

**Impact of Plastic Waste Disposal
on
Soil and Water Quality
at
Lucknow Dumpsites**



**CENTRAL POLLUTION CONTROL BOARD
(Ministry of Environment & Forests)
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FOREWORD

The soil and groundwater has been contaminated due to indiscriminate littering and dumping of various wastes including plastic waste. The existing MSW landfill sites are mostly filled with different categories of plastic waste which persist in nature for several years specially due to its non-biodegradability. Plastic waste dumping on land causes several environmental issues like imparting infertility in soil, releasing toxic gases on burning, causing death on eating by cattle and most importantly, the additives and colours used during manufacturing processes have potential of leaching out heavy metals and other chemical compounds that may contaminate soil & ground-water quality. To study the effect of municipal and plastic waste dumping on soil and underground water, CPCB sponsored a project to Indian Institute of Toxicological Research (IITR), Lucknow to study "Impact of Plastic Waste Disposal on Soil and Water Quality at Lucknow Dumpsites". The soil and water quality data revealed that the heavy metals, chloride, phthalates etc. migrate from plastic waste into the surrounding medium because these are not chemically bound and remain present as mobile and leachable phase. The leachate can cause considerable pollution problems by contaminating the surrounding soil, ground or surface water.

I hope this report would be useful to the urban local bodies, State Pollution Control Boards and other agencies to understand the environmental issue due to improper dumping of MSW including Plastic waste. I would like to thank officials of IITR, Lucknow for completing the study. I would also like to appreciate sincere efforts made by Dr. S.K. Nigam, Additional Director, CPCB, Delhi for overall co-ordination of the study and Scientists of Zonal Office, Lucknow in assisting the field studies.


(A.K. MEHTA)
Chairman



Contents

| | |
|--|--------------|
| 1. Introduction | ...1 |
| 2. Aims & Objectives | |
| 3. Scope of the study | ...2 |
| 4. Plan of Work | |
| 5. Methodology | ...3 |
| 5.1 Sampling | |
| 5.2 Analysis | |
| 5.3 Sampling Condition | |
| 6. Sampling Details | ...18 |
| 6.1 List of Soil Samples | |
| 6.2 List of water samples | |
| 7. Analysis of Soil & Water samples | ...33 |
| 7.1 Physio-chemical Parameters of soil | |
| 7.2 Chemical Property of Soil Samples | |
| 7.3 Heavy Metals & Organic contaminants in Soil Samples | |
| 7.4 Heavy Metals in Water Samples | |
| 7.5 Phthalates in Water Samples | |
| 8. Conclusion | ...43 |
| 9. Recommendation | ...44 |

Executive Summary

Solid waste management (SWM) is an integral part of the urban environment and planning of the urban infrastructure to ensure safe and healthy environment. While considering the promotion of sustainable economic growth, the rapid and unplanned industrialization, urbanization and population growth have resulted in proliferation of consumer articles vis a vis generation of waste.

Lucknow city is situated at the banks of river Gomti. Geographically, Lucknow city is situated at coordinates 26.85°N and 80.92°E having 2,528 km² area. As per 2001 census its population was approximately 27.50 lakhs generating more than 1200 tonnes per day of municipal solid waste. The purpose of the study was to assess the impact of plastic waste disposal on soil and ground water quality of Lucknow dumpsite. The following two dumpsite locations of Lucknow city: a) Ghaila, Hardoi Road and b) Dudauli, Sitapur Road have been under taken for the sampling and study.

Samples of soil and water were collected and analyzed in both pre monsoon and post monsoon seasons. It was found through the determination of Toxicity Characteristic Leaching Procedure (TCLP) that chemical moieties like heavy metals, chloride, phthalates etc. migrate from plastic waste to the surrounding medium. Since these plastic additives are not chemically bound with the polymeric chain and remain present as free and leachable phase, hence, they can migrate from plastic to the recipient medium during landfilled conditions due to physico-chemical exertion and microbial degradation. These leachates can cause considerable pollution problems by contaminating the surrounding soil, ground or surface waters.

1. Introduction

Plastics are petro-based polymer made-up of long chain of hydrocarbons and non-biodegradable. Plastics are widely used for storage and packaging of food stuffs and transportation. The usage includes disposable and reusable containers, plastic wraps, cutlery, water bottles and baby bottles. Plastic products can be easily found in human residential and occupational environments in high concentrations. After their service life, the plastic products may be landfilled where due to biotic and abiotic degradation, leaching of plastic additives i.e. heavy metals, plasticizers, stabilizers, unreacted monomers and harmful moieties of colorants occur which ultimately percolate in different segments of environment contaminates soil and water bodies.)

The toxicological effects of several plastic additives have been sporadically studied and there is a need for holistic study on impact of plastics waste disposal on soil and ground water. The aim of this study is to monitor and assess the impact of polymeric and plastic additives with special reference to heavy metals and phthalate esters on soil and water medium as they are landfilled along with municipal solid waste. An effort has been made to understand the toxicological implications due to leaching of plastic waste and to generate baseline data to draw recommendations for identifying the health risk due to the presence of heavy metals and phthalate esters migrating food chain through various polymeric and plastic additives used by plastic products manufacturing industries.

2. AIMS & OBJECTIVES

- To collect the soil and water samples from two identified dumpsite locations of Lucknow city (i.e. Dudauli and Ghaila sites) and compile the information regarding the commonly used practice for plastic waste disposal by municipal authorities and Consumers.
- To estimate the **migration** or leaching of heavy metals (Cd, Co, Cr, Cu, Pb, Mo, Ti and Zn) and phthalate esters in ground water and soil samples collected from landfill sites.

3. SCOPE OF THE STUDY

- To collect and identify different types of plastic products and waste from market and dumpsites such as colored plastic bags and containers and gift items, plastic crockery and multilayered plastic and find out leachability of plastic products and waste in laboratory through appropriate testing methods.
- To collect water and soil samples near the dumpsites at Lucknow.
- To **study the migrations of phthalate esters from dump sites.**
- To suggest remedial measures on use of additives in production of plastic products.

4. PLAN OF WORK

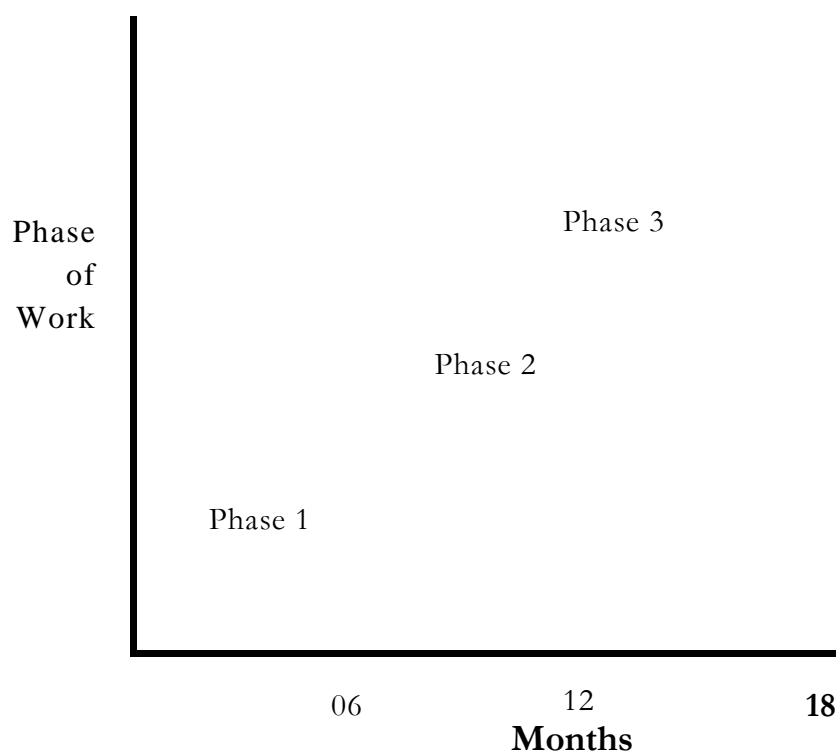


Table-1: Work Plan

| Phases | Proposed Plan | Status |
|-----------------|---|---|
| Phase 1: | Initiation of sample collection, procurement of chemicals and glassware, processing, preparation of reagents, standardization of method and appointment of staff. | <ul style="list-style-type: none">• Control samples of and water had been analyzed during November, 08- January, 09.• Procurement of chemicals and glass wares, processing, preparation of reagents, standardization of method had been completed.• Project staff as envisaged in the project had been appointed.• Pre-monsoon sampling from Dudauli dumpsite was completed. |
| Phase 2: | Estimation of plastic additives viz. heavy metals and phthalates using standard procedure. | Analysis of pre-monsoon samples was done |
| Phase 3: | Continued the analysis of phthalates, metals etc, and interpretation of available data and compilation of report. | Post-monsoon sampling from Dudauli dumpsite was completed on September 28-30, 2009 and sampling on Ghaila dumpsite was completed on December 9-10, 2009. |

5. METHODOLOGY

5.1 Sampling

5.1.1 Identification of Sampling Location:

On the basis of field survey and data concerning to municipal and plastic waste dumping provided by Lucknow Nagar Nigem, relating to two dumpsite location i.e. (a) Ghaila, Hardoi Road and (b) Dudauli, Sitapur Road have been under taken for digging borewell of 30 meter deep at each locations. The samples were taken for soil and water quality testing using Standard Methods. Samples were taken at two locations on Ghaila dumpsite and four locations on Dudauli dumpsite in pre and post monsoon period. From each location respective soil samples were collected at the surface and further at regular intervals of 3 metres upto the depth of the constructed well. After construction of well first static water samples were drawn in triplicate at each location. Summary of the sample collection is presented in **Table 2**.

