| | 6C | 93.95 | 99.19 | 98.34 | 16.34 | |
| 21 | 7A | 102.43 | 105.39 | 104.90 | 16.63 | 18.71±2.22 |
| | 7B | 96.33 | 99.50 | 98.83 | 21.05 | |
| | 7C | 109.74 | 114.05 | 113.26 | 18.45 | |
| 24 | 8A | 93.97 | 97.65 | 96.88 | 20.84 | 17.52±2.90 |
| | 8B | 105.87 | 110.51 | 109.76 | 16.18 | |
| | 8C | 101.34 | 106.75 | 105.91 | 15.52 | |
| 27 | 9A | 102.43 | 106.93 | 106.26 | 14.72 | 14.30±0.37 |
| | 9B | 109.75 | 113.47 | 112.94 | 14.14 | |
| | 9C | 96.33 | 101.68 | 100.92 | 14.05 | |
| 30 | 10A | 101.34 | 105.44 | 104.86 | 14.17 | 16.46±2.54 |
| | 10B | 93.97 | 97.25 | 96.73 | 16.02 | |
| | 10C | 105.87 | 109.55 | 108.84 | 19.20 | |
| 33 | 11A | 105.87 | 109.36 | 108.88 | 13.80 | 19.99±3.33 |
| | 11B | 101.34 | 105.15 | 104.40 | 19.73 | |
| | 11C | 93.96 | 98.61 | 97.38 | 26.45 | |
| 36 | 12A | 96.33 | 100.38 | 99.62 | 18.71 | 16.90±1.84 |
| | 12B | 109.75 | 113.45 | 112.89 | 15.04 | |
| | 12C | 102.43 | 106.05 | 105.44 | 16.94 | |
| 39 | 13A | 105.87 | 110.45 | 109.75 | 15.29 | 15.56±0.43 |
| | 13B | 101.33 | 106.75 | 105.92 | 15.33 | |
| | 13C | 93.97 | 97.70 | 97.10 | 16.06 | |
| 41.7 | 14A | 96.32 | 100.71 | 100.09 | 14.13 | 14.04±2.56 |
| | 14B | 102.42 | 108.21 | 107.55 | 11.44 | |
| | 14C | 109.74 | 114.43 | 113.65 | 16.56 | |
| | | | | **Avg (±SD)** | **17.31±3.08** | |

**Table B.13** Organic matter results for Borehole-13

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 93.96 | 98.39 | 97.52 | 19.58 | 19.97±2.46 |
| | 1B | 101.33 | 104.43 | 103.88 | 17.73 | |
| | 1C | 105.87 | 108.91 | 108.22 | 22.59 | |
| 6 | 2A | 109.74 | 113.95 | 113.18 | 18.39 | 19.81±2.19 |
| | 2B | 102.43 | 105.31 | 104.67 | 22.33 | |
| | 2C | 96.32 | 100.42 | 99.66 | 18.70 | |
| 9 | 3A | 93.96 | 96.92 | 96.39 | 17.89 | 17.36±1.55 |
| | 3B | 101.33 | 105.03 | 104.35 | 18.57 | |
| | 3C | 105.87 | 109.92 | 109.29 | 15.62 | |
| 12 | 4A | 101.33 | 106.06 | 105.17 | 18.95 | 19.91±1.02 |
| | 4B | 105.87 | 110.34 | 109.40 | 20.98 | |
| | 4C | 93.98 | 98.81 | 97.86 | 19.79 | |
| 15 | 5A | 96.33 | 99.63 | 99.00 | 19.04 | 21.46±4.44 |
| | 5B | 109.74 | 112.59 | 111.84 | 26.59 | |
| | 5C | 102.42 | 106.44 | 105.69 | 18.76 | |
| 18 | 6A | 105.86 | 111.07 | 110.21 | 16.54 | 18.05±1.35 |
| | 6B | 93.96 | 99.26 | 98.28 | 18.47 | |
| | 6C | 101.33 | 107.26 | 106.13 | 19.14 | |
| 21 | 7A | 96.33 | 101.22 | 100.46 | 15.40 | 18.04±3.81 |
| | 7B | 109.75 | 116.19 | 115.14 | 16.31 | |
| | 7C | 102.43 | 107.08 | 106.04 | 22.40 | |
| 24 | 8A | 101.33 | 104.11 | 103.21 | 32.21 | 30.10±1.99 |
| | 8B | 105.87 | 109.07 | 108.16 | 28.25 | |
| | 8C | 93.96 | 96.47 | 95.72 | 29.85 | |
| 27 | 9A | 105.87 | 109.70 | 108.86 | 21.88 | 20.66±1.74 |
| | 9B | 93.96 | 98.90 | 97.98 | 18.67 | |
| | 9C | 101.33 | 104.63 | 103.92 | 21.42 | |
| 30 | 10A | 109.75 | 116.75 | 115.48 | 18.09 | 21.76±3.38 |
| | 10B | 102.43 | 108.27 | 106.96 | 22.44 | |
| | 10C | 96.34 | 100.40 | 99.39 | 24.74 | |
| 31.5 | 11A | 101.33 | 107.25 | 106.34 | 15.31 | 16.42±0.96 |
| | 11B | 93.97 | 98.46 | 97.70 | 16.91 | |
| | 11C | 105.87 | 110.20 | 109.46 | 17.04 | |
| 33 | 12A | 109.74 | 113.19 | 112.33 | 24.83 | 24.08±1.02 |
| | 12B | 102.42 | 107.57 | 106.39 | 22.92 | |
| | 12C | 96.32 | 99.70 | 98.87 | 24.48 | |
| 33.6 | 13A | 102.43 | 106.53 | 105.75 | 19.16 | 22.05±3.03 |
| | 13B | 109.74 | 114.26 | 113.12 | 25.20 | |
| | 13C | 96.33 | 100.77 | 99.80 | 21.79 | |
| | | | | **Avg (±SD)** | **20.74±3.99** | |

**Table B.14** Organic matter results for Borehole-14

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 1.5 | 1A | 102.42 | 107.54 | 107.06 | 9.37 | 9.72±0.46 |
| | 1B | 96.33 | 100.59 | 100.15 | 10.25 | |
| | 1C | 109.75 | 113.96 | 113.56 | 9.55 | |
| 3 | 2A | 93.96 | 98.11 | 97.69 | 9.99 | 9.86±0.28 |
| | 2B | 101.33 | 106.00 | 105.55 | 9.54 | |
| | 2C | 105.87 | 110.82 | 110.32 | 10.04 | |
| 4.5 | 3A | 105.86 | 110.53 | 110.09 | 9.29 | 8.61±0.60 |
| | 3B | 93.97 | 99.02 | 98.61 | 8.15 | |
| | 3C | 101.33 | 107.63 | 107.10 | 8.40 | |
| 6 | 4A | 96.32 | 101.26 | 100.76 | 10.09 | 11.26±1.98 |
| | 4B | 102.42 | 108.39 | 107.78 | 10.14 | |
| | 4C | 109.74 | 113.97 | 113.40 | 13.54 | |
| 9 | 5A | 105.87 | 112.39 | 112.27 | 1.90 | 1.63±0.23 |
| | 5B | 101.34 | 108.51 | 108.40 | 1.53 | |
| | 5C | 93.96 | 101.06 | 100.96 | 1.47 | |
| | | | | **Avg (±SD)** | 8.22±3.61 | |

**Table B.15** Organic matter results for Borehole-15

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 109.75 | 113.86 | 113.41 | 10.78 | 10.07±0.80 |
| | 1B | 102.43 | 107.88 | 107.33 | 10.21 | |
| | 1C | 96.33 | 100.82 | 100.41 | 9.20 | |
| 6 | 2A | 101.33 | 105.27 | 104.89 | 9.67 | 10.80±1.31 |
| | 2B | 105.87 | 111.66 | 111.05 | 10.49 | |
| | 2C | 93.97 | 98.36 | 97.82 | 12.24 | |
| 9 | 3A | 109.74 | 113.49 | 112.89 | 16.13 | 12.60±3.28 |
| | 3B | 96.32 | 101.05 | 100.48 | 11.99 | |
| | 3C | 102.43 | 108.53 | 107.94 | 9.66 | |
| 12 | 4A | 93.96 | 97.37 | 96.91 | 13.44 | 13.71±0.25 |
| | 4B | 105.87 | 111.12 | 110.40 | 13.78 | |
| | 4C | 101.33 | 106.95 | 106.16 | 13.92 | |
| 15 | 5A | 102.43 | 106.38 | 105.67 | 18.08 | 17.31±1.38 |
| | 5B | 109.75 | 113.90 | 113.15 | 18.13 | |
| | 5C | 96.33 | 100.91 | 100.19 | 15.72 | |
| | | | | **Avg (±SD)** | **12.90±3.02** | |

