# IMPACT ASSESSMENT ON SOIL DUE TO BHALSWA LANDFILL

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

MASTER OF TECHNOLOGY

IN

**GEOTECHNICAL ENGINEERING**


Submitted by:

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# CANDIDATE'S DECLARATION

I, Chirag 2K21/GTE/25 student of M. Tech (Geotechnical Engineering) hereby declare that the project Dissertation titled "Impact Assessment on Soil due to Bhalswa Landfill" which is submitted by me to the Department of Civil Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship, or other similar title or recognition.

Place: Delhi

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## CERTIFICATE

I hereby certify that the Project Dissertation titled "Impact Assessment on Soil due to Bhalswa Landfill" which is submitted by Chirag 2K21/GTE/25 Civil Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the student under my supervision. To the best of my knowledge, this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: Delhi

Date:

**ASHOK KUMAR GUPTA**

**(SUPERVISOR)**

# ABSTRACT

The disposal of waste from anthropogenic activity has been done by landfilling for centuries. This technique of waste disposal provides an efficient and cost-effective methodology of the urban waste elimination. However, this technique suffers from many imperfections such as odour, biogas, and especially leachate. Field studies carried out by researchers proved that solid waste leachates may migrate to superficial water, even in landfills with geotextile protection at the base. These contaminants can percolate to greater depths. Consequently, it is necessary to control compacted soil layers to prevent the advance of contamination front as well as the effect of leachate to soils that are exposed to pollutants. In this study a physiochemical analysis is done of soil samples around Bhalswa Landfill near Rohini (Delhi), which is based on parameters like pH, total dissolved solids (TDS), alkalinity, chloride content, total hardness, calcium, magnesium content of soil in liquid form and other parameters from centrifuged sample of soil to find content of sulphate, nitrate and phosphate. At present 10 soil samples are collected between Bhalswa Landfill and Delhi Technological University. Some samples collected had pH of 8.0-8.2 which shows that soil is alkaline. The results obtained are compared with the virgin soil samples in DTU area so as to understand the horizontal variation of physiochemical parameters of soil and comparison with the standard range of chemical contents in soil.

Keywords: Bhalswa Landfill, virgin soil, leachate, Soil contamination, comparison

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| | |
|---|---|
| MSW | Municipal Solid Waste |
| Pb | Lead |
| Zn | Zinc |
| Cd | Cadmium |
| EC | Electronic Conductivity |
| N | Nitrogen |
| $PO_4$ | Phosphate |
| $SO_4$ | Sulphate |
| $NO_3$ | Nitrate |
| Cr | Chromium |
| OC | Organic Carbon |
| Meq | Milliequivalent |
| WHC | Water Holding Capacity |
| P | Phosphorous |
| K | Potassium |
| Na | Sodium |
| MDD | Maximum Dry Density |
| mm | millimeters |
| m | meters |
| km | kilometer |
| ml | milliliters |
| mg/l | milligram per liter |
| µS/cm | micro-Siemens per centimetre |

# CHAPTER 1 INTRODUCTION

## 1.1 GENERAL

The disposal of waste and creation of huge dump mountains is clearly visible in Delhi which are being neglected for too long there are several studies related to environmental and surrounding aspects but what is happening underneath is where it is affecting soil and groundwater in higher extent which needs to be researched upon. The purpose of the study was to assess the impact of MSW landfills on the nearby geological soil, focusing on leachate and other harmful substances. Through a thorough analysis of literature, experimental data, and field investigations, it was determined that landfill leachate emerged as the primary factor influencing the surrounding geological environment.

With total population of Delhi in 2023 is around 3.2 crore which is approx. 11500 per $km^2$ most of the districts generate thousands of tons of municipal solid wastes. The proper management of large volumes of waste has become an urgent and challenging environmental issue. Insufficient resources such as funding, appropriate planning, and civil infrastructure in relation to the rapid growth in service demand have had a detrimental impact on the environment and human health.

In the modern world, population growth and industrialisation lead to an increase in the production of effluents. Specifically, the discharge of untreated or insufficiently treated effluents from synthetic operations like dyeing and tanneries contaminates soil constituents. Continuously accumulating untreated effluents on the ground surface modify the inherent geotechnical qualities of the soil, which hinders construction activities. As a result, the local soil's shear strength properties undergo considerable modifications. Small-scale manufacturing businesses frequently disregard accepted standards for wastewater discharge in many developing nations. These industries let their toxic effluent into streams and open areas without sufficient treatment due to financial considerations.