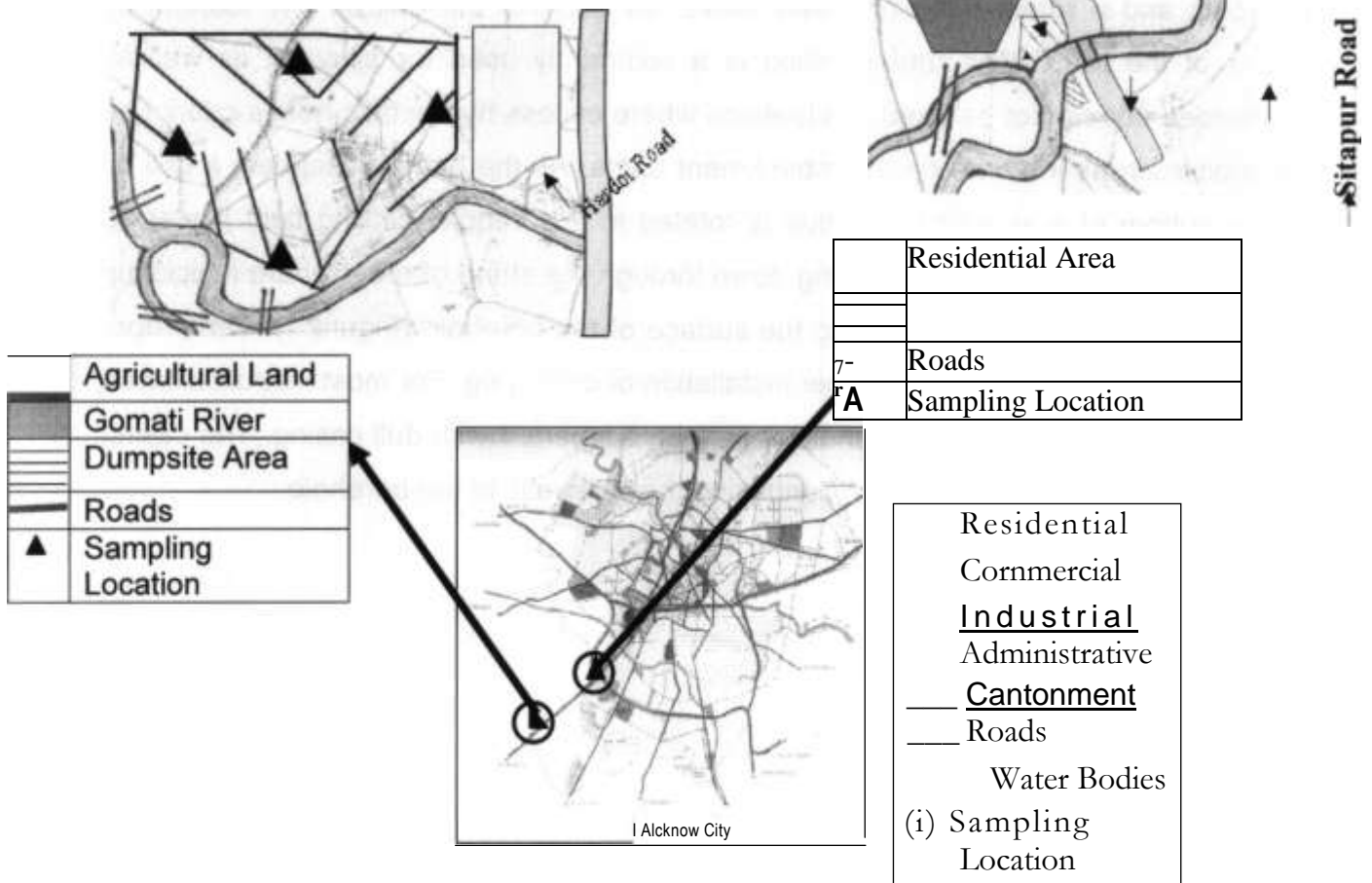
Table - 2

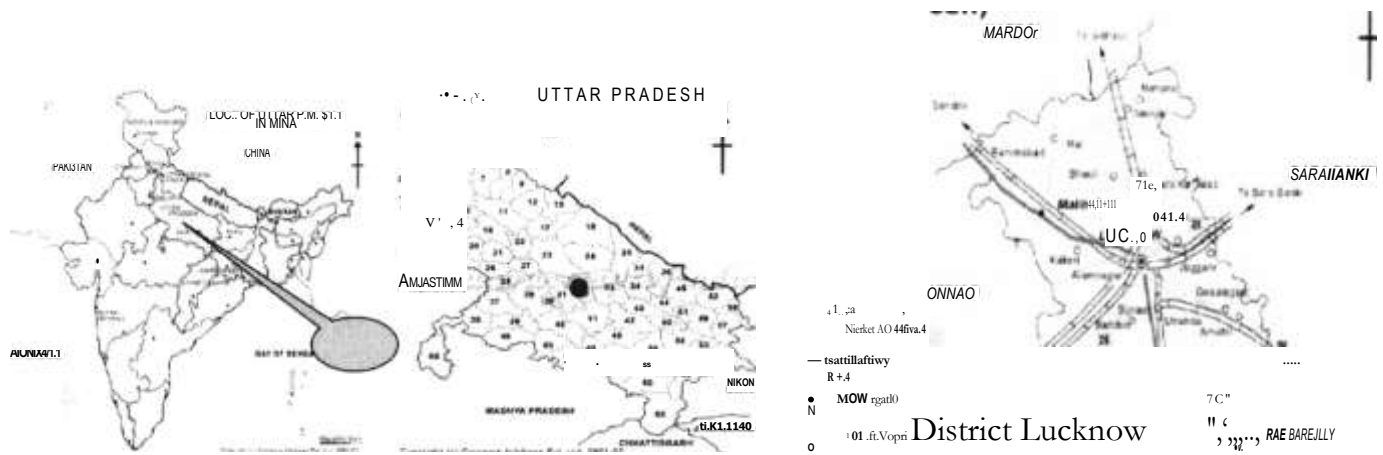
| S. No. | Sample Site | No. of Samples | | | |
|---------------------------|--|-------------------------------|------|--------------------------------|------|
| | | Pre-Monsoon Plan for Sampling | | Post-Monsoon Plan for Sampling | |
| | | Water | Soil | Water | Soil |
| 1. | Municipal Solid Waste Dumpsite, Ghaila , Hardoi Road, Lucknow (2 locations, 3 each) | 06 | 06 | 06 | 06 |
| 2. | Municipal Solid Waste Dumpsite, Dudauli , Sitapur Road, Lucknow (4 locations, 3 each) | 12 | 12 | 12 | 12 |
| Total (72 Samples) | | 18 | 18 | 18 | 18 |

Total No. of construction of 30 meter deep test wells: 06
Total No. of samples involving lysimetric method: Water (36 samples) and Soil (36 samples)

Ghaila Municipal Solid Waste Dumpsite, Hardoi Road, Lucknow

Dudauli Municipal Solid Waste Dumpsite, Sitapur Road, Lucknow





India

5.1.2. Sampling Procedure:

Sampling was carried out through direct circulation system rotary (Mud Rotary Drilling) method using DC mini rig (suitable capacity 300 mm diameter and 120 meter depth in alluvial soil). This method and system includes a drill bit, a drill string having drill rods, and a rotary table or power swivel for bringing the drill bit into rotation by means of the rods. Mud rotary drilling is a commonly used for alluvium as well as overburden but cannot be used in situations where excess hydrostatic heads cannot be tolerated such as in some earth embankment dams. As the name describes, a drill bit on the bottom of a string of drill rods is rotated in a borehole. Drilling fluid (water) is circulated in the borehole by pumping down through the string of rods, where it picks up the drill cuttings and carries them to the surface of the borehole (Figure 1). The proper drilling fluid is essential for the proper installation of drilling rig. For most instrumentation installations the sides of the borehole should be supported with drill casing. The casing also prevents the drilling fluid from contacting the sidewalls of the borehole.

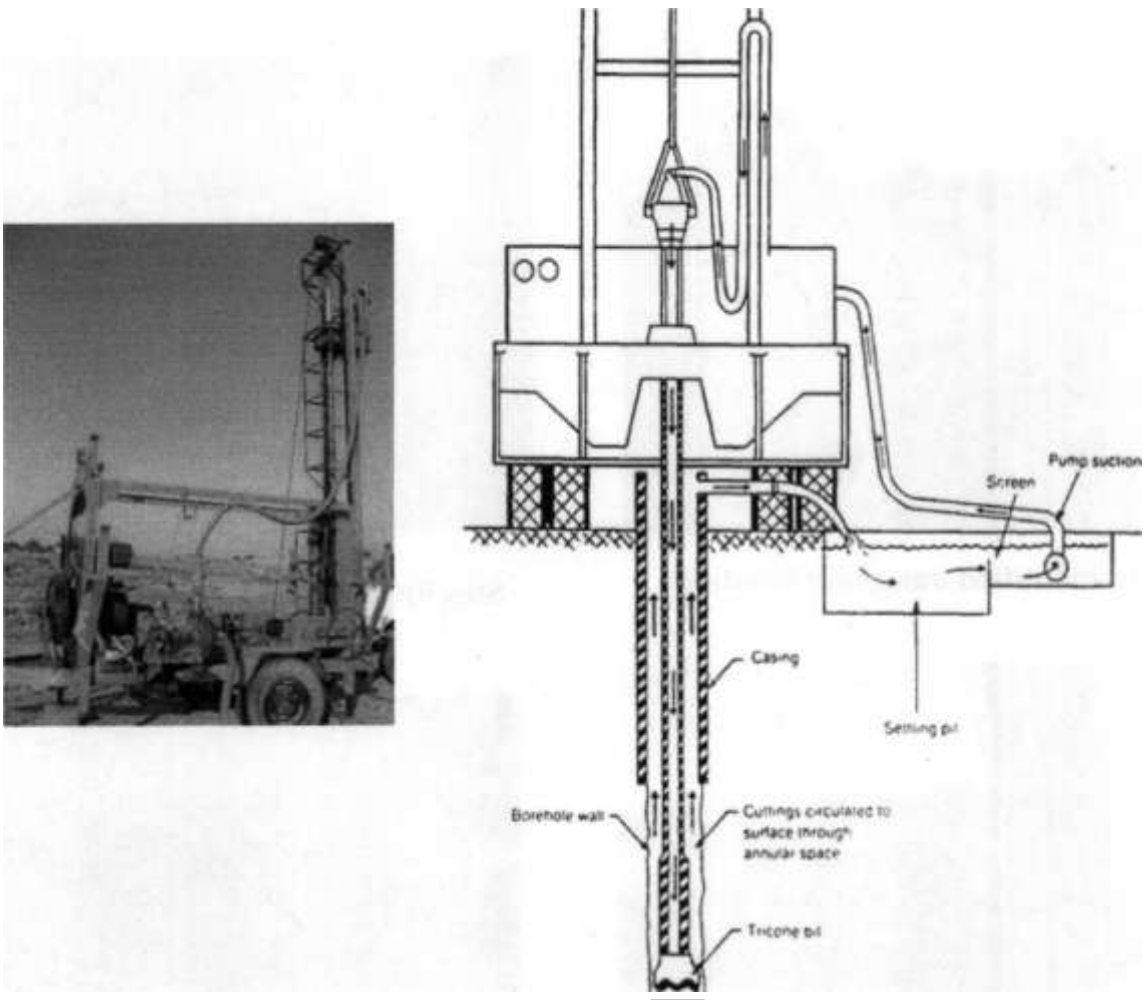
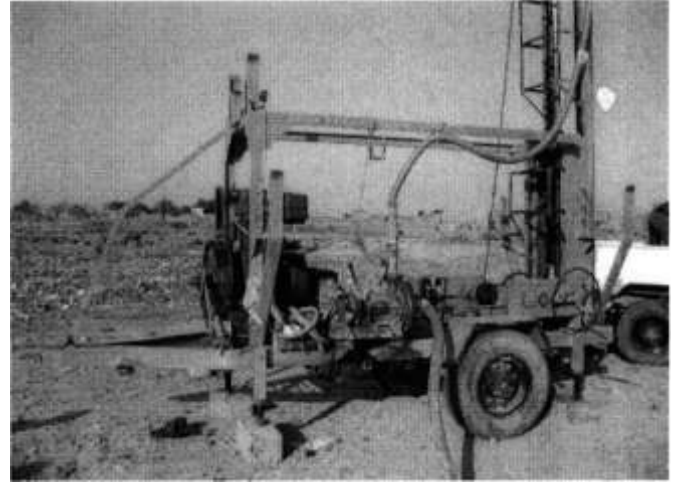


Fig 1: Direct Circulation System Rotary (Mud Rotary Drilling) method using DC mini rig

5.1.3. Step of Sampling:



Step i): Identified sampling location



Step ii): Installation of DC mini rig for drilling bottles



Step iii): Mode of drilling using Direct Circulation System Rotary (Mud Rotary Drilling) method



Step iv): Formation of recycled water micro well



Step v: Soil sample collection in cloth bag



Step vi: Drawing water samples by installation of submersible pump in constructed well



Step vii): Collection of water samples in glass bottles



Step viii): Sealing of construction well using concrete cement material

5.1.4. Preservation of Samples:

Soil samples were collected in cloth bag and glass bottles. Samples of water collected in 2 litre glass bottles and LDPE containers as per USEPA guidelines for waste and solid waste: SW 846. All samples were preserved at refrigerated conditions. During sampling and processing of the samples, precautions were taken to avoid external contamination. This is important since phthalates are ubiquitous chemicals in the indoor

environment. Therefore, use of plasticized plastic equipments were avoided during sampling and processing. For phthalate analysis, all glassware's were properly cleaned with Dichloromethane (DCM/HPLC grade) before use. Detergents were not used during washing of glassware's and all equipments were preconditioned and checked for blank levels of phthalates before analysis. The sample for analysis of heavy metals were preserved by adding 5 ml Nitric acid per liter of water sample.

5.2 ANALYSIS

Parameters of soil and water samples collected and analysed are given below **Table-3** :

| S.No. | Sample | Parameters |
|-------|-----------|--|
| i) | Soil | pH, Heavy metals (Cd, Co, Cr, Cu, Pb, Mo, Ti and Zn), Nitrogen, Phosphorous, Potassium, Phthalates. |
| ii) | Water | Heavy metals (Cd, Co, Cr, Cu, Pb, Mo, Ti and Zn) and Phthalates. |
| iii) | Leachates | TCLP for heavy metals (Cd, Co, Cr, Cu, Pb, Mo, Ti and Zn), <i>Carbon Black</i> , Nigrosine Dye, Chlorides, Phthalates. |

5.2.1. Determination of Hazardous Characteristics of Wastes: Toxicity Characteristic Leaching Procedure (TCLP)

This method is based on USEPA Method 1311-Toxicity Characteristics Leaching Procedure (TCLP). This is applicable to the determination of mobility of metals and semi-volatile organic compound in solids. The principle involved in leaching procedure consists of 3 main steps:

Step I- Crushing/grinding: The solid sample has been passed through 9.5-mm sieve.

Step II- Determination of appropriate extraction fluid: Depending on the pH of the solid sample, one of two extraction fluids is used to extract the soil.

Step III- Extraction of solid sample: The solid sample is extracted (20:1 liquid to solid ratio) by shaking it end over end for 18 ± 2 hours at a controlled temperature at 30 rpm. The extract also known as the leachate is then filtered and analyzed for desired analytes. The moisture content of the solid sample is determined separately and reported alongwith the analytical results.

Preparation of Extraction Fluid No.1:

- 5.7 ml of glacial acetic acid added to 500 ml of double distilled water.
- Then 64.3 ml of 1 M NaOH added to above solution and diluted to 1 liter.
- The pH of this fluid maintained at 4.93 ± 0.05.

Preparation of Extraction Fluid No.2:

- 5.7 ml of glacial acetic acid diluted to 1 liter.
- The pH of this fluid maintained 2.88 ± 0.05.

Note: The extraction fluids should be monitored frequently for impurities and the pH concentration and it may be discarded, if impurities found or pH is not within specifications.

Determination of Appropriate Extraction Fluid:

- 5.0 g (± 0.1 g) of the sample (<9.5 mm) transferred into a 500 ml beaker or Erlenmeyer flask. 96.5 ml of DDW added to the beaker and covered with a watch glass. It then stirred vigorously for 5 minutes using a magnetic stirrer.
- The pH solution measured and recorded.
- When the pH 5.0, extraction fluid No.1 used.
- When the pH > 5.0, added 3.5 ml 1 M HCl, covered with a watch glass, heated to 50°C±2 for 10 minutes. Solution allowed to cool at room temperature and then pH recorded. When the pH was 5, use extraction fluid No.1. Otherwise, use Extraction fluid No.2

Analysis of leachate:

The leachates have been prepared and analyzed as per standard guidelines.

5.2.2. Estimation of Heavy Metals:

200 ml of water sample or the TCLP extract of soil/plastic material were taken in conical flask, digested it for organic substances, if any, with 20 ml concentrated nitric acid in a fuming chamber. The digested samples were made upto 20 ml with 0.1 N HNO₃ and analyzed for Cd, Co, Cr, Cu, Pb, Mo, Ti and Zn with the help of Atomic Absorption Spectrophotometer (ZEEnit- 700) under following conditions are mentioned at **Table-4**.

Table:- 4

| S. No | Metals | Lamp current (m A) | Wave length (nm) | Slit Width (nm) |
|-------|--------|-----------------------|---------------------|-----------------|
| 1 | Cd | 6 | 228.8 | 0.2 |
| 2 | Co | 4 | 240.7 | 0.2 |
| 3 | Cr | 6 | 357.9 | 0.2 |
| 4 | Cu | 3 | 324.8 | 0.5 |
| 5 | Pb | 3 | 283.3 | 0.5 |
| 6 | Mo | 3 | 313.4 | 0.5 |
| 7 | Ti | 3 | 320.0 | 0.5 |
| 8 | Zn | 3 | 213.9 | 0.5 |

5.2.3. Estimation of Phthalates:

A 500 ml of water sample collected from each location or TCLP leachate was extracted three times using 30 ml of dichloromethane (HPLC grade) solvent in one litre separatory funnel each time. The micelle formation was suppressed by adding 10 ml of saturated sodium chloride solution during each operation. The organic layers were combined together and demistered by passing through anhydrous granular sodium sulphate bed [EPA method-8060, Analysis of phthalate esters in water and waste water (1986); EPA method-3510, Separatory funnel liquid-liquid extraction (1986)]. Each sample was processed for column cleanup prior to analysis on HPLC. For proper cleanup, chromatographic column (300 mm length X 10 mm I.D.) was prepared by placing 10 g of activated Florisil on bed of Pyrex glass wool at the bottom. The column was tapped properly to settle the Florisil and further added 1 cm of anhydrous sodium sulfate to the top [EPA method-3620, Florisil column cleanup-1986]. Column was preluted with 40 ml n-Hexane (v/v). The compounds were eluted with 100 ml of 20% ethyl ether in hexane (v/v). The extract in hexane was concentrated under reduced pressure using rotary evaporator (Buchi, B 490). The exchange of solvent was done by replacing hexane with methanol (HPLC grade) and final volume was made up to 10 ml in volumetric flask.