**Table B.16** Organic matter results for Borehole-16

| Depth (m) | Sample No. | $W_1$ (g) | $W_2$ (g) | $W_3$ (g) | Organic matter (%) | Avg. (±SD) Organic matter (%) |
|---|---|---|---|---|---|---|
| 3 | 1A | 96.32 | 100.31 | 99.66 | 16.25 | 14.92±2.16 |
| | 1B | 102.43 | 107.09 | 106.34 | 16.08 | |
| | 1C | 109.75 | 114.69 | 114.07 | 12.43 | |
| 4.5 | 2A | 101.33 | 105.11 | 104.46 | 17.06 | 15.94±1.02 |
| | 2B | 93.97 | 98.14 | 97.48 | 15.71 | |
| | 2C | 105.87 | 110.94 | 110.17 | 15.05 | |
| 6 | 3A | 93.96 | 98.36 | 97.70 | 15.01 | 12.88±2.23 |
| | 3B | 105.87 | 110.93 | 110.39 | 10.55 | |
| | 3C | 101.33 | 105.42 | 104.89 | 13.07 | |
| | | | | **Avg (±SD)** | **14.58±2.12** | |

## Appendix C

**Table C.1** Specific gravity results for fine fraction retrieved from Borehole-01

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 3 | 2.18 | 2.26 | 2.28 | 2.24±0.05 |
| 6 | 2.11 | 2.19 | 2.15 | 2.15±0.04 |
| 9 | 2.25 | 2.27 | 2.29 | 2.27±0.02 |
| 12 | 2.29 | 2.32 | 2.33 | 2.32±0.02 |
| 15 | 2.16 | 2.19 | 2.20 | 2.18±0.02 |
| 18 | 2.22 | 2.31 | 2.32 | 2.29±0.05 |
| 21 | 2.34 | 2.39 | 2.36 | 2.36±0.02 |
| 24 | 2.25 | 2.26 | 2.26 | 2.26±0.01 |

**Table C.2** Specific gravity results for fine fraction retrieved from Borehole-02

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 3 | 2.37 | 2.39 | 2.39 | 2.38±0.02 |
| 6 | 2.18 | 2.24 | 2.24 | 2.22±0.03 |
| 9 | 2.10 | 2.15 | 2.16 | 2.14±0.03 |
| 12 | 2.21 | 2.24 | 2.26 | 2.24±0.02 |
| 15 | 2.20 | 2.24 | 2.24 | 2.23±0.02 |
| 18 | 2.08 | 2.09 | 2.10 | 2.09±0.01 |
| 21 | 2.23 | 2.25 | 2.25 | 2.25±0.01 |
| 24 | 2.21 | 2.23 | 2.24 | 2.23±0.02 |
| 27 | 1.91 | 1.93 | 1.93 | 1.92±0.01 |
| 30 | 2.08 | 2.09 | 2.11 | 2.10±0.01 |

**Table C.3** Specific gravity results for fine fraction retrieved from Borehole-03

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 3 | 2.22 | 2.24 | 2.25 | 2.24±0.02 |
| 6 | 2.13 | 2.16 | 2.18 | 2.16±0.03 |
| 9 | 2.26 | 2.29 | 2.30 | 2.29±0.02 |
| 12 | 2.13 | 2.16 | 2.16 | 2.15±0.02 |
| 15 | 2.06 | 2.07 | 2.08 | 2.07±0.01 |
| 18 | 2.33 | 2.34 | 2.35 | 2.34±0.01 |
| 21 | 2.28 | 2.29 | 2.29 | 2.29±0.01 |
| 24 | 2.28 | 2.28 | 2.28 | 2.28±0.00 |

**Table C.4** Specific gravity results for fine fraction retrieved from Borehole-04

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 3 | 2.30 | 2.30 | 2.30 | 2.30±0.00 |
| 6 | 2.23 | 2.25 | 2.24 | 2.24±0.01 |
| 9 | 2.25 | 2.25 | 2.26 | 2.25±0.00 |
| 12 | 2.16 | 2.17 | 2.17 | 2.17±0.01 |
| 15 | 2.12 | 2.13 | 2.12 | 2.12±0.01 |
| 18 | 2.14 | 2.15 | 2.14 | 2.15±0.00 |
| 21 | 2.03 | 2.06 | 2.06 | 2.05±0.01 |
| 24 | 2.24 | 2.27 | 2.28 | 2.26±0.02 |
| 27 | 2.21 | 2.24 | 2.25 | 2.23±0.02 |
| 30 | 2.26 | 2.28 | 2.28 | 2.27±0.01 |
| 33 | 2.19 | 2.21 | 2.27 | 2.22±0.05 |
| 36 | 2.20 | 2.22 | 2.23 | 2.22±0.01 |

**Table C.5** Specific gravity results for fine fraction retrieved from Borehole-05

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 3 | 2.09 | 2.14 | 2.16 | 2.13±0.04 |
| 6 | 2.17 | 2.20 | 2.22 | 2.20±0.02 |
| 9 | 2.20 | 2.23 | 2.23 | 2.22±0.02 |
| 12 | 2.23 | 2.26 | 2.27 | 2.26±0.02 |
| 15 | 2.17 | 2.21 | 2.22 | 2.20±0.03 |
| 18 | 2.42 | 2.44 | 2.45 | 2.44±0.02 |
| 21 | 2.45 | 2.48 | 2.48 | 2.47±0.02 |
| 27 | 2.42 | 2.44 | 2.45 | 2.44±0.01 |
| 30 | 2.42 | 2.44 | 2.45 | 2.43±0.01 |
| 33 | 2.33 | 2.36 | 2.36 | 2.35±0.02 |

**Table C.6** Specific gravity results for fine fraction retrieved from Borehole-06

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 3 | 2.29 | 2.29 | 2.30 | 2.30±0.00 |
| 6 | 2.30 | 2.32 | 2.33 | 2.32±0.01 |
| 9 | 2.42 | 2.45 | 2.43 | 2.44±0.02 |
| 12 | 2.44 | 2.45 | 2.47 | 2.46±0.01 |
| 15 | 2.46 | 2.47 | 2.47 | 2.47±0.01 |
| 18 | 2.45 | 2.46 | 2.46 | 2.46±0.01 |
| 21 | 2.44 | 2.45 | 2.45 | 2.45±0.01 |
| 24 | 2.18 | 2.19 | 2.19 | 2.19±0.01 |
| 27 | 2.38 | 2.39 | 2.40 | 2.39±0.01 |
| 30 | 2.35 | 2.38 | 2.39 | 2.37±0.02 |
| 33 | 2.29 | 2.32 | 2.34 | 2.32±0.02 |
| 36 | 2.21 | 2.14 | 2.16 | 2.17±0.04 |

**Table C.7** Specific gravity results for fine fraction retrieved from Borehole-07

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 3 | 2.15 | 2.17 | 2.18 | 2.17±0.02 |
| 6 | 2.17 | 2.20 | 2.20 | 2.19±0.01 |
| 9 | 2.23 | 2.24 | 2.25 | 2.24±0.01 |
| 12 | 2.18 | 2.21 | 2.22 | 2.21±0.02 |
| 15 | 2.18 | 2.21 | 2.21 | 2.20±0.01 |
| 18 | 2.33 | 2.34 | 2.34 | 2.34±0.01 |
| 21 | 2.30 | 2.32 | 2.33 | 2.32±0.02 |
| 24 | 2.27 | 2.28 | 2.25 | 2.26±0.02 |
| 27 | 2.40 | 2.41 | 2.42 | 2.41±0.01 |
| 30 | 2.25 | 2.28 | 2.28 | 2.27±0.02 |
| 33 | 2.39 | 2.41 | 2.42 | 2.41±0.02 |
| 36 | 2.28 | 2.30 | 2.31 | 2.30±0.01 |

**Table C.8** Specific gravity results for fine fraction retrieved from Borehole-08

| Depth (m) | Specific gravity | | | Avg. (±SD) S/pecific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 1.5 | 2.60 | 2.61 | 2.62 | 2.61±0.01 |
| 3 | 2.55 | 2.58 | 2.59 | 2.58±0.02 |
| 4.5 | 2.62 | 2.66 | 2.66 | 2.65±0.02 |