Furthermore, whenever water comes into contact with solid waste, landfill leachate continues to be produced. Dissolved organic matter, inorganic compounds (such as ammonium, calcium, magnesium, sodium, potassium, iron, sulphates, and chlorides), heavy metals (such as cadmium, chromium, copper, lead, zinc, and nickel), and organic substances are the four main categories of contaminants found in landfill leachate. According to Kjeldsen et al. (2003), the discharge of these toxins poses substantial environmental risks to the nearby soil, groundwater, and even surface water. Based on the make-up of the solid waste and the concurrent physical, chemical, and biological activity occurring inside the landfill, the pollutants carried in the leachate are determined.

While landfills are generally considered a safe waste disposal method, this is true only for engineered landfills equipped with liners made of absorbent materials and plastic sheets to prevent leachate leakage into groundwater and soil. Properly designed and maintained landfills are rarely found in emerging economies like India.

However, due to a lack of funding, research, planning, and appropriate technology, there is still a considerable gap between policy and implementation. Delhi's MSW dumps and landfills have experienced a number of catastrophic failures. In addition, although there is a paucity of information, it is thought that landfill leachate and gas have negative effects on the neighbouring metropolitan settings. A significant factor in global warming and the greenhouse effect is the unchecked discharge of landfill gas (methane and carbon dioxide) from tens of thousands of MSW dumps and landfills in Delhi and other regions of India.

There are mechanical composting plants at Bhalswa Landfill with treatment capacity of 150 tonnes/day but actual need is for 500 tonnes/day although there are times when it runs at pace of 200-250 tonnes/day which is still not adequate by looking at current scenario.

## 1.2 NEED OF STUDY

The types of contaminants that are present in leachate depend on the nature of the solid waste as well as the concurrent physical, chemical, and biological processes taking place inside the landfill. Hazardous metals like Pb, Zn, and Cd participate in biogeochemical cycles, and rather than the elements' overall concentration, their mobility is mostly influenced by their chemical forms. Because of this, heavy metals in leachate may travel outside the confines of the disposal site and constitute a serious threat to the soil and water table nearby the landfill. By examining soil samples obtained from ten different sites, this study intends to evaluate the current status of key soil physicochemical parameters, including soil pH, electrical conductivity (EC), accessible nitrogen (N), phosphorus (P), and sulphate (SO4).

Soil testing plays a crucial role in nutrient management for agricultural productivity enhancement. In recent years, agriculture practices have shifted from conventional and traditional methods to more intensive approaches involving the use of chemical fertilizers, pesticides, and irrigation. The continuous application of chemical fertilizers gradually alters soil properties, ultimately leading to reduced long-term productivity. This has resulted in the leaching of chemicals into surface and groundwater.

The National Research Council in the United States defined soil's multi-functionality from an environmental perspective in 1993. It highlights soil's ability to support plant growth, safeguard watersheds by controlling precipitation infiltration and distribution, and prevent water and air pollution by sponging up potential pollutants like industrial and agricultural chemicals and organic waste. Soil testing serves as a valuable diagnostic tool for evaluating soil quality, with organic matter content and physicochemical parameters determining soil quality, which is in turn influenced by changes in soil conditions.

Given the transportation of contaminants from soil to neighboring media through evaporation, erosion, and infiltration, it is crucial to conduct a comprehensive evaluation and risk analysis of landfill soil. While many researchers worldwide have focused on leachate pollution resulting from landfill sites, the pollution of landfill soil and its toxicological effects have often been overlooked.

Leachate frequently seems to be black or dark greyish in colour and typically has a high organic carbon content, high nitrogen concentrations, and a tendency to be slightly acidic. The rainy season is often when leachate formation is greatest. Municipal solid trash is frequently deposited in an open area in India without being broken down or separated. The engineering qualities of lateritic soil have been studied by a number of researchers, with a focus on its subgrade characteristics and interactions. Leachate frequently modifies the chemical composition of the soil, which can contaminate water and food supplies.

## 1.3 OBJECTIVES OF STUDY

The main idea to carry out this study is to find out how a waste Landfill effects the Soil when we look at environmental aspect of it. There are several studies of soil investigations around landfills but there is a need of similar detailed investigation for all open dump sites in Delhi. Objectives of study are shown below:

- To determine the physiochemical characteristics of Soil between Bhalswa Landfill and Delhi Technological University