The methodology was tested using water samples. Each sample was screened for 5 Phthalates viz. Di-methyl phthalate (DMP), Di-ethyl phthalate (DEP), Di-butyl phthalate (DBP), Di (2-ethylhexyl) phthalate (DEHP) and Di-octyl phthalate (DOP) by using HPLC under following conditions:

Equipment: HPLC, Waters make, pump-515; Column: RP, C-18; Temperature: 27° C.

Mobile phase: Methanol-water (90:10), Flow Rate 2 ml/min.

Detector: UV-VIS detector (Model 2487; Waters make), Wavelength: 254 nm.

To identify the chromatographic peaks, the five representative samples were analyzed on Gas chromatograph-Mass Spectrophotometer (GC-MS) using following conditions:

Equipment: GC-MS, Turbo Mass, Perkin Elmer, USA.

Column: DB-5ms low bleed (30X0.25 mm), Film thickness: 0.25 μ m; Temperature programme: 1 min. hold at 70°C and raised the temperature up to 325°C @ 10° C/min.

Injector temperature: 250° C.

Mobile phase: Helium, Flow Rate 1.25 ml/min.

Ionization mode: EI; Mass resolution (m/z): 30-550; Scan rate: 10/sec; Ionization energy: 70 eV; Detector: Mass; Source temperature: 280° C.

Schematic Flow-Diagram of Phthalate Extraction from Water Samples ITCLP Leachate

500 ml of sample was taken in a separating funnel

Add 20 ml of sodium chloride to the sample

Thenafter add 30 ml of dichloromethane to the sample

1.

Resulting sample was shaken vigorously for 5 min with periodic venting to release excess pressure

Stand and allowed the organic layer to separate from water phase for a minimum of 10 min.

Collected organic layer and pool in a separate conical flask

Repeat the extraction two more times using fresh portions of solvent in the same manner

Combined three solvent extracts and process it for column cleanup

Concentrated the extract (eluate) up to dryness on rotavapour

Final volume was made up to 10 ml with filtered methanol solution

Estimation of Phthalate using HPLC

Source: EPA method-3510, Separatory funnel liquid-liquid extraction; 1986.
EPA method-3620, Florisil column cleanup; 1986.

Schematic Flow-Diagram of Phthalate Extraction from Soil Samples

5 gm of dry sample was taken

Extracted using Soxhlet apparatus with the help of 1:1 Acetone/n- Hexane mixture for approx. 18 hours

Collect the extract and process it for column cleanup

Concentrate the extract (eluate) upto dryness on rotavapour

Made up the final volume upto 10 ml with filtered methanol solution

Estimation of Phthalate using HPLC

Source: EPA method-8060, Analysis of phthalate esters in water and waste water; 1986.

5.2.4. Estimation of Chloride in leachates

In the leachate (each 20 ml), add 3 drops of $K_2Cr_2O_7$, stirred well and titrated against 0.014 $AgNO_3$. The formula used is as follows:

$$CI \text{ mg/L} = \frac{S-B}{ml \text{ of sample}} \times 0.5 \times 1000$$

5.3 Sampling Conditions

5.3.1 Pre-monsoon Sampling

First phase of pre-monsoon sampling was conducted at four identified locations of Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow during April 12, 2009 to April 15, 2009 while second phase of pre-monsoon sampling was conducted at two identified locations of Municipal Solid Waste Dumpsite, Dudauli, Ghaila, Hardoi Road, Lucknow during May 04, 2009 to May 05, 2009. Conditions during sampling are given below.

Location I: Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow

| Date | Time | Site | Location of Drilling | Temperature |
|----------|----------------------|--|----------------------|-------------|
| 12.04.09 | 6: 00 pm — 10: 30 pm | Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow | Point I | 36°±2 C |
| 13.04.09 | 1:30 pm — 5:45 pm | Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow | Point II | 41° ±2 C |
| 14.04.09 | 10:15 am — 12:15 pm | Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow | Point III | 42° ±2 C |
| 15.04.09 | 3:30 pm — 6: 45 pm | Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow | Point IV | 39°±2C |

Location II: Municipal Solid Waste Dumpsite, Ghaila, Hardoi Road, Lucknow

| Date | Time | Site | Location of Drilling | Temperature |
|----------|---------------------|--|----------------------|-------------|
| 04.05.09 | 9: 00 am — 5: 00 pm | Municipal Solid Waste Dumpsite, Ghaila, Hardoi Road, Lucknow | Point I | 35°±2 C |
| 05.05.09 | 8:30 am — 4:45 pm | Municipal Solid Waste Dumpsite, Ghaila, Hardoi Road, Lucknow | Point II | 39°±2 C |




5.3.2 Post-monsoon Sampling

The proposed post-monsoon sampling was delayed for three months due to late monsoon conditions and prolonged water logging after heavy rains at Ghaila Municipal Solid Waste Dumpsite, Hardoi Road, Lucknow. Post-monsoon sampling was conducted at one identified location of Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow during September 28-30, 2009 while last phase of post-monsoon sampling was also conducted at one identified location of Municipal Solid Waste Dumpsite, Ghaila, Hardoi Road, Lucknow during December 9-10, 2009. Conditions during sampling are charted below.

| | Date | Time | Site | Location of Drilling | Temperature |
|-------------|----------|-------------------------|--|----------------------|-------------|
| Location I | 29.10.09 | 10:00 am — 05: 30 pm | Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow | Point I | 29°±2C |
| Location II | 09.12.09 | 9:30 am — 5:30 pm | Municipal Solid Waste Dumpsite, Ghaila, Hardoi Road , Lucknow | Point II | 26°±2C |

5.4 Geo-physical and Drilling Features of Dumpsite Area:

| | |
|--|--------------------------------|
| Strata Chart: Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow | |
| Test Well No. 1 | Static Water Level: 13.7 meter |

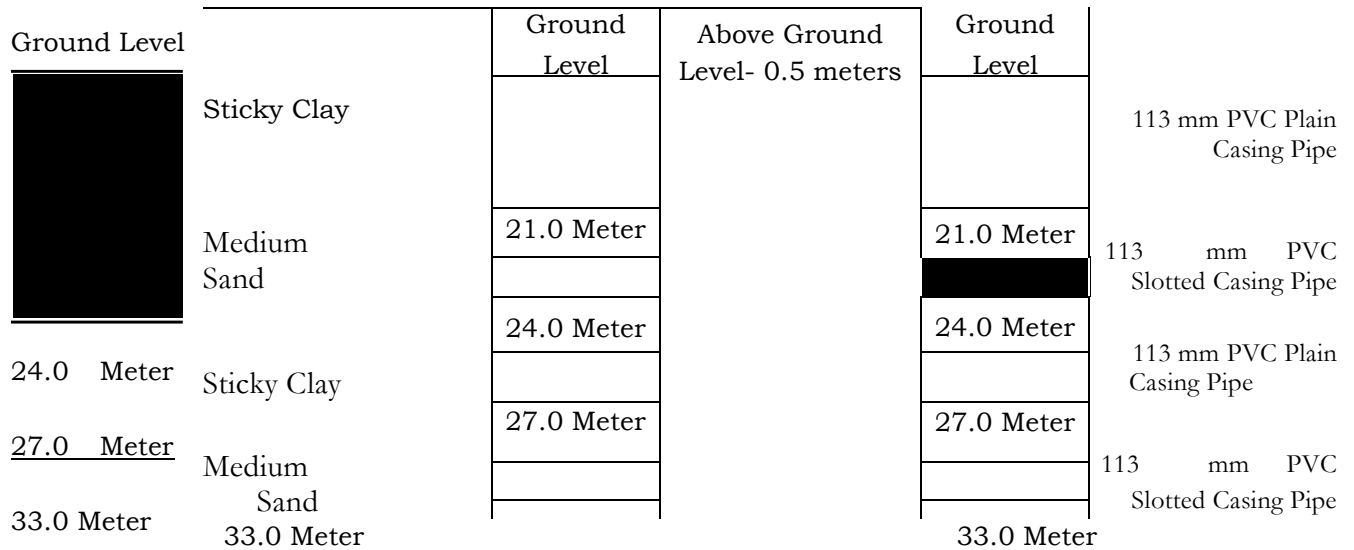
| STRATA DETAILS | | LOWERING DETAILS | | ASSEMBLY DETAILS | |
|---|---------------------|------------------|-------------------|------------------|--------------------------------|
| Ground Level | | Ground Level | Above Ground | Ground Level | |
|  | Coarse Sand | | Level- 0.5 meters | | 113 mm PVC Plain Casing Pipe |
| 12.0 Meter | | | | | |
|  | Sticky Clay | | | | 113 mm PVC Slotted Casing Pipe |
| 27.0 Meter | | | | | |
|  | Fine to Medium Sand | 30.0 Meter | | 30.0 Meter | |
| 36.0 Meter | | 36.0 Meter | | 36.0 Meter | |

| | |
|---|--|
| Strata Chart: Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow | |
| Test Well No. 2 | Static Water Level: 10.70 meter |

STRATA DETAILS

LOWERING DETAILS

ASSEMBLY DETAILS

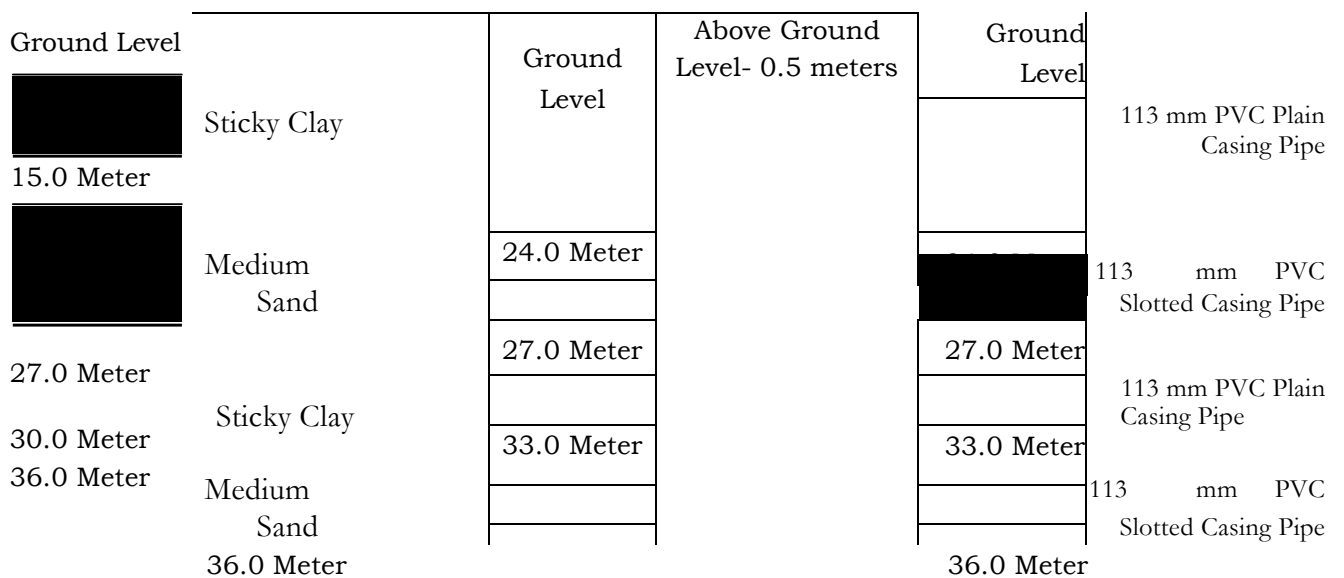


| | |
|---|---------------------------------------|
| Strata Chart: Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow | |
| Test Well No. 3 | Static Water Level: 13.7 meter |