**Table C.9** Specific gravity results for fine fraction retrieved from Borehole-09

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 1.5 | 2.65 | 2.66 | 2.66 | 2.66±0.01 |
| 4.5 | 2.68 | 2.69 | 2.69 | 2.69±0.01 |

**Table C.10** Specific gravity results for fine fraction retrieved from Borehole-10

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 3 | 1.88 | 1.93 | 1.95 | 1.92±0.04 |
| 6 | 2.38 | 2.40 | 2.40 | 2.40±0.01 |
| 9 | 2.36 | 2.37 | 2.37 | 2.37±0.00 |
| 12 | 2.34 | 2.35 | 2.35 | 2.35±0.00 |
| 15 | 2.47 | 2.48 | 2.47 | 2.47±0.00 |
| 18 | 2.38 | 2.40 | 2.40 | 2.40±0.02 |
| 21 | 2.33 | 2.33 | 2.34 | 2.34±0.01 |
| 24 | 2.43 | 2.45 | 2.45 | 2.44±0.01 |
| 27 | 2.23 | 2.26 | 2.26 | 2.25±0.02 |
| 30 | 2.36 | 2.42 | 2.42 | 2.40±0.04 |
| 33 | 2.31 | 2.34 | 2.34 | 2.33±0.02 |
| 36 | 2.23 | 2.23 | 2.25 | 2.24±0.01 |
| 39 | 2.25 | 2.26 | 2.26 | 2.26±0.01 |
| 41.7 | 2.25 | 2.27 | 2.29 | 2.27±0.02 |

**Table C.11** Specific gravity results for fine fraction retrieved from Borehole-11

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 3 | 2.34 | 2.35 | 2.36 | 2.35±0.01 |
| 6 | 2.28 | 2.30 | 2.31 | 2.30±0.01 |
| 9 | 2.15 | 2.19 | 2.20 | 2.19±0.03 |
| 12 | 2.16 | 2.18 | 2.19 | 2.18±0.01 |
| 15 | 2.32 | 2.35 | 2.35 | 2.34±0.02 |
| 18 | 2.31 | 2.30 | 2.34 | 2.32±0.02 |
| 21 | 2.28 | 2.30 | 2.32 | 2.30±0.02 |
| 24 | 2.37 | 2.37 | 2.37 | 2.37±0.00 |
| 27 | 2.31 | 2.31 | 2.31 | 2.31±0.00 |
| 30 | 2.27 | 2.27 | 2.27 | 2.27±0.00 |
| 33 | 2.31 | 2.34 | 2.35 | 2.34±0.02 |
| 36 | 2.30 | 2.32 | 2.32 | 2.32±0.01 |
| 39 | 2.34 | 2.34 | 2.34 | 2.34±0.00 |

**Table C.12** Specific gravity results for fine fraction retrieved from Borehole-12

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 3 | 2.17 | 2.19 | 2.20 | 2.19±0.02 |
| 6 | 2.15 | 2.18 | 2.19 | 2.17±0.02 |
| 9 | 2.23 | 2.23 | 2.24 | 2.24±0.00 |
| 12 | 2.24 | 2.26 | 2.27 | 2.26±0.02 |
| 15 | 2.21 | 2.25 | 2.26 | 2.24±0.03 |
| 18 | 2.18 | 2.21 | 2.22 | 2.21±0.02 |
| 21 | 2.22 | 2.25 | 2.25 | 2.24±0.02 |
| 24 | 2.22 | 2.25 | 2.25 | 2.24±0.02 |
| 27 | 2.29 | 2.30 | 2.31 | 2.30±0.01 |
| 30 | 2.17 | 2.21 | 2.23 | 2.21±0.03 |
| 33 | 2.17 | 2.19 | 2.20 | 2.19±0.02 |
| 36 | 2.17 | 2.21 | 2.22 | 2.20±0.03 |
| 39 | 2.26 | 2.28 | 2.27 | 2.27±0.01 |
| 41.7 | 2.26 | 2.26 | 2.26 | 2.26±0.01 |

**Table C.13** Specific gravity results for fine fraction retrieved from Borehole-13

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 3 | 2.22 | 2.24 | 2.24 | 2.23±0.01 |
| 6 | 2.20 | 2.22 | 2.22 | 2.22±0.01 |
| 9 | 2.31 | 2.31 | 2.32 | 2.31±0.01 |
| 12 | 2.27 | 2.29 | 2.29 | 2.28±0.01 |
| 15 | 2.24 | 2.25 | 2.25 | 2.25±0.01 |
| 18 | 2.26 | 2.27 | 2.27 | 2.27±0.01 |
| 21 | 2.18 | 2.21 | 2.22 | 2.21±0.02 |
| 24 | 2.26 | 2.28 | 2.29 | 2.28±0.01 |
| 27 | 2.28 | 2.28 | 2.28 | 2.28±0.01 |
| 30 | 2.27 | 2.28 | 2.29 | 2.28±0.01 |
| 31.5 | 2.29 | 2.32 | 2.33 | 2.31±0.02 |
| 33 | 2.23 | 2.25 | 2.26 | 2.24±0.02 |
| 33.6 | 2.18 | 2.19 | 2.21 | 2.19±0.01 |

**Table C.14** Specific gravity results for fine fraction retrieved from Borehole-14

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 1.5 | 2.50 | 2.51 | 2.51 | 2.51±0.00 |
| 3 | 2.42 | 2.43 | 2.43 | 2.43±0.01 |
| 4.5 | 2.45 | 2.46 | 2.46 | 2.46±0.00 |
| 6 | 2.39 | 2.40 | 2.40 | 2.40±0.01 |
| 9 | 2.62 | 2.63 | 2.63 | 2.63±0.00 |

**Table C.15** Specific gravity results for fine fraction retrieved from Borehole-15

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 3 | 2.46 | 2.45 | 2.45 | 2.46±0.00 |
| 6 | 2.47 | 2.46 | 2.46 | 2.46±0.00 |
| 9 | 2.38 | 2.38 | 2.37 | 2.38±0.00 |
| 12 | 2.70 | 2.70 | 2.70 | 2.71±0.00 |
| 15 | 2.38 | 2.38 | 2.38 | 2.38±0.00 |

**Table C.16** Specific gravity results for fine fraction retrieved from Borehole-16

| Depth (m) | Specific gravity | | | Avg. (±SD) Specific gravity |
|---|---|---|---|---|
| | Trail-1 | Trail-2 | Trail-3 | |
| 3 | 2.33 | 2.32 | 2.32 | 2.33±0.01 |
| 4.5 | 2.27 | 2.29 | 2.29 | 2.29±0.01 |
| 6 | 2.38 | 2.39 | 2.39 | 2.39±0.01 |

**References**

ASTM D 5550, 2006. Standard test: method for specific gravity of soil solids by helium gas pycnometer. American Society of Testing and Materials 19428–2959.

ASTM International, 2020. ASTM D2974-2020: Standard Test Methods for Determining the Water (Moisture) Content, Ash Content, and Organic Material of Peat and Other Organic Soils, ASTM International. United States of America.

Goli, V.S.N.S., Singh, P., Singh, D.N., Tak, L.K., 2022. Investigations on characteristics of landfill-mined-soil-like-fractions and their dependency on organic matter. Process Safety and Environmental Protection 162, 795–812. https://doi.org/10.1016/j.psep.2022.04.052

Mohammad, A., Goli, V.S.N.S., Chembukavu, A.A., Singh, D.N., 2021. DecoMSW: A Methodology to Assess Decomposition of Municipal Solid Waste for Initiation of Landfill Mining Activities. The Journal of Solid Waste Technology and Management 47, 465–481. https://doi.org/10.5276/JSWTM/2021.465

Patil, B.S., Agnes Anto, C., Singh, D.N., 2017. Simulation of municipal solid waste degradation in aerobic and anaerobic bioreactor landfills. Waste Management and Research. https://doi.org/10.1177/0734242X16679258

## Photographs of collection & treatment of leachate from the capped legacy dump

Leachate Collection Sumps

Collection of leachate sample for testing from the lateral pipes

Waste Water Complex: Pre-treatment, RO shed, MEE-ATFD system (left to right)

Permeate (treated water)used for watering green cover on top of capped dump

Permeate used to maintain greenery in the site

Gmail

**Executive Engineer SWM GHMC <eeswmc@gmail.com>**

# Greater Hyderabad Municipal Corporation (GHMC) - OA 606/2018 - Constitution of Committee of Experts to review the capping works of GHMC- VC dated 30.12.2022 –Request to communicate the minutes of the meeting/ reportfor submitting to NGT – Reg.

1 message

**Lokesh Kumar D.S.** <commissioner-ghmc@gov.in> Wed, Jun 7, 2023 at 1:34 PM
To: DIVYA SINHA <divyasinha.cpcb@nic.in>
Cc: Member Secretary CPCB <mscb.cpcb@nic.in>, "R. P. GURUNG" <rpgurung.cpcb@nic.in>, Ms Neetu Kumari Prasad <ms-tspcb@telangana.gov.in>, EESWM GHMC <eeswmc@gmail.com>

Good Morning Madam,

It is to bring to your notice that, in compliance to the orders dated 29.09.2022 of the Hon'ble NGT (PB) in OA 606 of 2018, the CPCB has constituted a Committee of Experts to finalize its viewpoint if the capping of legacy dumpsite already executed in GHMC can be retained. The Committee of Experts interacted with GHMC, CPCB and TSPCB through Video Conference on 30.12.2022 in which the capping works were critically examined vis a vis the measures being taken by GHMC to protect the environment.

Simultaneously, the Hon'ble NGT (SZ) in OA 199/2021 is also reviewing the compliance of GHMC to the orders of the Hon'ble NGT (PB) regarding Bio-mining of legacy waste. In this regard, during the hearing dated 10.04.2023, the NGT (SZ) has enquired about the report of the Committee of Experts constituted by CPCB and it was submitted by GHMC that the report is awaited (orders are attached).

In this regard, it is requested to communicate the minutes of the meeting/report of the Committee of Experts so as to submit the same to the NGT (SZ) in OA 199/2021 which is posted for hearing on 10.07.2023

Regards,

O/o. the Commissioner, GHMC
040-23224564

**GREATER HYDERABAD MUNICIPAL CORPORATION**

CC Complex, Tank bund Road, Lower Tank bund, Hyderabad – 500 063
WEBSITE: www.ghmc.gov.in; TELEPHONE: 040 – 2322 5397

From
The Commissioner,
Greater Hyderabad Municipal Corporation,
1st Floor, CC complex,
Hyderabad, Telangana

**To**
The District Forest Officer,
Sangareddy Division,
Telangana.

Lr.No. SWM/0013/2020/AE-3(SWM)HO Dated: .05.2023

Sir,

Sub : GHMC- SWM – Proposed alternate MSW T&D facility at Pyaranagar - Diversion of forest land for formation of approach road – Representation of HIMSW regarding interest in tree cutting/ translocation for the approach road to Pyaranagar site – For taking necessary action - Reg.

Ref : 1. Ref no.FC1/FC03/24/2022 15221/ 2018/ FCA-1 dated 07.01.2023
2.Agreement with DFO, Sangareddy dated 08.03.2023
3.Lr.No.HIMSW/GHMC/2023-24/2348 dt.22.05.2023

*******

Anent the subject and references cited above, the following details are brought to your notice:

i. As per the revised demand notice, GHMC has paid the necessary charges towards **"Extraction of tree growth as per FSR"** to the Account No.37249920410 – SBI (RTGS/IFSC no SBIN0021217) of the District Forest Officer, Sangareddy.
ii. Subsequently, working permission was accorded vide reference 1st cited for tree cutting /translocation of trees and commencement of work in the forest land proposed to be diverted from the date of entering into agreement with the District Forest Officer, Sangareddy District for a period upto one year, subject to certain conditions.
iii. Accordingly, agreement was entered between GHMC & the DFO, Sangareddy on 08.03.2023 and as per clause 5 of the said agreement at reference 2nd cited, the DFO, Sangareddy shall fell and transport or translocate standing tress, if any, in the forest area being diverted for the project and the user agency undertook not to touch or fell or translocate in any manner. Both parties agreed, bound and stated that they shall reduce the number of trees to be felled & transported or translocated and shall be as per the enumeration list submitted to the DFO.

In this regard, it has come to the notice of GHMC that the O/o.

District Forest Officer, Sangareddy has floated tenders for the work of felling/ translocating the trees in the diverted forest land but no contractors have come forward for bidding & taking up the work **even after 3rd call.** Whereas, M/s Hyderabad Integrated MSW Ltd., the Concessionaire of the Integrated Municipal Solid Waste Management Project of GHMC has expressed willingness to take up the work of tree felling/ translocation under the permission & supervision of the District Forest Officer, Sangareddy & Greater Hyderabad Municipal Corporation.

In view of the above, you are requested to look into the possibility of allotting the work of felling/ translocating the trees in the diverted forest land at Pyaranagar to M/s Hyderabad Integrated MSW Ltd., for enabling GHMC to expedite the work of laying approach road in the diverted forest land and commence the work of establishing the alternated MSW T&D facility at Pyaranagar, Sangareddy.

**Commissioner,**
**GHMC**

Signed by Lokesh Kumar
D.s las
Date: 30-05-2023 17:44:39
Reason: Approved

OFF

సుండి గాని పొందపచ్చును.

సం/-

కాసాగ్రాండ్ హైదర్‌వైజ్ ప్రైవేట్ లిమిటెడ్

తెలంగాణ ప్రభుత్వం

## జిల్లా అటవీ శాఖాధికారి కార్యాలయం, సంగారెడ్డి

**టెండరు ప్రకటన**

లేక సంఖ్య 457/ఎస్5/2020, తేది: 31.07.2023

తెలియచేయునదేమనగా సంగారెడ్డి రేంజ్ విభాగము సంగారెడ్డి జిల్లా నల్లవల్లి మరియు మంబాపూర్ రిజర్వు ఫారెస్ట్ గుమ్మడిదల పరిధిలో పురపాలక వ్యర్థల శుద్ధి మరియు పారవేసే సౌకర్యము కొరకు వివిధ రకాల (453) చెట్ల నరికివేత కొరకు ఆసక్తిగల కాంట్రాక్టర్ల నుండి సీల్డ్ టెండర్లు ఆహ్వానించబడుచున్నవి. టెండర్ ఫారాము కార్యలయ పని వేళ్లలో స్వీకరించగలరు.

మిగత వివరములకు 9573870666 dfosangareddy@gmail.com ను సంప్రదించగలరు.

సం/- జిల్లా అటవీశాఖాధికారి

**DIPR R.O.No. 1182-DP/CL/ADVT/1/2023-24, Dt. 02-08-2023**

(ii) No. of trees including their species in the diverted 0.6228 ha of the forest land along with categorization of trees which shall either be felled or translocated.

(iii) Any other relevant details.

Yours faithfully,

**Superintending Engineer (SWM),**
**GHMC**

Copy submitted for kind favour of information to :

1) The Commissioner, GHMC

2) The Principal Chief Conservator of Forests (Head of Forest Force), Telangana

HYDERABAD
ON MISSION TOMORROW

# GREATER HYDERABAD MUNICIPAL CORPORATION

CC Complex, Tank bund Road, Lower Tank bund, Hyderabad – 500 063
WEBSITE: www.ghmc.gov.in; TELEPHONE: 040 – 2322 5397

From
The Superintending Engineer (SWM),
Greater Hyderabad Municipal Corporation,
4th Floor, CC complex,
Hyderabad, Telangana

**To**
The District Forest Officer,
Sangareddy Division,
Telangana.

Lr.No. SWM/0013/2020/AE-3(SWM)HO dated: 19.05.2023

Sir,

Sub : GHMC- SWM – Proposed alternate MSW T&D facility at Pyaranagar - Diversion of 0.6228 ha of forest land for formation of approach road– Orders of the Hon'ble NGT (SZ) in O.A.No.199 of 2021 – Details on number of trees and species of trees to be felled or translocated, no of trees under compensatory afforestation –Req.– Reg.

Ref : 1. Orders dated 10.04.2023 of the Hon'ble NGT (SZ) in OA 199 of 2021
2. Agreement with DFO, Sangareddy dated 08.03.2023

*******

It is to bring to your notice that the Hon'ble NGT (SZ) vide its orders dated 10.04.2023 in OA 199 of 2021 has directed GHMC to submit the following information with respect to the diverted forest land for laying approach road to the proposed alternate MSW T&D facility of GHMC at Pyaranagar:

"In this regard, it is stated that about 450 trees, species of which are not known, are to be felled. We direct the GHMC to bring the details of the trees to be felled/translocated and also the number of trees to be replanted for this purpose".