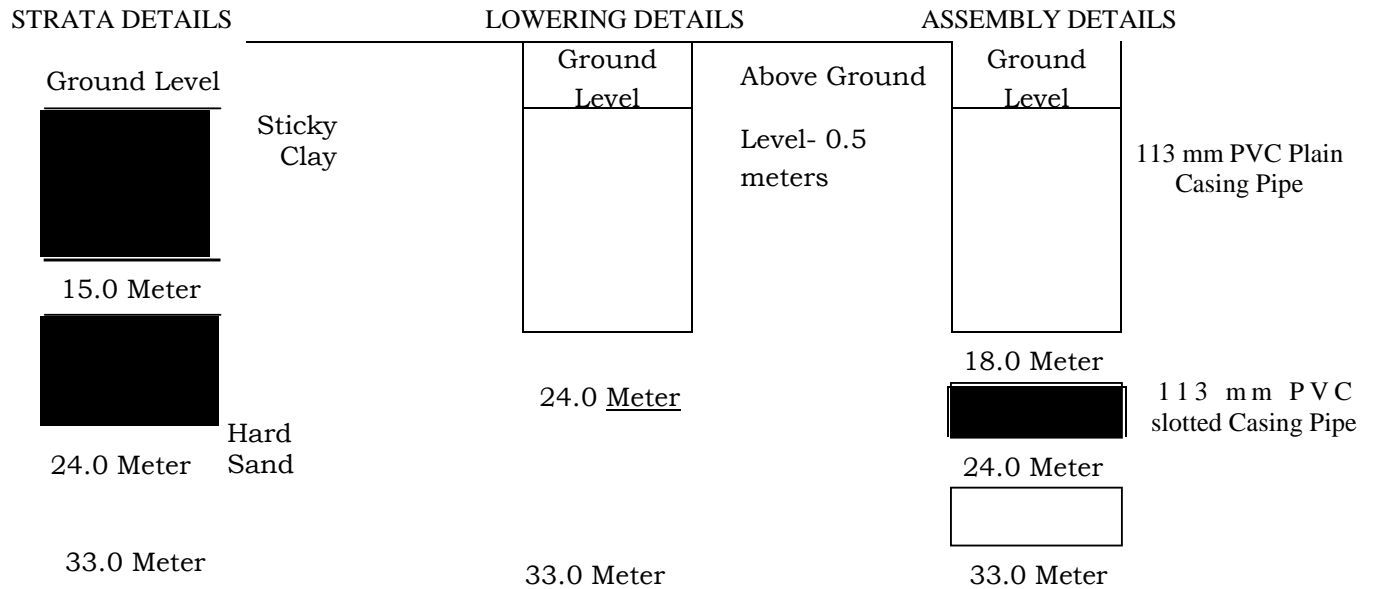
STRATA DETAILS

LOWERING DETAILS

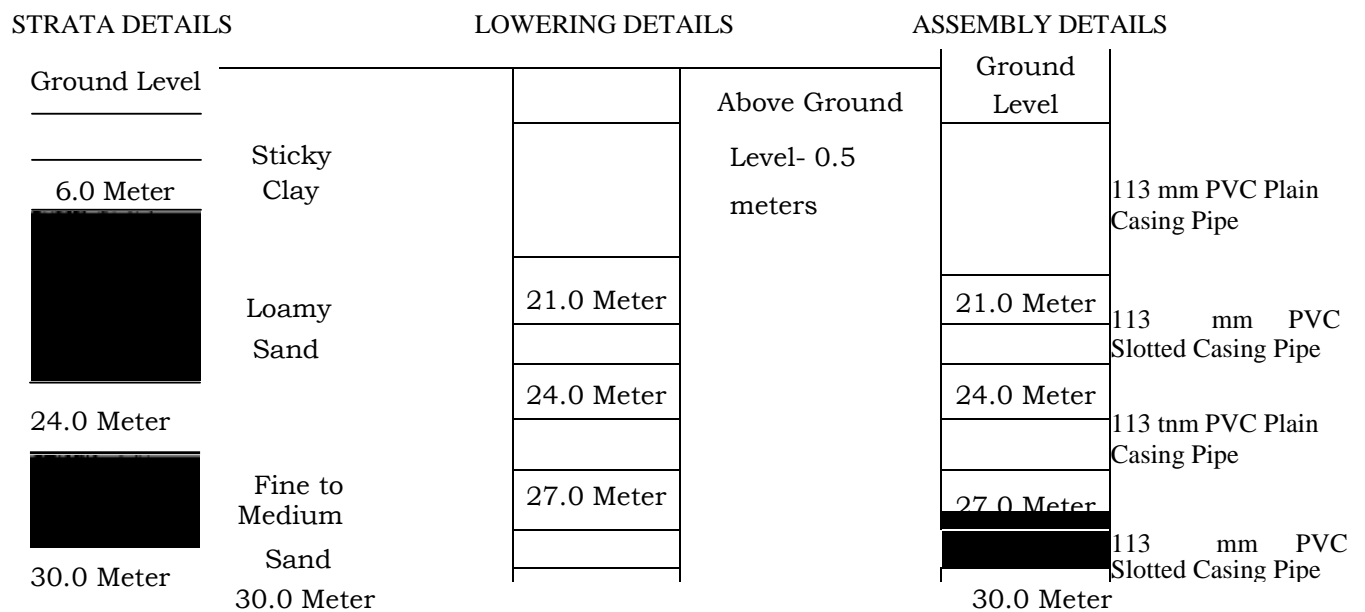
ASSEMBLY DETAILS



Strata Chart: Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow
Test Well No. 4 Static Water Level: 12.70 meter



Strata Chart: Municipal Solid Waste Dumpsite, Ghaila, Hardoi Road, Lucknow
Test Well No. 1 Static Water Level: 10.70 meter

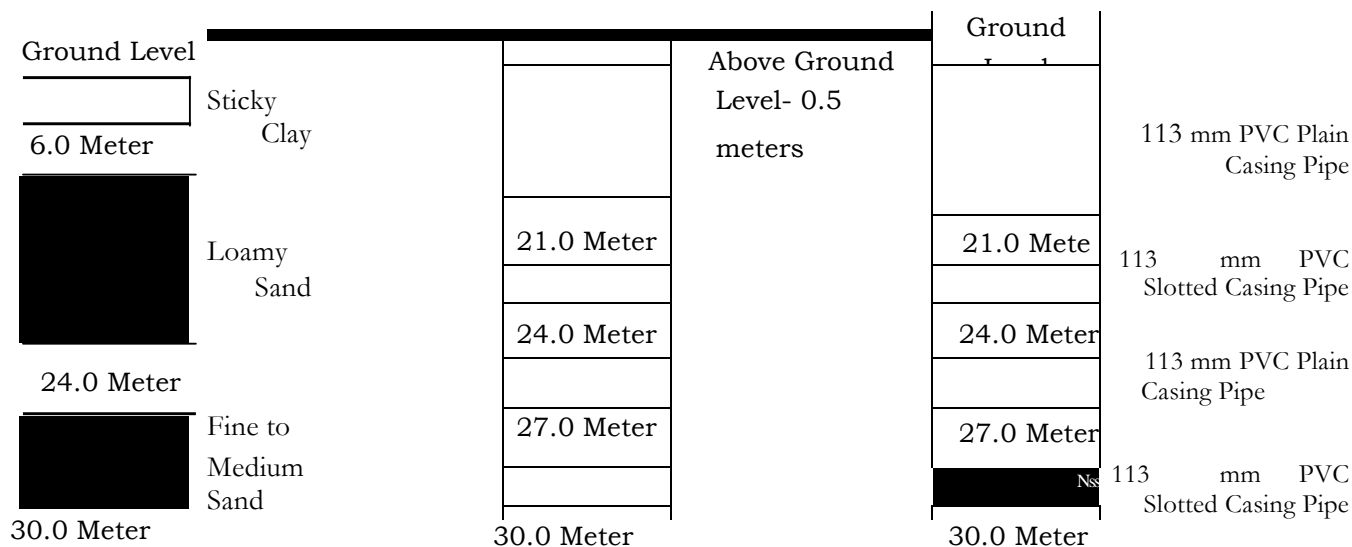


| | |
|--|---------------------------------|
| Strata Chart: Municipal Solid Waste Dumpsite, Ghaila, Hardoi Road, Lucknow | |
| Test Well No. 2 | Static Water Level: 10.70 meter |

STRATA DETAILS

LOWERING DETAILS

ASSEMBLY DETAILS



6. Sampling Details

6.1 List of Soil Samples

| Sample Code | IITR Code No. | Texture | Depth | Sample Container | Date of Sampling | Remarks, if any |
|--|--|----------------------|-----------------------------|------------------|------------------|--------------------------------|
| Point I, Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road Lucknow (6: 00 pm — 10: 30 | | | | | | |
| 1. | AS 01/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Medium sand | 3.4 meter | Cloth | 12.04.09 | Pre-monsoon [Experimental] |
| 2. | AS 021D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sticky clay | 6.45 meter (3.05 meter) | Cloth | 12.04.09 | Pre-monsoon [Experimental] |
| 3. | AS 03/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Clay + Gravel | 9.50 meter (3.05 meter) | Cloth | 12.04.09 | Pre-monsoon [Experimental] |
| 4. | AS 04/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sticky clay + Gravel | 12.50 meter (3.0 meter) | Cloth | 12.04.09 | Pre-monsoon [Experimental] |
| 5. | AS 05/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sticky clay + Gravel | 15.50 meter (3.0 meter) | Cloth | 12.04.09 | Pre-monsoon [Experimental] |

| | | | | | | |
|---|--|------------------------------------|----------------------------------|---------|--------------|--------------------------------|
| 6. | AS 06/0/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy clay + Gravel | 18.50 meter (3.0 meter) | Cloth | 12.04.0 9 | Pre-monsoon [Experimental] |
| 7. | AS 07/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy clay + Gravel+ Sand | 21.50 meter (3.0 meter) | Cloth | 12.04.0 9 | Pre-monsoon [Experimental] |
| 8. | AS 08/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy clay + Gravel | 24.50 meter (3.0 meter) | Plastic | 12.04.0 9 | Pre-monsoon [Experimental] |
| 9. | AS 09/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy clay + Gravel | 27.50 meter (3.0 meter) | Plastic | 12.04.0 9 | Pre-monsoon [Experimental] |
| 10. | AS 10/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy clay + Gravel | 30.50 meter (3.0 meter) | Plastic | 12.04.0 9 | Pre-monsoon [Experimental] |
| 11. | AS 11/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Clay + Sand | 33.50 meter (3.0 meter) | Cloth | 12.04.0 9 | Pre-monsoon [Experimental] |
| 12. | AS 12/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sand | 36.50 meter (3.0 meter) | Cloth | 12.04.0 9 | Pre-monsoon [Experimental] |
| Point II, Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow (1:30 pm - 5:45 pm) | | | | | | |
| 13. | AS 13/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sticky clay+ small gravels | 3.4 meter | Cloth | 13.04.0 9 | Pre-monsoon [Experimental] |
| 14. | AS 14/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sticky clay+ small gravels | 6.45 meter (3.05 meter) | Cloth | 13.04.0 9 | Pre-monsoon [Experimental] |
| 15. | AS 15/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sticky clay | 9.50 meter (3.05 meter) | Cloth | 13.04.0 9 | Pre-monsoon [Experimental] |
| 16. | AS 16/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sticky clay | 12.50 meter (3.0 meter) | Cloth | 13.04.0 9 | Pre-monsoon [Experimental] |

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|---|--|---------------------------|-------------------------------|-------|----------|-------------------------------|
| 17. | AS 17/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sticky clay | 15.50 meter (3.0 meter) | Cloth | 13.04.09 | Pre-monsoon [Experimental] |
| 18. | AS 18/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sand + Gravel | 18.50 meter (3.0 meter) | Cloth | 13.04.09 | Pre-monsoon [Experimental] |
| 19. | AS 19/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy Sand | 21.50 meter (3.0 meter) | Cloth | 13.04.09 | Pre-monsoon [Experimental] |
| 20. | AS 20/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy Sand | 24.50 meter (3.0 meter) | Cloth | 13.04.09 | Pre-monsoon [Experimental] |
| 21. | AS 21/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy Sand | 27.50 meter (3.0 meter) | Cloth | 13.04.09 | Pre-monsoon [Experimental] |
| 22. | AS 22/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sand | 30.50 meter (3.0 meter) | Cloth | 13.04.09 | Pre-monsoon [Experimental] |
| 23. | AS 23/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sand | 33.50 meter (3.0 meter) | Cloth | 13.04.09 | Pre-monsoon [Experimental] |
| Point II, Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow (10:15 am - 12:15 Pm) | | | | | | |
| 24. | AS 24/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy Sand | 3.4 meter | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 25. | AS 25/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy Sand + gravel | 6.45 meter (3.05 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 26. | AS 26/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Clay + garvel | 9.50 meter (3.05 m) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 27. | AS 27/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Clay + garvel | 12.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |

| | | | | | | |
|---|---|------------------|-------------------------------|-------|----------|-------------------------------|
| 28. | AS 28/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Clay + garvel | 15.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 29. | AS 29/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Clay + garvel | 18.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 30. | AS 30/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy Sand | 21.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 31. | AS 31/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy Sand | 24.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 32. | AS 32/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy Sand | 27.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 33. | AS 33/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy Sand | 30.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 34. | AS 34/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sand | 33.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 35. | AS 35/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sand | 36.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| Point IV, Municipal Solid Waste Dumpsite, Dudaul", Sitapur Road, Lucknow (3:30 pm- 6: 45 pm) | | | | | | |
| 36. | AS 36/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Clay + Mud | 3.4 meter | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 37. | AS 37/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Clay + Mud | 6.45 meter (3.05 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 38. | AS 38/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Clay + Gravel | 9.50 meter (3.05 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |

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|---|--|----------------------------|-------------------------------|-------|----------|-------------------------------|
| 39. | AS 39/D/Soil/IITR Dudauli, Sitapur Road, Lucknow | Clay + Gravel | 12.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 40. | AS 40/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Clay + Gravel | 15.50 meter (3.0 meter) | Cloth | | Pre-monsoon [Experimental] |
| 41. | AS 41/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy Sand | 18.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 42. | AS 42/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy Sand | 21.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 43. | AS 43/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sticky Clay | 24.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 44. | AS 44/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Clay + sand + Gravel | 27.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 45. | AS 45/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sand | 30.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| 46. | AS 46/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sand | 33.50 meter (3.0 meter) | Cloth | 14.04.09 | Pre-monsoon [Experimental] |
| Point I, Municipal Solid Waste Dumpsite, Ghaila, Hardoi Road, Lucknow (10:30 am- 4: 45 pm) | | | | | | |
| 47. | AS 47/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Sticky clay | 3.4 meter | Cloth | 04.05.09 | Pre-monsoon [Experimental] |
| 48. | AS 48/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Loamy Sand | 6.45 meter (3.05 meter) | Cloth | 04.05.09 | Pre-monsoon [Experimental] |
| 49. | AS 49/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Loamy Sand | 9.50 meter (3.05 meter) | Cloth | 04.05.09 | Pre-monsoon [Experimental] |

| | | | | | | |
|-----|--|------------|-------------------------|-------|----------|----------------------------|
| 50. | AS 50/G/Soil/IITR, Ghaila, Hardoi Road, Lucknow | Loamy Sand | 12.50 meter (3.0 meter) | Cloth | 04.05.09 | Pre-monsoon [Experimental] |
| 51. | AS 51/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Loamy Sand | 15.50 meter (3.0 meter) | Cloth | 04.05.09 | Pre-monsoon [Experimental] |
| 52. | AS 52/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Loamy Sand | 18.50 meter (3.0 meter) | Cloth | 04.05.09 | Pre-monsoon [Experimental] |
| 53. | AS 53/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Loamy Sand | 21.50 meter (3.0 meter) | Cloth | 04.05.09 | Pre-monsoon [Experimental] |
| 54. | AS 54/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Loamy Sand | 24.50 meter (3.0 meter) | Cloth | 04.05.09 | Pre-monsoon [Experimental] |
| 55. | AS 55/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Sand | 27.50 meter (3.0 meter) | Cloth | 04.05.09 | Pre-monsoon [Experimental] |
| 56. | AS 56/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Sand | 30.50 meter (3.0 meter) | Cloth | 04.05.09 | Pre-monsoon [Experimental] |