As GHMC has made payment of Rs.32,90,192/- towards CAMPA account of Telangana state which includes payment towards compensatory afforestation works and also enumeration of tress was done by the concerned forest officials of Sangareddy. It is requested to submit the following information so as to furnish the same to the Hon'ble NGT (SZ).

(i) No. of trees that shall be replanted by the forest department as part of compensatory afforestation.

Nallavally R.F

Girth Enumaration list

Letter Libe

| C.No | tree No | spicies | GBH (mts) | Height (mts) |
|---|---|---|---|---|
| 1 | 1 | Nuluva | 0.51 | 3.00 |
| 2 | 2 | Teak | 0.54 | 5.00 |
| 3 | 3 | Teak | 0.55 | 5.00 |
| 4 | 4 | Teak | 0.47 | 3.00 |
| 5 | 5 | Teak | 0.51 | 5.00 |
| 6 | 6 | Teak | 0.51 | 6.00 |
| 7 | 7 | Teak | 0.54 | 6.00 |
| 8 | 8 | Chuppana | 0.84 | 4.00 |
| 9 | 9 | Nuluva | 0.20 | 1.75 |
| 10 | 10 | Chuppana | 0.45 | 4.00 |
| 11 | 11 | Tani | 0.55 | 4.00 |
| 12 | 12 | palakodisa | 0.27 | 2.50 |
| 13 | 13 | Nuluva | 0.22 | 1.50 |
| 14 | 14 | Teak | 0.57 | 6.00 |
| 15 | 15 | Dhirchinany | 0.17 | 2.00 |
| 16 | 16 | Tella Billudi | 0.21 | 1.50 |
| 17 | 17 | Teak | 0.44 | 4.00 |
| 18 | 18 | Dhirchinany | 0.64 | 4.00 |
| 19 | 19 | Tella Billudi | 0.38 | 4.00 |
| 20 | 20 | Jaana | 0.22 | 2.00 |
| 21 | 21 | Mulla Maddi | 0.19 | 1.50 |
| 22 | 22 | Mulla Maddi | 0.18 | 1.50 |
| 23 | 23 | Nuluva | 0.67 | 6.00 |
| 24 | 24 | Nuluva | 0.67 | 6.00 |

| I.NO | tree No | species | GBH | Height |
|---|---|---|---|---|
| 25 | 25 | Kasaka | 0.15 | 1.50 |
| 26 | 26 | Aluluva | 0.70 | 7.00 |
| 27 | 27 | Cumpena | 0.80 | 8.00 |
| 28 | 28 | Huluga | 0.18 | 1.00 |
| 29 | 29 | Huluga | 0.62 | 5.00 |
| 30 | 30 | Huluga/Aluluva | 0.61 | 7.00 |
| 31 | 30/1 | Huluga/Aluluva | 0.41 | 4.00 |
| 32 | 31 | Aluluva | 0.19 | 2.00 |
| 33 | 32 | Teak | 0.62 | 4.00 |
| 34 | 33 | Teak | 0.65 | 6.00 |
| 35 | 34 | Eppa | 0.24 | 1.00 |
| 36 | 35 | Teak | 0.63 | 6.00 |
| 37 | 36 | Huluga | 0.20 | 1.50 |
| 38 | 37 | Dankli | 0.24 | 2.00 |
| 39 | 38 | Huluva | 0.19 | 1.50 |
| 40 | 39 | Pala Kodisi | 0.22 | 2.00 |
| 41 | 40 | Teak | 0.79 | 8.00 |
| 42 | 41 | Teak | 0.80 | 8.00 |
| 43 | 42 | Medi | 0.57 | 2.00 |
| 44 | 42 | Teak | 0.32 | 2.00 |
| 45 | 44 | Teak | 0.24 | 2.50 |
| 46 | 45 | Illintha | 0.27 | 2.00 |
| 47 | 45/1 | Illintha | 0.25 | 2.00 |
| 48 | 46 | Hunga | 0.26 | 1.50 |
| 49 | 46/1 | Hunga | 0.22 | 1.50 |
| 50 | 47 | Teak | 0.54 | 4.00 |
| 51 | 48 | Eppa | 0.18 | 1.50 |

| S.NO | TREE NO | Species | GBH | Height |
|---|---|---|---|---|
| 52 | 49 | Teak | 0.45 | 1.00 |
| 53 | 50 | Nuluqu | 0.55 | 2.00 |
| 54 | 51 | Mohh | 0.60 | 4.00 |
| 55 | 52 | Teak | 0.52 | 4.00 |
| 56 | 53 | Nuluva | 0.18 | 2.00 |
| 57 | 54 | Thirumaye | 0.15 | 1.50 |
| 58 | 55 | Thirumane | 0.15 | 1.50 |
| 59 | 56 | Nuluva | 0.20 | 1.00 |
| 60 | 57 | Odhi/Nirudhi | 0.16 | 1.50 |
| 61 | 58 | Thirumay | 0.14 | 1.50 |
| 62 | 59 | Nuluva | 0.18 | 1.50 |
| 63 | 60 | Thirumay | 0.19 | 2.00 |
| 64 | 61 | Nuluva | 0.15 | 1.50 |
| 65 | 62 | Teak | 0.64 | 5.00 |
| 66 | 63 | Nuluva | 0.24 | 2.00 |
| 67 | 64 | Nuluva | 0.14 | 1.50 |
| 68 | 65 | Mulugu | 0.26 | 2.00 |
| 69 | 66 | Coppera | 0.95 | 10.00 |
| 70 | 67 | Nuluva | 0.39 | 3.00 |
| 71 | 68 | Nuluva | 0.22 | 3.00 |
| 72 | 69 | Nuluva | 0.22 | 3.00 |
| 73 | 70 | Nuluva | 0.25 | 3.00 |
| 74 | 71 | Nuluva | 0.13 | 1.50 |
| 75 | 72 | Nuluva | 0.46 | 5.00 |
| 76 | 73 | Teppa | 0.61 | 5.00 |
| 77 | 74 | palakodisha | 0.19 | 1.50 |

(2)

| S.No | tree no | species | GBH | height |
|---|---|---|---|---|
| 76 | [illegible] 75 | Odiga | 0.29 | 3.00 |
| 77 | 76 | Teak | 0.56 | 2.00 |
| 80 | 77 | Teak | 0.41 | 4.00 |
| 81 | 78 | Tani | 0.97 | 2.00 |
| 82 | 78/1 | Tani | 0.64 | 2.00 |
| 83 | 78/2 | Tani | 0.64 | 1.00 |
| 84 | 79 | Teak | 0.42 | 1.50 |
| 85 | 80 | Modiga | [illegible] 1.04 | 6.00 |
| 86 | 80/1 | Modiga | 0.90 | 1.00 |
| 87 | 80/2 | Modiga | 0.65 | 1.00 |
| 88 | 81 | Teak | 0.57 | 1.00 |
| 89 | 82 | Teak | 0.50 | 4.00 |
| 90 | 82/1 | Teak | 0.41 | 4.00 |
| 91 | 83 | Mulla Maddi | 1.03 | 3.00 |
| 92 | 83/1 | Mulla Maddi | 0.71 | 6.00 |
| 93 | 84 | Nukmva | 0.17 | 1.50 |
| 94 | 85 | Modiga | 0.68 | 2.00 |
| 95 | 85/1 | Modiga | 0.36 | 2.00 |
| 96 | 86 | Nukmva | 0.21 | 1.50 |
| 97 | 87 | Teak | 0.58 | 6.00 |
| 98 | 88 | Mukuga | 0.20 | 1.50 |
| 99 | 89 | Nallamaddi | 0.31 | 2.00 |
| 100 | 90 | Nukmva | 0.21 | 1.50 |
| 101 | 91 | Dhirghavanam | 0.53 | 5.00 |
| 102 | 92 | Nukmva | 0.17 | 1.00 |
| 103 | 93 | Teak | 0.23 | 2.00 |
| 104 | 94 | Teak | 0.62 | 2.00 |
| 105 | 95 | Teak | 0.71 | 2.00 |
| 106 | 96 | Nakkeswa | 0.19 | 1.50 |

| S.No | tree No | spicies | GBH | Height |
|---|---|---|---|---|
| 107 | 97 | Teak | 0.54 | 5.00 |
| 108 | 97/1 | Teak | 0.41 | 4.00 |
| 109 | 98 | Mulla Maddi | 0.60 | 7.00 |
| 110 | 99 | Teak | 0.62 | 5.00 |
| 111 | 100 | Mo dhuga | 0.62 | 5.00 |
| 112 | 101 | Mo dhuga | 0.71 | 5.00 |
| 113 | 101/1 | Modhuga | 0.24 | 3.00 |
| 114 | 102 | Nukuva | 0.47 | 4.00 |
| 115 | 103 | gotti | 0.27 | 1.50 |
| 116 | 104 | Mosri | 0.57 | 6.00 |
| 117 | 105 | Teak | 0.85 | 6.00 |
| 118 | 106 | Teak | 0.51 | 4.00 |
| 119 | 106/1 | Teak | 0.41 | 3.00 |
| 120 | 107 | Teak | 0.77 | 8.00 |
| 121 | 108 | Chemagi | 0.40 | 4.00 |
| 122 | 109 | Nirudhi | 0.28 | 1.50 |
| 123 | 110 | gotti | 0.42 | 1.50 |
| 124 | 111 | Nukuva | 0.90 | 5.00 |
| 125 | 111/1 | Nukuva | 0.27 | 2.00 |
| 126 | 112 | Nukuva | 0.34 | 2.00 |
| 127 | 113 | Nukuva | 0.18 | 1.50 |
| 128 | 114. | Nukuva | 0.20 | 2.00 |
| 129 | 115 | Nalla Maddi | 0.24 | 2.00 |
| 130 | 116 | Jaana | 0.27 | 2.00 |
| 131 | 117 | Teak | 0.57 | 5.00 |
| 132 | 118 | Jeedi | 0.52 | 5.00 |
| 133 | 119 | Teak | 0.46 | 7.00 |
| 134 | 120 | Nukuva | 0.14 | 1.50 |
| 135 | 121 | Nukuva | 0.17 | 2.00 |
| 136 | 122 | Nirudhi | 0.58 | 2.00 |
| 137 | 123 | [illegible] | 0.22 | 1.00 |

| S.NO | tree No | Spicies | GBH | Height |
|---|---|---|---|---|
| 128 | 123/1 | Nuluva | 0.18 | 1.00 |
| 139 | 123/1 | Nuluva | 0.18 | 1.00 |
| 140 | 124 | Teak | 0.59 | 4.00 |
| 141 | 125 | Nallamadi | 0.18 | 1.00 |
| 142 | 126 | Nalla maddi | 0.22 | 2.00 |
| 143 | 127 | Nallamaddi | 0.47 | 4.00 |
| 144 | 128 | Buddadhaguni | 0.28 | 3.00 |
| 145 | 129 | Nallamaddi | 0.15 | 1.50 |
| 146 | 130 | Teak | 0.67 | 6.00 |
| 147 | 131 | Mosri | 0.36 | 4.00 |
| 148 | 132 | Nallamaddi | 0.20 | 1.50 |
| 149 | 133 | Nallamaddi | 0.22 | 1.50 |
| 150 | 134 | Nallamaddi | 0.24 | 1.50 |
| 151 | 135 | Mosri | 0.70 | 6.00 |
| 152 | 136 | Nallamaddi | 0.42 | 3.00 |
| 153 | 137 | Mosri | 0.25 | 2.00 |
| 154 | 137/1 | Mosri | 0.32 | 1.00 |
| 155 | 138 | Teak | 0.13 | 1.00 |
| 156 | 139 | Nallamaddi | 0.16 | 1.50 |
| 157 | 140 | Teak | 0.19 | 1.50 |
| 158 | 141 | Teak | 0.36 | 2.00 |
| 159 | 142 | Teak | 0.22 | 2.00 |
| 160 | 143 | Nallamaddi | 0.15 | 1.50 |
| 161 | 144 | Teak | 0.53 | 3.00 |
| 162 | 145 | gottI | 0.18 | 1.00 |
| 163 | 146 | Teak | 0.21 | 2.00 |
| 164 | 147 | Teak | 0.20 | 1.00 |
| 165 | 148 | Teak | 0.26 | 3.00 |
| 166 | 149 | Jaana | 0.19 | 2.00 |
| 167 | 149/1 | Jaana | 0.16 | 2.00 |
| 168 | 150 | Maddhuga | 0.21 | 2.00 |

| S NO | tree NO | Spicies | GBH | Hight |
|---|---|---|---|---|
| 169 | 159 | Teak | 0.41 | 5.00 |
| 170 | 159/1 | Teak | 0.31 | 3.00 |

Right side

| | | | | |
|---|---|---|---|---|
| 171 | 152 | Nallamaddi | 0.22 | 2.00 |
| 172 | 153 | Mullamaddi | 0.24 | 2.00 |
| 173 | 154 | Nuluva | 0.33 | 3.00 |
| 174 | 155 | Modhuga | 0.22 | 1.00 |
| 175 | 156 | Chithimithi | 0.10 | 2.00 |
| 176 | 157 | Modhuga | 0.14 | 1.50 |
| 177 | 158 | Odhi | 0.60 | 3.00 |
| 178 | 159 | Teak | 0.61 | 5.00 |
| 179 | 160 | Teak | 0.42 | 4.00 |
| 180 | 161 | Modhuga | 0.14 | 1.00 |
| 181 | 162 | Modhuga | 0.13 | 1.50 |
| 182 | 163 | Nuluva | 0.52 | 5.00 |
| 183 | 164 | Jeedi | 0.21 | 2.00 |
| 184 | 165 | Teak | 0.16 | 1.50 |
| 185 | 166 | Nalla Maddi | 0.16 | 2.00 |
| 186 | 167 | Teak | 0.53 | 5.00 |
| 187 | 168 | Nallamaddi | 0.14 | 1.00 |
| 188 | 169 | Nallamaddi | 0.13 | 1.50 |
| 189 | 170 | Jeedi | 0.50 | 5.00 |
| 190 | 171 | Modhuga | 0.34 | 3.00 |
| 191 | 172 | Jeedi | 0.29 | 3.00 |
| 192 | 173 | Nallamaddi | 0.21 | 2.00 |
| 193 | 173/1 | Nallamaddi | 0.13 | 2.00 |
| 194 | 174 | Nallamaddi | 0.14 | 1.00 |
| 195 | 175 | palakodimma | 0.13 | 1.00 |
| 196 | 176 | Nallamaddi | 0.24 | 2.00 |
| 197 | 177 | Modhuga | 0.53 | 5.00 |
| 198 | 178 | Teak | 0.31 | 3.00 |

| S.No | Tree No | Species | GBH (mts) | Height (mts) |
|---|---|---|---|---|
| 199 | 179 | Teak | 0.41 | 4.00 |
| 200 | 180 | Chennagi | 0.31 | 3.00 |
| 201 | 181 | Jeedi | 0.41 | 4.00 |
| 202 | 182 | Nallamaddi | 0.14 | 1.00 |
| 203 | 183 | Teak | 0.22 | 2.00 |
| 204 | 184 | MORRi | 0.51 | 3.00 |
| 205 | 184/1 | MORRi | 0.22 | 3.00 |
| 206 | 185 | Teak | 0.49 | 4.00 |
| 207 | 186 | palakodicha | 0.15 | 2.00 |
| 208 | 187 | Nalamaddi | 0.29 | 3.00 |
| 209 | 188 | palakodicha | 0.15 | 1.50 |
| 210 | 189 | Nallamaddi | 0.22 | 2.00 |
| 211 | 189/1 | Nallamaddi | 0.19 | 2.00 |
| 212 | 190 | Teak | 0.52 | 4.00 |
| 213 | 191 | Teak | 0.31 | 2.00 |
| 214 | 192 | Teak | 0.21 | 3.00 |
| 215 | 193 | Chotti | 0.22 | 2.00 |
| 216 | 194 | Vepa | 0.15 | 1.50 |
| 217 | 195 | Teak | 0.44 | 6.00 |
| 218 | 195/1 | Teak | 0.46 | 5.00 |
| 219 | 196 | Teak | 0.58 | 5.00 |
| 220 | 197 | Teak | 0.23 | 3.00 |
| 221 | 198 | Nallamaddi | 0.12 | 1.50 |
| 222 | 199 | Nallamaddi | 0.56 | 6.00 |
| 223 | 199/1 | Nallamaddi | 0.41 | 5.00 |
| 224 | 199/2 | Nallamaddi | 0.29 | 5.00 |
| 225 | 199/2 | Nallamaddi | 0.44 | 5.00 |
| 226 | 200 | Rose wood | 0.57 | 4.00 |
| 227 | 200/1 | Rose wood | 0.20 | 4.00 |
| 228 | 201 | Jaana | 0.17 | 2.00 |
| 229 | 202 | TUNKI | 0.16 | 1.50 |
| 230 | 202 | TUNKI | 0.21 | 2.00 |