Point II, Municipal Solid Waste Dumpsite, Ghila, Hardoi Road, Lucknow (8:30 am- 11:30am)

| | | | | | | |
|-----|--|-------------|-------------------------|-------|----------|----------------------------|
| 57. | AS 57/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Sticky clay | 3.4 meter | Cloth | 05.05.09 | Pre-monsoon [Experimental] |
| 58. | AS 58/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Sticky clay | 6.45 meter (3.05 meter) | Cloth | 05.05.09 | Pre-monsoon [Experimental] |
| 59. | AS 59/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Loamy Sand | 9.50 meter (3.05 meter) | Cloth | 05.05.09 | Pre-monsoon [Experimental] |
| 60. | AS 60/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Loamy Sand | 12.50 meter (3.0 meter) | Cloth | 05.05.09 | Pre-monsoon [Experimental] |
| 61. | AS 61/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Loamy Sand | 15.50 meter (3.0 meter) | Cloth | 05.05.09 | Pre-monsoon [Experimental] |
| 62. | AS 62/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Loamy Sand | 18.50 meter (3.0 meter) | Cloth | 05.05.09 | Pre-monsoon [Experimental] |

| | | | | | | |
|-----|--|---------------|-----------------------------|-------|----------|----------------------------|
| 63. | AS 63/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Loamy Sand | 21.50 meter (3.0 meter) | Cloth | 05.05.09 | Pre-monsoon [Experimental] |
| 64. | AS 64/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Loamy Sand | 24.50 meter (3.0 meter) | Cloth | 05.05.09 | Pre-monsoon [Experimental] |
| 65. | AS 65/G/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Sand | 27.50 meter (3.0 meter) | Cloth | 05.05.09 | Pre-monsoon [Experimental] |
| 66. | AS 66/0/Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Sand | 30.50 meter (3.0 meter) | Cloth | 04.05.09 | Pre-monsoon [Experimental] |
| 67. | AS 67/C/Soil/ IITR, Sitapur Road (Faizulla Ganj, near old Kisan Mandi), Lucknow | Clay + gravel | 5 cm below from upper layer | Cloth | 07.08.08 | Pre-monsoon [Control] |
| 68. | AS 68/ C /Soil/ IITR, Ghaila, Hardoi Road, Lucknow | Loamy clay | 5 cm below from upper layer | Cloth | 07.08.08 | Pre-monsoon [Control] |
| 69. | AS 69/ C /Soil/ IITR, Ghaila, Hardoi Road (Near temple, opposite to dumpsite), Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 07.08.08 | Pre-monsoon [Control] |
| 70. | AS 70/ C /Soil/ IITR, Jiamau, Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 07.08.08 | Pre-monsoon [Control] |
| 71. | AS 71/ C /Soil/ IITR, Jiamau, Lucknow | Loamy clay | 5 cm below from upper layer | Cloth | 07.08.08 | Pre-monsoon [Control] |
| 72. | AS 72/ C /Soil/ IITR, Manas Nagar, Jiamau, Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 06.11.08 | Pre-monsoon [Control] |
| 73. | AS 73/ C /Soil/ IITR, Rama Bai Sthali, Ashiana Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 06.11.08 | Pre-monsoon [Control] |
| 74. | AS 74/ C /Soil/ IITR, Kila Mohannmadi Nagar, Smriti Park, Ashiana, Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 06.11.08 | Pre-monsoon [Control] |
| 75. | AS 75/ C /Soil/ IITR, B Block, Indira Nagar, Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 06.11.08 | Pre-monsoon [Control] |
| 76. | AS 76/ C /Soil/ IITR, C Block, Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 06.11.08 | Pre-monsoon [Control] |
| 77. | AS 77/ C /Soil/ IITR, Gheru Soil, Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 3.12.08 | Pre-monsoon [Control] |

| | | | | | | |
|-----|---|---------------|--------------------------------|-------|----------|---------------------------|
| 78. | AS 78/ C /Soil/ IITR, Alambagh, Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 3.12.08 | Pre-monsoon [Control] |
| 79. | AS 79/ C /Soil/ IITR, IITR Gate, Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 06.01.09 | Pre-monsoon [Control] |
| 80. | AS 80/ C /Soil/ IITR, IITR Gate, Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 06.08.09 | Pre-monsoon [Control] |
| 81. | AS 81/ C /Soil/ IITR, Sitapur Road (Faizulla Ganj, near old Kisan Mandi), Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 29.10.09 | Post-monsoon [Control] |
| 82. | AS 82/ C /Soil/ IITR, Kila Mall Ghaila, Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 29.10.09 | Post-monsoon [Control] |
| 83. | AS 83/ C /Soil/ IITR, Ghaila, Hardoi Road (Near temple, opposite to dumpsite). Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 29.10.09 | Post-monsoon [Control] |
| 84. | AS 84/ C /Soil/ IITR, Jiamau, Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 30.10.09 | Post-monsoon [Control] |
| 85. | AS 85/ C /Soil/ IITR, Jiamau, Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 30.10.09 | Post-monsoon [Control] |
| 86. | AS 86/ C /Soil/ IITR, Manas Nagar, Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 30.10.09 | Post-monsoon [Control] |
| 87. | AS 87/ C /Soil/ IITR, Rama Bai Sthali, Ashiana | Rough clay | 5 cm below from upper layer | Cloth | 30.10.09 | Post-monsoon [Control] |
| 88. | AS 88/ C /Soil/ IITR, IITR Gate, Lucknow | Rough clay | 5 cm below from upper layer | Cloth | 30.10.09 | Post-monsoon [Control] |

| Sample Code | IITR Code No. | Texture | Depth | Sample Container | Date of Sampling | Remarks, if any |
|--|--|---------------------------|-------------------------|------------------|------------------|-----------------------------|
| Point I – Municipal Solid Waste Dumpsite Dudauli, Sitapur Road, Lucknow (9:00 am -12:00 pm) | | | | | | |
| | AS 89/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Medium sand | 3.4 meter | Cloth | 29.10.09 | Post-monsoon [Experimental] |
| 90. | AS 901D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sticky clay | 6.45 meter (3.05 meter) | Cloth | 29.10.09 | Post-monsoon [Experimental] |
| 91. | AS 91/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Clay + Gravel | 9.50 meter (3.05 meter) | Cloth | 29.10.09 | Post-monsoon [Experimental] |
| 92. | AS 92/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sticky clay + Gravel | 12.50 meter (3.0 meter) | Cloth | 29.10.09 | Post-monsoon [Experimental] |
| 93. | AS 93/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sticky clay + Gravel | 15.50 meter (3.0 meter) | Cloth | 29.10.09 | Post-monsoon [Experimental] |
| 94. | AS 94/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy clay + Gravel | 18.50 meter (3.0 meter) | Cloth | 29.10.09 | Post-monsoon [Experimental] |
| 95. | AS 951D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy clay + Gravel+ Sand | 21.50 meter (3.0 meter) | Cloth | 29.10.09 | Post-monsoon [Experimental] |
| 96. | AS 96/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy clay + Gravel | 24.50 meter (3.0 meter) | Cloth | 29.10.09 | Post-monsoon [Experimental] |
| 97. | AS 97/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy clay + Gravel | 27.50 meter (3.0 meter) | Cloth | 29.10.09 | Post-monsoon [Experimental] |
| 98. | AS 98/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Loamy clay + Gravel | 30.50 meter (3.0 meter) | Cloth | 29.10.09 | Post-monsoon [Experimental] |
| 99. | AS 991D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Clay + Sand | 33.50 meter (3.0 meter) | Cloth | 29.10.09 | Post-monsoon [Experimental] |
| 100. | AS 100/D/Soil/ IITR Dudauli, Sitapur Road, Lucknow | Sand | 36.50 meter (3.0 meter) | Cloth | 29.10.09 | Post-monsoon [Experimental] |

| Sample code | IITR Code No. | Texture | Depth | Sample Container | Date of Sampling | Remarks, if any |
|---|--|-------------|-------------------------|------------------|------------------|----------------------------|
| Point I Municipal Solid Waste Dumpsite, Ghaila, Hardoi, Lucknow (9:00 am -5:00 pm) | | | | | | |
| 101. | AS 101/0/Soil/ IITR Ghaila, Hardoi Road , Lucknow | Sticky Clay | 3.4 meter | Cloth | 09.12.09 | Postmonsoon [Experiment] |
| 102. | AS 102/0/Soil/ IITR Ghaila, Hardoi Road , Lucknow | Loamy Sand | 6.45 meter (3.05 meter) | Cloth | 09.12.09 | Postmonsoon [Experiment] |
| 103. | AS 103/ G /Soil/ IITR Ghaila, Hardoi Road, Lucknow | Loamy Sand | 9.50 meter (3.05 meter) | Cloth | 09.12.09 | Postmonsoon [Experimental] |
| 104. | AS 104/C /Soil/ IITR Ghaila, Hardoi Road, Lucknow | Loamy Sand | 12.50 meter (3.0 meter) | Cloth | 09.12.09 | Postmonsoon [Experimental] |
| 105. | AS 105/ G /Soil/ IITR Ghaila, Hardoi Road, Lucknow | Loamy Sand | 15.50 meter (3.0 meter) | Cloth | 09.12.09 | Postmonsoon [Experimental] |
| 106. | AS 106/ G /Soil/ IITR Ghaila, Hardoi Road, Lucknow | Loamy Sand | 18.50 meter (3.0 meter) | Cloth | 09.12.09 | Postmonsoon [Experimental] |
| 107. | AS 107/ G /Soil/ IITR Ghaila, Hardoi Road, Lucknow | Loamy Sand | 21.50 meter (3.0 meter) | Cloth | 09.12.09 | Postmonsoon [Experimental] |
| 108. | AS 108/ G /Soil/ IITR Ghaila, Hardoi Road, Lucknow | Loamy Sand | 24.50 meter (3.0 Meter) | Cloth | 09.12.09 | Postmonsoon [Experimental] |
| 109. | AS 109/C /Soil/ IITR Ghaila, Hardoi Road, Lucknow | Sand | 27.50 meter (3.0 meter) | Cloth | 90.12.09 | Postmonsoon [experimental] |
| 110. | AS 110/ G /Soil/ IITR Ghaila, Hardoi Road, Lucknow | Sand | 30.50 meter (3.0 meter) | Cloth | 09.12.09 | Postmonsoon [Experimental] |

6.2 List of Water Samples

| Sample Code | IITR Code No. | Depth | Sample Container | Date of Sampling | Remarks, if any |
|---|--|----------------|------------------|------------------|----------------------------------|
| Pre-monsoon Experimental Water Samples (collected from MSW dumpsite) | | | | | |
| Point I, Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow (6:30 am— 7:45 am) | | | | | |
| 1. | AS 01/D/Water/ IITR Dudauli, Sitapur Road, Lucknow | 36.50 meter | Glass Bottle | 17.04.09 | Premonsoon [Experiment all |
| 2. | AS 02/D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 36.50 meter | Glass Bottle | 17.04.09 | Premonsoon [Experiment all |
| 3. | AS 03/D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 36.50 meter | Glass Bottle | 17.04.09 | Premonsoon [Experiment al] |
| Point II, Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow (3:00 pm-4:45pm) | | | | | |
| 4. | AS 04/D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 33.50 meter | Glass Bottle | 15.04.09 | Premonsoon [Experiment al] |
| 5. | AS 05/D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 33.50 meter | Glass Bottle | 15.04.09 | Premonsoon [Experiment al] |
| 6. | AS 06/D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 33.50 meter | Glass Bottle | 15.04.09 | Premonsoon [Experiment al] |
| Point III, Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow (11:00am-1:45pm) | | | | | |
| 7. | AS 07/D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 36.50 meter | Glass Bottle | 15.04.09 | Premonsoon [Experiment all |

| | | | | | |
|--|--|----------------|-----------------|----------|----------------------------------|
| 8. | AS 08/D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 36.50 meter | Glass Bottle | 15.04.09 | Premonsoon [Experiment al] |
| 9. | AS 09/D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 36.50 meter | Glass Bottle | 15.04.09 | Premonsoon [Experiment al] |
| Point IV, Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow (8:30 am- 10: 15 am) | | | | | |
| 10. | AS 10/D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 33.50 meter | Glass Bottle | 17.04.09 | Premonsoon [Experiment al] |
| 11. | AS 11/D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 33.50 meter | Glass Bottle | 17.04.09 | Premonsoon [Experiment al] |
| 12. | AS 12/D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 33.50 meter | Glass Bottle | 17.04.09 | Premonsoon [Experiment al] |

| Sample Code | IITR Code No. | Depth | Sample Container | Date of Sampling | Remarks, if any |
|---|--|----------------|-------------------------|-------------------------|----------------------------------|
| Point V, Municipal Solid Waste Dumpsite, Ghaila Hardoi Road, Lucknow (10:30 am—3: 30 pm) | | | | | |
| 13. | AS 13/GNWater/ IITR Ghaila, Hardoi Road, Lucknow | 30.85 meter | Glass Bottle | 04.05.09 | Premonsoon [Experiment al] |
| 14. | AS 14/G/ Water / IITR Ghaila, Hardoi Road, Lucknow | 30.85 meter | Glass Bottle | 04.05.09 | Premonsoon [Experiment al] |
| 15. | AS 15/G/ Water / IITR Ghaila, Hardoi Road, Lucknow | 30.85 meter | Glass Bottle | 04.05.09 | Premonsoon [Experiment al] |