| S.No | tree No | Species | GBH | Height |
|---|---|---|---|---|
| 221 | 204 | Jeedi | 0.26 | 2.00 |
| 222 | 204/1 | Jeedi | 0.21 | 2.00 |
| 223 | 205 | Teak | 0.63 | 5.00 |
| 224 | 206 | Morri | 0.19 | 2.00 |
| 225 | 207 | Nallaniga | 0.29 | 2.00 |
| 226 | 208 | Nallamaddi | 0.19 | 2.00 |
| 227 | 209 | Tppa | 0.29 | 3.00 |
| 228 | 210 | Nuluva | 0.19 | 2.00 |
| 229 | 211 | Kasuka | 0.17 | 2.00 |
| 240 | 212 | Teak | 0.50 | 5.00 |
| 241 | 213 | Teak | 0.56 | 6.00 |
| 242 | 214 | Morri | 0.20 | 2.00 |
| 242 | 215 | Patta Chanam | 0.40 | 3.00 |
| 244 | 215/1 | Patta Chanam | 0.24 | 1.50 |
| 245 | 216 | Nallamaddi | 0.12 | 1.50 |
| 246 | 217 | Nallamaddi | 0.22 | 2.00 |
| 247 | 218 | Teak | 0.52 | 4.00 |
| 248 | 219 | Nallamaddi | 0.14 | 1.50 |
| 249 | 220 | Nallamaddi | 0.16 | 1.00 |
| 250 | 221 | Teak | 0.12 | 1.00 |
| 251 | 222 | Morri | 0.28 | 2.00 |
| 252 | 223 | Kasaka | 0.16 | 2.00 |
| 253 | 224 | Jeedi | 0.60 | 5.00 |
| 254 | 224/1 | Jeedi | 0.42 | 3.00 |
| 255 | 224/2 | Jeedi | 0.42 | 3.00 |
| 256 | 224/3 | Jeedi | 0.21 | 3.00 |
| 257 | 224/4 | Jeedi | 0.40 | 4.00 |
| 258 | 224/5 | Jeedi | 0.42 | 5.00 |
| 259 | 225 | Mullamaddi | 0.27 | 2.00 |
| 260 | 226 | Tumiki | 0.20 | 2.00 |
| 261 | 227 | Buddadarmi | 0.24 | 1.50 |
| 262 | 228 | Nukuva | 0.19 | 2.00 |
| 263 | 229 | Nukuva | 0.12 | 2.00 |

| S.No | Tree no | Species | GBH | Height |
|---|---|---|---|---|
| 264 | 230 | Nuluva | 0.14 | 1.50 |
| 265 | 231 | Nallamaddi | 0.15 | 1.50 |
| 266 | 232 | Teak | 0.74 | 8.00 |
| 267 | 233 | Nallamaddi | 0.20 | 2.50 |
| 268 | 234 | Bhadadarni | 0.20 | 1.50 |
| 269 | 235 | Nallamaddi | 0.23 | 2.50 |
| 270 | 236 | Nallamaddi | 0.19 | 2.00 |
| 271 | 237 | Nuluva | 0.12 | 1.50 |
| 272 | 238 | Teak | 0.80 | 7.00 |
| 273 | 239 | Teak | 0.26 | 4.00 |
| 274 | 240 | Teak | 0.64 | 7.00 |
| 275 | 241 | Nallamaddi | 0.44 | 4.00 |
| 276 | 242 | Nallamaddi | 0.13 | 1.50 |
| 277 | 243 | Mosai | 0.81 | 8.00 |
| 278 | 244 | Teak | 0.52 | 7.00 |
| 279 | 245 | Teak | 0.22 | 2.00 |
| 280 | 246 | Nallamaddi | 0.26 | 3.00 |
| 281 | 246/1 | Nallamaddi | 0.24 | 2.00 |
| 282 | 247 | Kasaka | 0.23 | 3.00 |
| 283 | 247/1 | Kasaka | 0.12 | 2.00 |
| 284 | 248 | Teak | 0.76 | 7.00 |
| 285 | 249 | Teak | 0.88 | 8.00 |
| 286 | 250 | Nallamaddi | 0.52 | 5.00 |
| 287 | 251 | Muluga | 0.29 | 3.00 |
| 288 | 252 | Mullamaddi | 0.25 | 2.00 |
| 289 | 253 | Moduga | 0.29 | 4.00 |
| 290 | 254 | Chennagi | 0.14 | 2.00 |
| 291 | 255 | Cumpena | 0.67 | 6.00 |
| 292 | 256 | Nallamaddi | 0.56 | 6.00 |
| 293 | 257 | Jeedi | 0.35 | 4.00 |
| 294 | 258 | Teak | 0.66 | 5.00 |
| 295 | 259 | Teak | 0.53 | 6.00 |
| 296 | 260 | Nuluva | 0.16 | 1.50 |
| 297 | 261 | Nuluva | 0.13 | 1.50 |

| S.NO | tree NO | Species | GBH | Height |
|---|---|---|---|---|
| 298 | 262 | Nakkera | 0.54 | 5.00 |
| 299 | 262 | Nakkera | 0.51 | 4.00 |
| 200 | 262/1 | Nakkera | 0.26 | 2.00 |
| 201 | 264 | Rela | 0.24 | 4.00 |
| 202 | 265 | Nuluva | 0.25 | 3.00 |
| 203 | 265/1 | Nuluva | 0.19 | 1.50 |
| 204 | 266 | Tumki | 0.14 | 1.50 |
| 205 | 267 | Modhuga | 0.53 | 5.00 |
| 206 | 268 | Modhuga | 0.65 | 6.00 |
| 207 | 268/1 | Modhuga | 0.58 | 4.00 |
| 208 | 268/2 | Modhuga | 0.51 | 4.00 |
| 209 | 269 | Nakkera | 0.23 | 3.00 |
| 210 | 269/1 | Nakkera | 0.24 | 1.50 |
| 211 | 270 | ponna | 0.26 | 3.00 |
| 212 | 270/1 | ponna | 0.24 | 3.00 |
| 213 | 271 | Nakkera | 0.32 | 2.00 |
| 214 | 272 | Nallamaddi | 0.19 | 1.00 |
| 215 | 273 | Modhuga | 0.36 | 2.00 |
| 216 | 273/1 | Modhuga | 0.25 | 2.00 |
| 217 | 274 | Nuluva | 0.12 | 3.00 |
| 218 | 274/1 | Nuluva | 0.20 | 2.00 |
| 219 | 275 | Teak | 0.42 | 4.00 |
| 220 | 276 | Teak | 0.49 | 6.00 |
| 221 | 277 | Teak | 0.41 | 5.00 |
| 222 | 278 | Nuluva | 0.62 | 5.00 |
| 223 | 278/1 | Nuluva | 0.52 | 4.00 |
| 224 | 279 | Nuluva | 0.20 | 2.00 |
| 225 | 280 | Nuluva | 0.16 | 2.00 |
| 226 | 281 | Nuluva | 0.32 | 3.00 |
| 227 | 281/1 | Nuluva | 0.32 | 3.00 |
| 228 | 282 | Nuluva | 0.11 | 2.00 |