| Point VI, Municipal Solid Waste Dumpsite, Ghaila, Hardoi Road, Lucknow (8:00am-11:45am) | | | | | |
|---|--|-----------------|------------------|------------------|-----------------------------|
| 16. | AS 16/G/ Water / IITR Ghaila, Hardoi Road, Lucknow | 30.85 meter | Glass Bottle | 06.05.09 | Premonsoon [Experimental] |
| 17. | AS 17/G/ Water / IITR Ghaila, Hardoi Road, Lucknow | 30.85 meter | Glass Bottle | 06.05.09 | Premonsoon [Experimental] |
| 18. | AS 18/G/ Water / IITR Ghaila, Hardoi Road, Lucknow | 30.85 meter | Glass Bottle | 06.05.09 | Premonsoon [Experimental] |
| Pre-monsoon Control Water Samples | | | | | |
| 19. | AS 19/C/Water/ IITR HP Water, Dudauli, Sitapur Road, Lucknow | Hand Pump | Glass Bottle | 04.05.09 | Pre- monsoon [Control] |
| 20. | AS 20/C/ Water / IITR Ghaila, Hardoi Road, Lucknow | Hand Pump | Glass Bottle | 07.08.08 | Premonsoon [Control] |
| 21. | AS 21/C/ Water / IITR IITR, Main Campus, Lucknow | Tap Water | Glass Bottle | 10.01.09 | Premonsoon [Control] |
| 22. | AS 22/C/ Ghaila Tube well water,, Hardoi Road, Lko | Tube well water | Glass Bottle | 04.05.09 | Pre- monsoon [Control] |
| 23. | AS 23/C/ Water / IITR Ghaila Pond water,, Hardoi Road, Lko | Pond Water | Glass Bottle | 05.05.09 | Premonsoon [Control] |
| 24. | AS 24/C/ Water / IITR Dudauli Tube well water, Sitapur Road, Lko | Tube well water | Glass Bottle | 21.04.09 | Premonsoon [Control] |
| Sample Code | IITR Code No. | Depth | Sample Container | Date of Sampling | Remarks, if any |
| Post-monsoon Experimental Water Samples (collected from MSW dumpsite) | | | | | |
| Point I, Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow (6:30 am— 7:45 am) | | | | | |
| 25. | AS 25/D/Water/ IITR Dudauli, Sitapur Road, Lucknow | 36.50 meter | Glass Bottle | 30.10.09 | Post-monsoon [Experimental] |
| 26. | AS 26/D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 36.50 meter | Glass Bottle | 30.10.09 | Post-monsoon [Experimental] |
| 27. | AS 27/D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 36.50 meter | Glass Bottle | 30.10.09 | Post-monsoon [Experimental] |

Point II Municipal Solid Waste Dumpsite Dudauli, Sitapur Road, Lucknow (3:00 pm— 4: 45 pm)

| | | | | | |
|-----|--|-------------|--------------|----------|-----------------------------|
| 28. | AS 28D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 33.50 meter | Glass Bottle | 30.10.09 | Post-monsoon [Experimental] |
| 29. | AS 29/D/ Water / IITR Dudauli, Sitapur Road, Lucknow | 33.50 meter | Glass Bottle | 30.10.09 | Post-monsoon [Experimental] |
| 30. | AS 30/D/ Water! I ITR Dudauli, Sitapur Road, Lucknow | 33.50 meter | Glass Bottle | 30.10.09 | Post-monsoon [Experimental] |

Point III, Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow (11:00 am— 1: 45 pm)

| | | | | | |
|-----|---|-------------|--------------|----------|-----------------------------|
| 31. | AS 31/D/ Water / I ITR Dudauli, Sitapur Road, Lucknow | 36.50 meter | Glass Bottle | 30.10.09 | Post-monsoon [Experimental] |
| 32. | AS 32/D/ Water! I ITR Dudauli, Sitapur Road, Lucknow | 36.50 meter | Glass Bottle | 30.10.09 | Post-monsoon [Experimental] |
| 33. | AS 33/D/ Water / I ITR Dudauli, Sitapur Road, Lucknow | 36.50 meter | Glass Bottle | 30.10.09 | Post-monsoon [Experimental] |

Point IV, Municipal Solid Waste Dumpsite, Dudauli, Sitapur Road, Lucknow (8:30 am— 10: 15 am)

| | | | | | |
|-----|---|-------------|--------------|----------|-----------------------------|
| 34. | AS 34D/ Water! IITR Dudauli, Sitapur Road, Lucknow | 33.50 meter | Glass Bottle | 30.10.09 | Post-monsoon [Experimental] |
| 35. | AS 35/D/ Water / I ITR Dudauli, Sitapur Road, Lucknow | 33.50 meter | Glass Bottle | 30.10.09 | Post-monsoon [Experimental] |
| 36. | AS 36/D/ Water! I ITR Dudauli, Sitapur Road, Lucknow | 33.50 meter | Glass Bottle | 30.10.09 | Post-monsoon [Experimental] |

| Sample Code | IITR Code No. | Depth | Sample Container | Date of Sampling | Remarks, if any |
|-------------|---------------|-------|------------------|------------------|-----------------|
|-------------|---------------|-------|------------------|------------------|-----------------|

Point V Municipal Solid Waste Dumpsite Ghaila, Hardoi Road, Lucknow (10:30 am— 3: 30 pm)

| | | | | | |
|-----|--|--------------|--------------|----------|-----------------------------|
| 37. | AS 37/G/VVater/ IITR Ghaila, Hardoi Road, Lucknow | 30.85 meter | Glass Bottle | 10.12.09 | Post-monsoon [Experimental] |
| 38. | AS 38/G/ Water / IITR Ghaila, Hardoi Road, Lucknow | 30. 85 meter | Glass Bottle | 10.12.09 | Post-monsoon [ExRerimental] |

| | | | | | |
|--|--|-----------------------|-----------------|----------|--------------------------------|
| 39. | AS 39/G/ Water / IITR Ghaila, Hardoi Road, Lucknow | 30.85 meter | Glass Bottle | 10.12.09 | Post-monsoon [Experimental] |
| Point VI, Municipal Solid Waste Dumpsite, Ghaila, Hardoi Road, Lucknow (9:00am-10:45am) | | | | | |
| 40. | AS 40/G/ Water / I ITR Ghaila, Hardoi Road, Lucknow | 30.85 meter | Glass Bottle | 10.12.09 | Post-monsoon [Experimental] |
| 41. | AS 41/G/ Water / IITR Ghaila, Hardoi Road, Lucknow | 30.85 meter | Glass Bottle | 10.12.09 | Post-monsoon [Experimental] |
| 42. | AS 42/G/ Water / IITR Ghaila, Hardoi Road, Lucknow | 30.85 meter | Glass Bottle | 10.12.09 | Post-monsoon [Experimental] |
| Post-monsoon Control Water Samples | | | | | |
| 43. | AS 43/C/ VWater/ IITR HP Water, Dudauli, Sitapur Road, Lucknow | Hand Pump | Glass Bottle | 30.10.09 | Post-monsoon [Control] |
| 44. | AS 44/C/ Water / I ITR Ghaila, Hardoi Road, Lucknow | Hand Pump | Glass Bottle | 30.10.09 | Post-monsoon [Control] |
| 45. | AS 45/C/ Water / I ITR IITR, Main Campus, Lucknow | Tap Water | Glass Bottle | 30.10.09 | Post-monsoon [Control] |
| 46. | AS 46/C/ Ghaila Tube well water, Hardoi Road, Lko | Tube well water | Glass Bottle | 30.10.09 | Post-monsoon [Control] |
| 47. | AS 47/C/ Water / I ITR Ghaila Pond water,, Hardoi Road, Lko | Pond Water | Glass Bottle | 30.10.09 | Post-monsoon [Control] |
| 48. | AS 48/C/ Water / I ITR Dudauli Tube well water, Sitapur Road, Lko | Tube well water | Glass Bottle | 30.10.09 | Post-monsoon [Control] |

7. Analysis of soil & water samples:

7.1 Physio-chemical Parameters of Soil;

(Soil pH is a measurement of the soil acidity ($\text{pH} < 7$) or soil alkalinity ($\text{pH} > 7$). Soil solutions were extracted from the dumpsite as well as control soil by **lysimetric method** for determination of pH. The data obtained are presented in Figure 1. Observations revealed that **the pH of dumpsite soil samples** collected in **post monsoon season was comparatively more basic than the pre monsoon** sample. The similar trend was also observed in control soil samples. All the samples have $\text{pH} > 7$ indicating occurrence of alkaline soil. It may be due to poor soil texture of sampling point 1-4, and upper soil portion of sampling point 5-6 which have thick hard calcareous (kankar) layers of low infiltration capacity in their soil profile. Such soil becomes alkaline due to presence of carbonates and bicarbonates of calcium, magnesium, sodium, and potassium held by soil colloids. During post-monsoon season, high rainfall occurred at both sampling location at **dumped waste containing high plastic contents** as well as **hard soil profile of low infiltration capacity caused water logging** at Ghaila dumpsite area. The irrigated water contained lime which might precipitated in the upper regions of dumpsite area nearest the water delivery inlets and in the water flow path. Due to prolonged water logging it has resulted into higher alkalinity of soil and pH levels rising to 7.0 and above until equilibrium is reached with atmospheric carbon dioxide levels. Such increase in soil pH occurs more rapidly on coarse and medium-textured soils than on clays which are more highly buffered. Higher pH values of soil may be due to above factors at Dudauli dumpsite and Locations 5 and 6 of Ghaila dumpsite area.

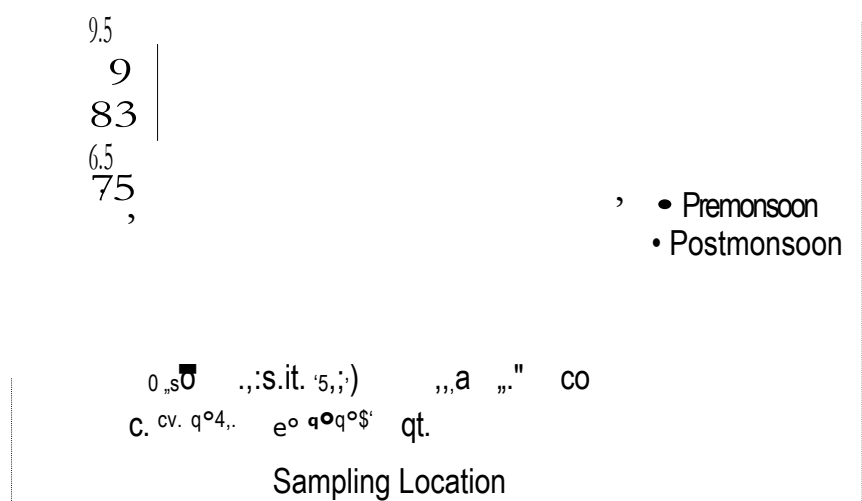


Fig. 1: Mean pH of collected soil samples of each sampling location in different monsoon seasons

7.2 Chemical Property of Soil Samples

Assessment of soil quality with respect to its chemical composition was also done by evaluating essential mineral level viz, available phosphorous as phosphate (in kg/ha), available potassium (in kg/ha), available nitrogen (in kg/ha) and chloride level (mg/kg). The data obtained are presented in **figure 2-5** revealed that control and dumpsite soil samples collected after rainfall (post monsoon samples) were comparatively found to be more enriched with essential minerals/ions. Availability of phosphorous and potassium was found to be higher in control soil samples than dumpsite samples indicating the depletion of nutritional quality of dumpsite soil due to dumping of municipal solid waste. However, higher concentration of nitrogen and chloride ion was found throughout the soil profile of dumpsite area. The probable reason may be decomposition of landfilled/dumped waste under environmental conditions leading to formation of different characteristic chemical moieties viz, nitrogen, methane, chloride, phosphate etc. Such species were prominently found in higher concentration at Dudauli Municipal Solid Waste dumpsite area in comparison to Ghaila Municipal Solid Waste dumpsite because of high load of dumped waste in larger area at Dudauli dumpsite. It is worth to mention that significant amount of analytes were found throughout different soil layers and levels were comparatively higher in post monsoon season, specially in case of Ghaila dumpsite samples, indicating constant percolation of such analytes in the soil profile.

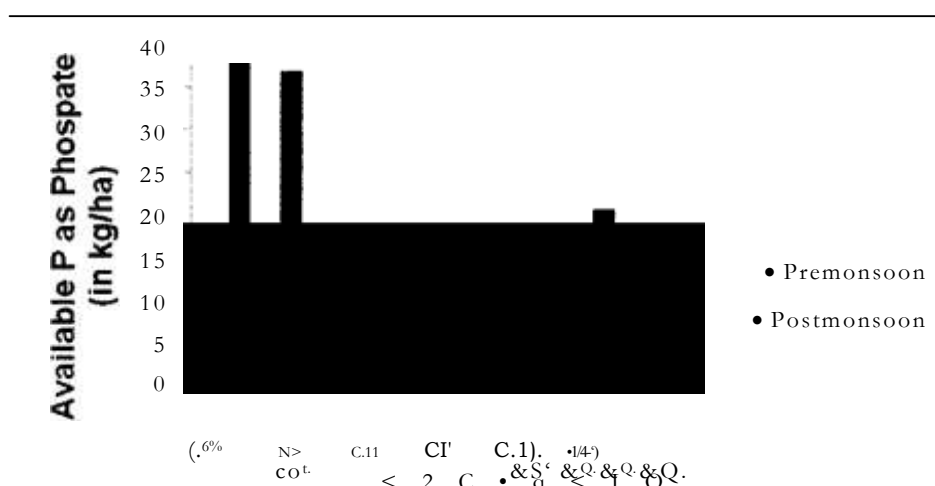


Fig 2: Mean Concentration of Available Phosphorous (P) as Phosphate in Collected Soil Samples of each Sampling location in different Monsoon Seasons

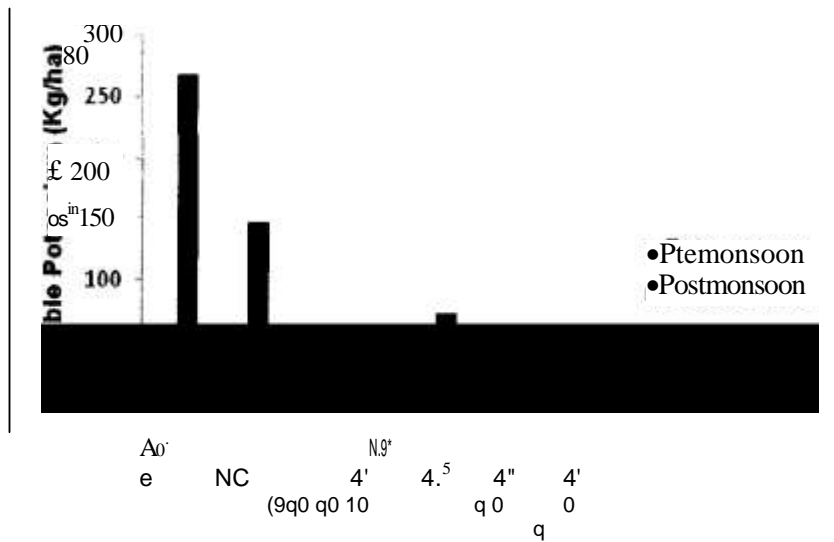


Fig 3: Mean concentration of available potassium in collected soil samples of each sampling location in different monsoon seasons

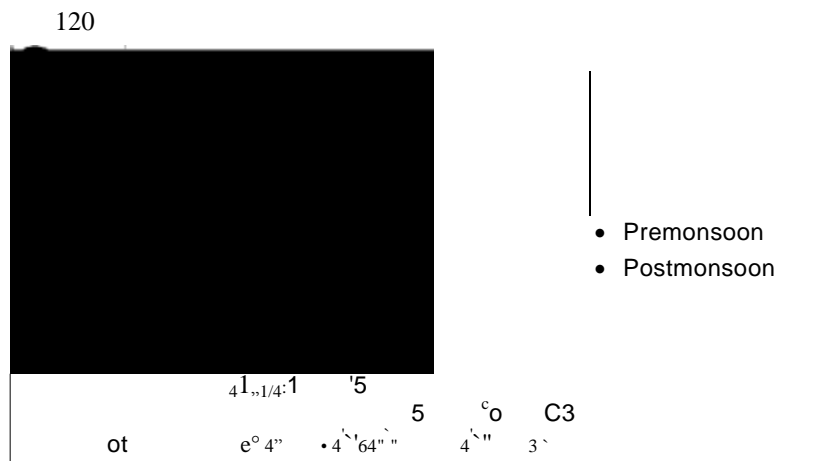


Fig 4: Mean values of available nitrogen in collected soil samples of each sampling location in different monsoon seasons

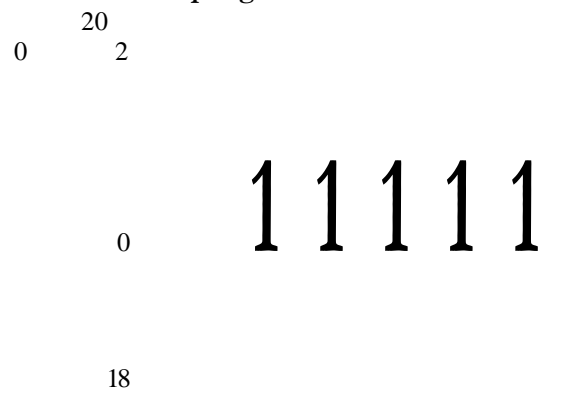


Fig 5: Samples of each sampling location in different monsoon seasons

7.3 Heavy Metals and Organic Contaminants in Soil Samples:

Heavy metals viz Cd,Co,Cr, Cu, Pb, Mo, Ti and Zn were analyzed in all control soil (22 nos.) samples (14 pre monsoon + 08 post monsoon) and experimental/dumpsite soil (88 nos.) samples (66 pre-monsoon + 22 Post monsoon). In addition level of phthalates viz. Di-methyl phthalate (DMP), Diethylphthalate (DEP), Di-butyl phthalate (DBP), Di (2-ethylhexyl) phthalate (DEHP) and Di-octyl phthalate (DOP) were also determined in leachates (TCLP) of soil samples. Data revealed that Ghaila Landfill site having coarse or sandy texture of soil have greater contamination of inorganic and organic moieties throughout soil profile and in deep aquifers because rain water leachates containing pool of contaminants may easily percolate through)On the other hand, impact of pollutants appeared more on upper strata soil and side streams at Dudauli waste dumpsite having clay, gravels or rocky soil texture. In addition, seasonal fluctuations also dominates on the quality and quantity of landfill leachate produced. During the wet season period (post monsoon), low-strength leachate may suppose to generate, while during the dry season period (pre monsoon), reduced percolation and enhanced evaporation increase the leachate strength.

Soils have property to bind various chemicals and it depends on the form in which they exist in the environment. It consists of mineral particles, organic matter and organic-mineral particles. They play important role in giving the soil's ability to absorb exchange, oxidize, reduce, catalyze and precipitate chemical and metal ions in particular. The inorganic colloidal fraction of soil is the most responsible for absorption by its mineral particles. Its large surface area and porosity makes it good absorber of organic and inorganic materials. Organic and inorganic moieties physically adsorb on soil surface instead of being chemically absorb. Due to variation in pH, temperature, weathering or flow of water from refusal tips such contaminants may migrate and percolates into lower soil strata or underground water profile. The period of waste dumping was also found to be an important parameter to characterize the leachate and to predict the environmental implications of waste dumping. Age of the landfill corresponding to stabilization stage has a significant effect on characteristic composition of leachate, as found at Dudauli dumpsite where dumping is continued since last five years and Ghaila dumpsite which is active since last three years. The observed value revealed that the quantity of leachate produced may be regarded as proportional to the volume of water percolating through the landfilled waste. Reduction of the quantity of water entering the tip is of great importance in reducing the rate of leachate generation. Leachate production has been found to be higher when the disposed refuse is less compacted since compaction was found to reduce the filtration rate.

7.3 Heavy Metals in Water Samples :

Heavy metals viz. Cd, Co, Cr, Cu, Pb, Mo, Ti and Zn were analyzed in all control water (12 nos.) samples (06 pre monsoon + 06 post monsoon) and experimental/dumpsite water (36 nos.) samples (18 pre monsoon + 18 post monsoon). The analytical data as presented in **table 5** revealed that Cd, Co and Ti were found below detection limit (BDL) in all 48 samples. However, Cu and Zn are present in significant concentration in all samples. Further, levels of Pb, Mo and Cr were found in traces and the concentration above permissible limit was found only in few samples of first strata water. There was no significant difference in level of heavy metals in pre-monsoon and post-monsoon water samples as seen in case of soil samples. This may be due to dilution factor because of rainfall. However, presence of heavy metals in traces in first strata in the underground water of d psite area, may occur due to percolation of such heavy metals from dumping of municipal solid waste including plastic waste. The effect of percolation was more at Ghaila dumpsite area having sandy soil texture than Dudauli dumpsite area with hard clay and gravels in soil profile. The concentration of Heavy Metals is mentioned at **Table-5**.

Table- 5: Concentration of Heavy Metals in Water Samples

| CADMIUM (Cd) | Pre-monsoon Samples | Post-monsoon Samples | COBALT (Co) | Pre-monsoon Samples | Post-monsoon Samples |
|----------------------|----------------------------|-----------------------------|----------------------|----------------------------|-----------------------------|
| Concentration (mg/l) | Control | Control | Concentration (mg/l) | Control | Control |
| Total | 0 | 0 | Total | 0 | 0 |
| Average | 0 | 0 | Average | 0 | 0 |
| Standard Deviation | 0 | 0 | Standard Deviation | 0 | 0 |
| Maximum value | 0 | 0 | Maximum value | 0 | 0 |
| Minimum value | 0 | 0 | Minimum value | 0 | 0 |
| | Experimental | Experimental | | Experimental | Experimental |
| Total | 0 | 0 | Total | 0 | 0 |
| Average | 0 | 0 | Average | 0 | 0 |
| Standard Deviation | - | - | Standard Deviation | - | - |
| Maximum value | - | - | Maximum value | - | - |
| Minimum value | - | - | Minimum value | - | - |

| CHROMIUM (Cr) | Pre-monsoon Samples | Post-monsoon Samples |
|----------------------|----------------------------|-----------------------------|
| Concentration (mg/l) | Control | Control |
| Total | 0 | 0 |
| Average | 0 | 0 |
| Standard Deviation | 0 | 0 |
| Maximum value | 0 | |
| Minimum value | 0 | 0 |
| | Experimental | Experimental |
| Total | 1.108 | 0.080 |
| Average | 0.061 | 0.004 |
| Standard Deviation | 0.058 | 0.018 |
| Maximum value | 0.196 | 0.080 |
| Minimum value | 0 | |

| COPPER (Cu) | Pre-monsoon Samples | Post-monsoon Samples |
|----------------------|----------------------------|-----------------------------|
| Concentration (mg/l) | Control | Control |
| Total | 0.509 | 1.465 |
| Average | 0.084 | 0.244 |
| Standard Deviation | 0.085 | 0.324 |
| Maximum value | 0.213 | 0.900 |
| Minimum value | 0 | 0 |
| | Experimental | Experimental |
| Total | 0.857 | 1.129 |
| Average | 0.047 | 0.062 |
| Standard Deviation | 0.100 | 0.049 |
| Maximum value | 0.420 | 0.180 |
| Minimum value | 0 | 0 |

| LEAD (Pb) | Pre-monsoon Samples | Post-monsoon Samples |
|----------------------|----------------------------|-----------------------------|
| Concentration (mg/l) | Control | Control |
| Total | 0 | 0 |
| Average | 0 | 0 |
| Standard Deviation | 0 | 0 |
| Maximum value | 0 | 0 |
| Minimum value | 0 | 0 |
| | Experimental | Experimental |
| Total | 0.040 | 0 |
| Average | 0.002 | 0 |
| Standard Deviation | 0.022 | 0 |
| Maximum value | 0 | 0 |
| Minimum value | 0.040 | 0 |

| MOLYBDENUM (Mo) | Pre-monsoon Samples | Post-monsoon Samples |
|------------------------|----------------------------|-----------------------------|
| Concentration (mg/l) | Control | Control |
| Total | 0 | 0 |
| Average | 0 | 0 |
| Standard Deviation | 0 | 0 |
| Maximum value | 0 | 0 |
| Minimum value | 0 | 0 |
| | Experimental | Experimental |
| Total | | |
| Average | 0.105444 | 0 |
| Standard Deviation | 0.160629 | 0 |
| Maximum value | 0.417 | 0 |
| Minimum value | 0 | 0 |

| Titanium (Ti) | Pre-monsoon Samples | Post-monsoon Samples |
|----------------------|---------------------|----------------------|
| Concentration (mg/l) | Control | Control |
| Total | 0 | 0 |
| Average | 0 | 0 |
| Standard Deviation | 0 | 0 |
| Maximum value | 0 | 0 |
| Minimum value | 0 | 0 |
| | Experimental | Experimental |
| Total | 0 | 0 |
| Average | 0 | 0 |
| Standard Deviation | – | – |
| Maximum value | – | – |
| Minimum value | – | – |

| ZINC (Zn) | Pre-monsoon Samples | Post-monsoon Samples |
|----------------------|---------------------|----------------------|
| Concentration (mg/l) | Control | Control |
| Total | 4.197 | 3.120 |
| Average | 0.699 | 0.624 |
| Standard Deviation | 0.379 | 0.306 |
| Maximum value | 1.066 | 0.820 |
| Minimum value | 0 | 0 |
| | Experimental | Experimental |
| Total | 25.435 | 14.300 |
| Average | 1.413 | 0.841 |
| Standard Deviation | 1.279 | 0.648 |
| Maximum value | 4.410 | 2.500 |
| Minimum value | 0.006 | 0.100 |

7.5 Phthalates in Water Samples

The quality of water collected from dumpsite area was assessed with respect to phthalates. This was conducted to estimate the concentration level of phthalates viz. Di-methyl phthalate (DMP), Di-ethyl phthalate (DEP), Di-butyl phthalate (DBP), Di (2-ethylhexyl) phthalate (DEHP) and Di-octyl phthalate (DOP). The levels of different type of phthalates in the dumpsite water as well as control water samples at selected identified locations are presented in Table 4. During conducting experiment, Limit of Quantification (LOQ) and Limit of Detection (LOD) and recovery were determined by spiked sample method. The data analysed are presented at **Table 6**.

Table - 6

| Compound | Spiked Level in water (Ogil) | Mean Recovery | LOQ (Og/1) | LOD (DWI) |
|----------|------------------------------|---------------|------------|-----------|
| DMP | 10 | 70% | 1.67 | 0.55 |
| DEP | 10 | 90% | 0.28 | 0.09 |
| DBP | 10 | 76% | 0.34 | 0.11 |
| DEHP | 10 | 85% | 0.83 | 0.27 |
| DOP | 10 | 75% | 0.40 | 0.13 |

The processed samples were analyzed using High Performance/Pressure Liquid Chromatography (HPLC). One representative chromatograph of Standard and a sample is presented in **Fig.6**. The five representative samples were analyzed on Gas Chromatography-Mass Spectrophotometer (GC-MS) to get confirmation of the respective chromatographic peaks of phthalates. The identification of the phthalates found in the samples was confirmed on GC-MS by comparing the RT and fragmentation patterns of the compound in the standard and samples.