| S.NO | Tree NO | Species | GBH | Height |
|---|---|---|---|---|
| 329 | 282 | Teak | 0.70 | 6.00 |
| 220 | 284p | Chopera | 1.52 | 10.00 |
| 221 | 284/1 | chopera | 1.24 | 10.00 |
| 332 | 285 | Nedunga | 0.45 | 4.00 |
| 333 | 286 | Mossi | 0.62 | 6.00 |
| 334 | 287 | Teak | 0.57 | 1.00 |
| 335 | 288 | Teak | 0.70 | 1.20 |
| 336 | 289 | Teak | 0.12 | 2.00 |
| 337 | 290 | Teak | 0.34 | 7.00 |
| 338 | 291 | palakodiha | 0.21 | 2.00 |
| 339 | 292 | Nuluva | 0.15 | 1.50 |
| 340 | 292 | Nuluva | 0.10 | 2.00 |
| 341 | 294 | Teak | 0.57 | 8.00 |
| 342 | 295 | Mullamaddi | 0.18 | 1.50 |
| 342 | 296 | Mullamaddi | 0.24 | 2.00 |
| 344 | 297 | Nedunga | 0.71 | 5.00 |
| 345 | 297/1 | Nedunga | 0.56 | 4.00 |
| 346 | 298 | palakodiha | 0.17 | 1.50 |
| 347 | 299 | choppera | 1.40 | 11.00 |
| 348 | 299/1 | choppera | 0.40 | 2.00 |
| 349 | 299/2 | choppera | 1.00 | 10.00 |
| 350 | 300 | Odiga | 0.40 | 4.00 |
| 351 | 301 | Nedunga | 0.21 | 3.00 |
| 352 | 302 | Nuluva | 0.28 | 2.00 |
| 353 | 302 | Nuluva | 0.17 | 2.00 |
| 354 | 304 | choppera | 0.88 | 9.00 |
| 355 | 305 | Nuluva | 0.12 | 1.50 |
| 356 | 306 | soni | 0.34 | 8.00 |
| 357 | 307 | Teak | 0.68 | 8.00 |
| 358 | 308 | Thirman | 0.13 | 1.50 |
| 359 | 309 | Thirman | 0.14 | 1.50 |
| 360 | 310 | Thirman | 0.12 | 1.50 |
| 361 | 311 | Thirman | 0.14 | 2.00 |

| S.NO | tree No | Species | GBH | Height |
|---|---|---|---|---|
| 362 | 312 | Thikkumay | 0.17 | 2.50 |
| 363 | 313 | Nuluva | 0.28 | 2.00 |
| 364 | 314 | Teak | 0.52 | 5.00 |
| 365 | 315 | Nuluva | 0.17 | 2.00 |
| 366 | 316 | Nuluva | 0.49 | 5.00 |
| 367 | 317 | Thikkumay | 0.13 | 1.50 |
| 368 | 318 | Cumpena | 0.83 | 6.00 |
| 369 | 319 | Nuluva | 0.26 | 2.00 |
| 370 | 320 | Teak | 0.42 | 4.00 |
| 371 | 321 | Nuluva | 0.27 | 2.50 |
| 372 | 322 | Nuluva | 0.12 | 1.50 |
| 373 | 323 | Somi | 0.76 | 8.00 |
| 374 | 324 | Teak | 0.56 | 5.00 |
| 375 | 325 | Nuluva | 0.50 | 5.00 |
| 376 | 326 | Nuluva | 0.24 | 2.00 |
| 377 | 327 | Teak | 0.75 | 6.00 |
| 378 | 328 | palakodicha | 0.47 | 4.00 |
| 379 | 328/1 | palakodicha | 0.20 | 2.00 |
| 380 | 329 | Nuluva | 0.26 | 3.00 |
| 381 | 329/1 | Nuluva | 0.22 | 3.00 |
| 382 | 330 | Dhirikkinaay | 0.82 | 6.00 |
| 383 | 331 | Gothi | 0.33 | 2.00 |
| 384 | 332 | Teredi | 0.42 | 4.00 |
| 385 | 333 | Teak | 1.02 | 6.00 |
| 386 | 334 | Teak | 0.76 | 7.00 |
| 387 | 335 | Moissi | 0.55 | 6.00 |
| 388 | 336 | Nuluva | 0.19 | 2.00 |
| 389 | 337 | Teak | 0.69 | 7.00 |
| 390 | 338 | Teak | 0.37 | 5.00 |
| 391 | 339 | Nuluva | 0.15 | 1.50 |
| 392 | 340 | Nuluva | 0.68 | 7.00 |
| 393 | 340/1 | Nuluva | 0.69 | 7.00 |

| F.No | tree No | Species | GBH | Height |
|---|---|---|---|---|
| 394 | 341 | @Choppera | 0.22 | 2.00 |
| 395 | 342 | Choppera | 1.25 | 10.00 |
| 396 | 342/1 | Choppera | 0.54 | 6.00 |
| 397 | 343 | Teak | 0.27 | 3.00 |
| 398 | 344 | Jeedi | 0.42 | 4.00 |
| 399 | 345 | Teak | 0.55 | 5.00 |
| 400 | 346 | Nuluva | 0.31 | 3.00 |
| 401 | 347 | Mokki | 1.07 | 7.00 |
| 402 | 348 | Teak | 0.62 | 7.00 |
| 402 | 349 | Nuluva | 0.26 | 3.00 |
| 404 | 350 | Teak | 0.50 | 5.00 |
| 405 | 351 | Teak | 0.62 | 7.00 |
| 406 | 352 | Odhi | 0.76 | 7.00 |
| 407 | 352/1 | Odhi | 0.62 | 7.00 |
| 408 | 353 | Nuluva | 0.48 | 4.00 |
| 409 | 354 | Nallamaddi | 0.54 | 5.00 |
| 410 | 355 | Chinna Arre | 0.42 | 3.00 |
| 411 | 355/1 | Chinna Arre | 0.24 | 2.00 |
| 412 | 355/2 | Chinna Arre | 0.25 | 2.00 |
| 413 | 355/3 | Chinna Arre | 0.20 | 2.00 |
| 414 | 356 | Jaana | 0.16 | 1.50 |
| 415 | 357 | Nakkera | 0.17 | 1.50 |
| 416 | 358 | Nirudhi | 0.53 | 4.00 |
| 417 | 359 | Teak | 0.40 | 4.00 |
| 418 | 360 | Teak | 0.81 | 5.00 |
| 419 | 361 | Teak | 0.71 | 5.00 |
| 420 | 362 | Nuluva | 0.46 | 5.00 |
| 421 | 362/1 | Nuluva | 0.27 | 4.00 |
| 422 | 363 | Tunki | 0.17 | 1.50 |
| 423 | 364 | Choppera | [redacted] 1.09 | 10.00 |
| 424 | 364/1 | Choppera | 0.97 | 10.00 |
| 425 | 364/2 | Choppera | 0.75 | 6.00 |

| S.No | Tree No | Species | GBH | Height |
|---|---|---|---|---|
| 426 | 364/1 | Choppera | 0.72 | 6.00 |
| 427 | 365 | Nuluva | 0.68 | 6.00 |
| 428 | 365/1 | Nuluva | 0.52 | 5.00 |
| 429 | 366 | Teak | 0.60 | 5.00 |
| 430 | 367 | Teak | 0.47 | 5.00 |
| 431 | 368 | Gumpena | 0.65 | 5.00 |
| 432 | 369 | Teak | 0.44 | 4.00 |
| 433 | 370 | Mosai | 0.15 | 1.50 |
| 434 | 371 | Teak | 0.25 | 3.00 |
| 435 | 372 | Teak | 0.59 | 7.00 |
| 436 | 373 | Nallamaddi | 0.44 | 7.00 |
| 437 | 374 | Teak | 0.55 | 7.00 |
| 438 | 375 | Teak | 0.60 | 5.00 |
| 439 | 375/1 | Teak | 0.37 | 4.00 |
| 440 | 376 | Nuluva | 0.65 | 5.00 |
| 441 | 376/1 | Nuluva | 0.44 | 2.00 |
| 442 | 377 | Thani | 0.71 | 6.00 |
| 443 | 378 | Bhirchanam | 0.72 | 6.00 |
| 444 | 378/1 | Bhirchanam | 0.50 | 2.00 |
| 445 | 379 | Illuntha | 0.77 | 5.00 |
| 446 | 380 | Eppa | 0.87 | 7.00 |
| 447 | 380/1 | Eppa | 0.57 | 7.00 |
| 448 | 381 | Uduga | 0.22 | 1.50 |
| 449 | 382 | Chinnaasre | 0.11 | 1.50 |
| 450 | 383 | Teak | 0.61 | 7.00 |
| 451 | 384 | Bhirchanam | 0.95 | 6.00 |
| 452 | 385 | Nuluva | 0.12 | 1.50 |
| 453 | 386 | Choppera | 1.28 | 7.00 |
| ~~454~~ | | | | |
| ~~455~~ | | | | |
| ~~456~~ | | | | |
| ~~457~~ | | | | |

Bcost
SARADHI

S. Kamalakar
Committee