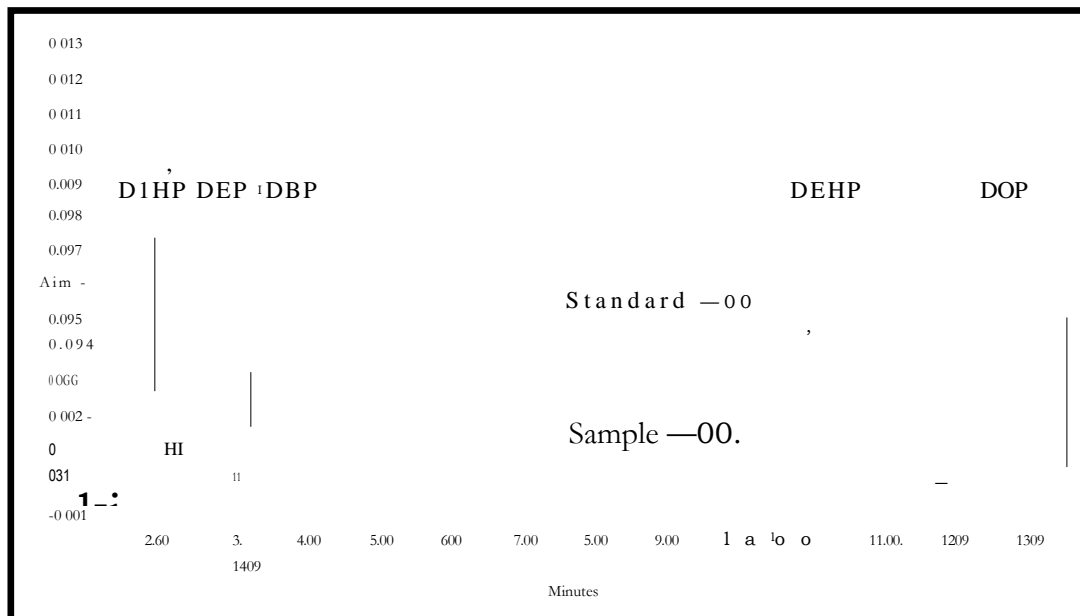
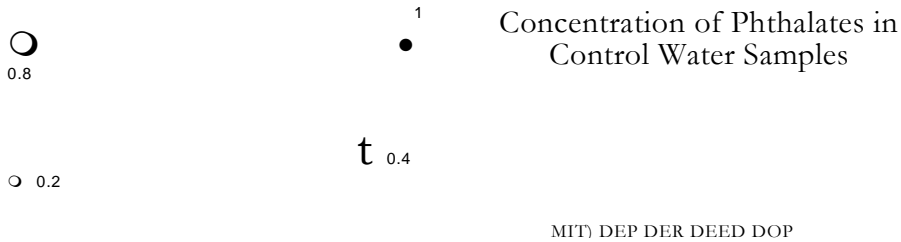


Fig-6: HPLC Chromatograph of representative Phthalate(s)

It is evident from the data of control water samples of all six locations that the values of phthalates are in traces (**Table 7**). In **pre-monsoon control** water samples the mean values of individual phthalates are BDL, 0.958 mg/l, 0.747 mg/l, 1.005 mg/l and 0.462 mg/l for DMP, DEP, DBP, DEHP and DOP, respectively. These values revealed that DEHP were found to be present in 52.0% of the total phthalate concentration, while the DMP was the least detected phthalate. Detected phthalate concentration was found in the order DEHP>DEP>DBP>DOP»DMP, hence, it found in lesser quantity as compared to DEHP, DEP and DBP. **Data obtained from the analysis of post-monsoon control** water samples revealed the occurrence of **phthalates concentration is** comparatively higher than the **pre-monsoon samples (Fig. 7 and Fig. 8)**. Mean values of individual phthalates concentration in post-monsoon control water samples are BDL, 1.033 mg/l, 0.832 mg/l, 1.358 mg/l and 0.517 mg/l for DMP, DEP, DBP, DEHP and DOP, respectively. Detected phthalate level was found to follow the same occurrence trend as pre-monsoon samples: DEHP>DEP>DBP>DOP>>DMP. Out of six control water samples, five samples were collected near (within 200 meters residential area) Dudauli and Ghaila Municipal waste dumpsite area from tube well or hand pump, which was used by local people. The presence of traces of phthalates in water samples of the dumpsite areas indicate the effect of dumping of municipal and plastic waste on the surroundings.

Fig 7: Mean Concentration of Phthalates (mg/l) in Control Water Samples



| Control Water Samples | Mean Concentrat'on (\pm SD) of Phthalates (mg/l) | | | | |
|-----------------------|---|---------------------|---------------------|---------------------|---------------------|
| | DMP | DEP | DBP | DEHP | DOP |
| Pre-monsoon | BDL | 0.958 \pm 2.76 | 0.747 \pm 2.12 | 1.005 \pm 2.46 | 0.462 \pm 1.35 |
| Post-monsoon | BDL | 1.033 \pm 2.95 | 0.832 \pm 2.37 | 1.358 \pm 3.45 | 0.517 \pm 1.51 |

Table 7: Concentration of Phthalates in Experimental Water Samples

| Sampling Location | Season | Mean Concentration (\pm SD) of Phthalates (in mg/l) | | | | |
|-------------------|--------------|--|-----------------------|----------------------|----------------------|----------------------|
| | | DMP | DEP | DBP | DEHP | DOP |
| Point 1 | Pre-monsoon | 0.014 \pm 0.005 | 0.073 \pm 0.014 | 0.003 \pm 0.005 | 0.003 \pm 0.002 | 0.002 \pm 0.002 |
| | Post-monsoon | 0.036 \pm 0.012 | 0.081 \pm 0.010 | 0.017 \pm 0.029 | 0.012 \pm 0.013 | BDL |
| Point 2 | Pre-monsoon | 0.009 \pm 0.001 | 0.105 \pm 0.013 | 0.009 \pm 0.005 | 0.009 \pm 0.001 | BDL |
| | Post-monsoon | 0.021 \pm 0.010 | 0.131 \pm 0.013 | 0.030 \pm 0.010 | 0.053 \pm 0.033 | BDL |
| Point 3 | Pre-monsoon | 0.027 \pm 0.006 | 0.084 \pm 0.012 | 0.011 \pm 0.004 | 0.011 \pm 0.004 | 0.003 \pm 0.003 |
| | Post-monsoon | 0.038 \pm 0.007 | 0.121 \pm 0.024 | 0.038 \pm 0.005 | 0.007 \pm 0.005 | BDL |
| Point 4 | Pre-monsoon | 0.016 \pm 0.006 | 0.058 \pm 0.053 | 0.006 \pm 0.002 | 0.009 \pm 0.001 | BDL |
| | Post-monsoon | 0.034 \pm 0.008 | 0.076 \pm 0.064 | BDL | 0.031 \pm 0.010 | BDL |
| Point 5 | Pre-monsoon | 0.041 \pm 0.006 | 0.085 \pm 0.015 | 0.040 \pm 0.005 | 0.069 \pm 0.019 | 0.003 \pm 0.005 |
| | Post-monsoon | 0.017 \pm 0.028 | 0.036 \pm 0.063 | BDL | 0.038 \pm 0.040 | BDL |
| Point 6 | Pre-monsoon | 0.050 \pm 0.005 | 0.0683 \pm 0.010 | 0.038 \pm 0.008 | 0.067 \pm 0.007 | 0.006 \pm 0.010 |
| | Post-monsoon | 0.045 \pm 0.039 | 0.079 \pm 0.071 | 0.037 \pm 0.032 | 0.121 \pm 0.022 | BDL |

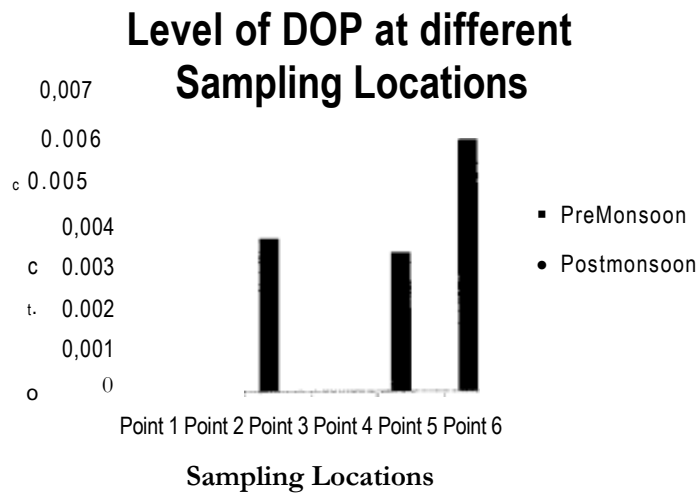
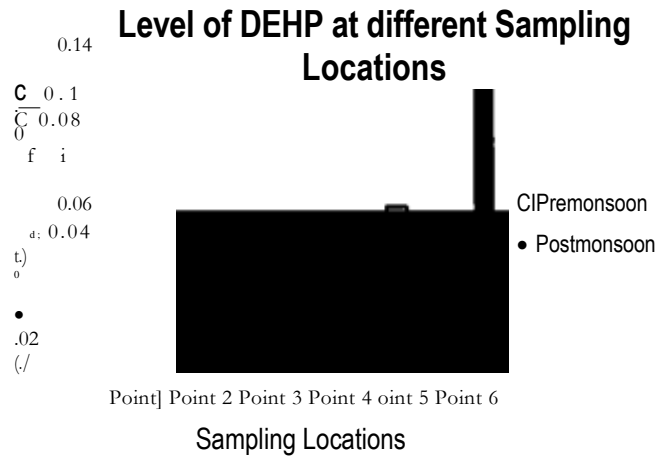
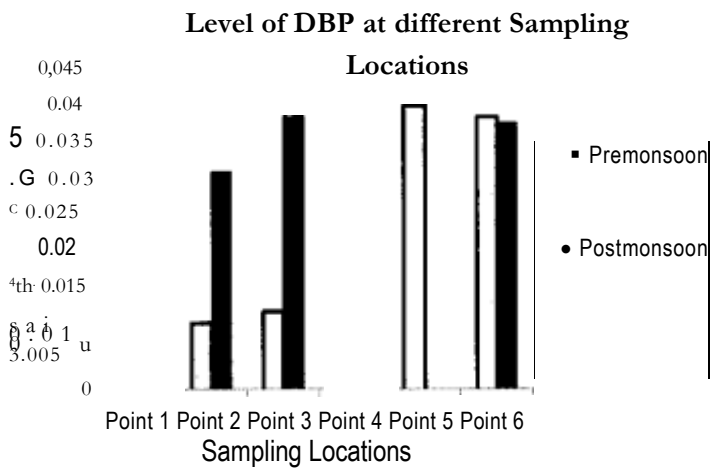
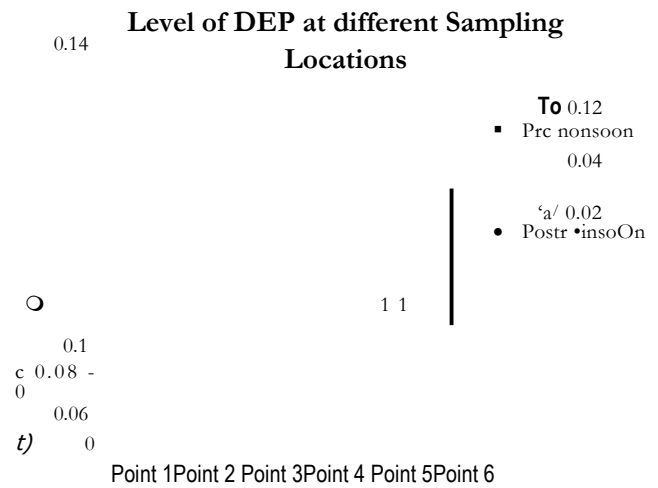
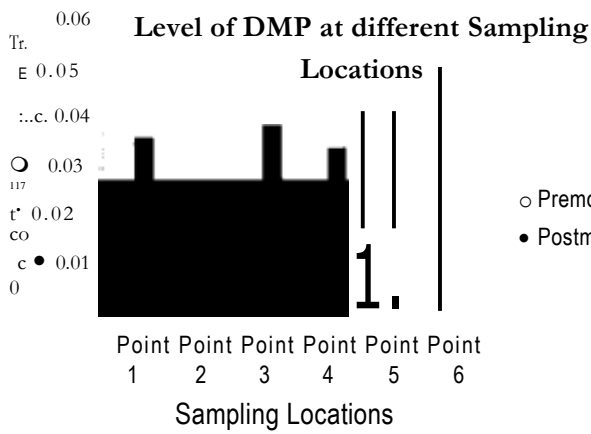


Fig 8: Mean Concentration of Phthalates (mg/l) in Experimental Water Samples

Conclusion:

- Characterization of dumpsite samples could be a yard-stick for the measurement of extent of pollution in surrounding environment. The biotic and abiotic transformation processes of different wastes give rise to pools of organic and inorganic compounds in the gaseous and liquid phases. During landfill operation, leachates are produced, mainly due to the infiltration of rainwater through the refuse tips. Such compounds may percolate through soil and contaminate groundwater basins in the drainage area of the landfill.
- The period of waste dumping (age of landfill site), geological and seasonal factors are important parameters to characterize the leachate and predict the environmental implications of waste dumping.
- The pH of dumpsite soil samples collected in post-monsoon season was found to be comparatively more basic than the pre-monsoon samples. Accumulated dumped waste containing high plastic contents as well as hard soil profile of low infiltration capacity caused water logging. This irrigated water contained much of the lime which might precipitate in the upper regions of dumpsite area and resulted into increase in the alkalinity of the soil.
- Availability of phosphorous and potassium was found to be higher in control soil samples than dumpsite samples indicating the depletion of nutritional quality of dumpsite soil due to dumping and degradation of plastics waste for more than 10 years.
- Decomposition of landfilled/dumped waste under environmental conditions caused higher concentration of nitrogen and chloride ions throughout the soil profile of dumpsite area.
- Presence of heavy metals and phthalates in first strata of underground water of dumpsite area is due to migration and percolation of dumping of municipal and plastic waste.
- Data obtained from Toxicity Characteristic Leaching Procedure (TCLP) of dumpsite samples also contained significant amount of analytes indicating migration of chemical moieties from plastic waste.

Recommendation:

It has been observed that dumping of plastic waste may deteriorates soil and underground water quality due to leaching of additives, colours, stabilizes and fillers present in the different categories of plastic products. It is therefore recommended that plastic dumping should not be allowed to preserve the soil and water quality vis-as-vis Environment.