- To compare results when moving away from waste site i.e., lateral variation

# CHAPTER 2 LITERATURE REVIEW

- **Karthika et al. (2022)** did study on the contamination of soil components, which is mostly brought on by the buildup of untreated effluents from a variety of synthetic industries, including the production of paper, dyes, yarn, and paint. These industries use external chemicals that contaminate the soil's physical characteristics. In order to reduce dangers related with building activities, it is essential to install an effective treatment system for polluted soil close to industrial zones. The direct discharge of effluents onto the ground surface has a negative impact on the geotechnical qualities, pH, and metal concentrations of the soil. As a result, the soil's strength properties degrade, changing from a better to a worse medium. However, the risk to soil properties for construction might be decreased by improving effluent discharge systems in industrial regions. They took three soil samples from the industrial area and compared their physicochemical characteristics to those of a virgin sample in order to evaluate the geotechnical properties. Added building and demolition waste to the contaminated soil samples as stabilisers. To enhance the performance of the soil, the assessment was carried out utilising various ratios of construction demolition waste, specifically 5%, 10%, and 15%. The assessed results show that using construction and demolition waste at these various ratios significantly improves the strength qualities in soil characterization.

- **Yamile et al. (2022)** discovered that the disposal of municipal solid waste is a significant global concern with environmental, economic, and social implications. The limited availability of land and inadequate leachate management facilities increase the risk of groundwater contamination. Therefore, the objective of this research was to predict variations in geotechnical properties of soil that has been subjected to landfill leachate, using a methodology that simulates the conditions of contaminated soils in a laboratory setting, based on a specific case study. Soil sample was treated to the percolation effect of leachate in the laboratory for a period of 30 days, and the changes in its geotechnical qualities were compared to a soil sample that had been exposed to the effect in the field for more than 15 years. There were changes in the void ratio, organic matter content, cationic interchange capability, particle agglomeration, compressibility, permeability, and shear strength and suction of both soil samples, both before and after exposure to uncontrolled solid waste leachates. The results of this study show that the suggested methodology makes it possible to forecast changes in the geotechnical characteristics of landfill foundation soils that have been damaged by the development of solid waste leachates.

- **Shinde et al. (2021)** Research on the dangers of landfill leachate was done by Shinde et al. in 2021. This toxic liquid has the ability to harm the environment, especially the subsurface soil and groundwater systems. This study's main emphasis was a non-engineered municipal solid waste landfill in Maharashtra's northern region. To assess the potential impacts of leachate percolation on soil and groundwater quality, samples of groundwater were gathered from neighbouring wells and tube wells as well as soil samples taken from the area surrounding the landfill site. As well as being measured, the amounts of heavy metals (Pb, Cd, Cr, Hg, and As) and other physio-chemical characteristics in the groundwater were compared to the Indian Standard for drinking water. Using a hand auger, soil samples were taken at shallow depths of 1 and 2 metres close to the dump site. The presence of heavy metals and the amount of organic matter were then determined. The normal soil samples collected nearby and the contaminated soil near the landfill were compared. The results showed high amounts of organic matter and heavy metals in the soil samples close to the landfill, indicating considerable leachate migration-related soil contamination. The outcomes also showed that the groundwater table, as seen in surrounding wells, was contaminated. This study emphasises the need for more action to address this serious danger to the subsurface environment by highlighting the potential harm that leachate may bring to soil and groundwater properties.

- **Manjunath et al. (2021)** found Leachate is a hazardous liquid that seeps into landfills and extracts toxic compounds as it does so. Large amounts of municipal solid waste, including chemical, industrial, and biomedical waste, are dumped in dump yards, which causes environmental problems such soil and groundwater pollution. The purpose of the study was to use laboratory tests to look at how landfill leachate affected the functionality of subgrade soil. A college campus's uncontaminated soil samples and contaminated soil samples that had been combined with MSW leachate in varying amounts (0%, 5%, 10%, and 20% by weight) were both examined. The results revealed that the leachate content had an effect on various properties of the contaminated soil, including increased Atterberg's limits with higher leachate content. Beyond a 10% leachate level, maximum dry density (MDD) was seen, after which it dropped. The results show that MSW leachate affects the lateritic soil's Atterberg limits, shear strength, and compaction characteristics.

- **Dandwate et al. (2020)** examined the physicochemical characteristics of soil with an emphasis on variables such soil pH, electrical conductivity (EC), organic carbon (OC), accessible nitrogen (N), phosphorus (P), potassium (K), and micronutrients (Fe, Mn, Cu, and Zn). At a depth of 0–20 cm, five representative soil samples were taken, and their alkalinity, pH, electrical conductivity, organic carbon, sodium, and potassium contents were measured. The pH ranged from 7.60 to 8.81, and the results showed that the soils were neutral to slightly alkaline. The organic carbon content varied from 0.52 to 0.72%, whereas the electrical conductivity ranged from 0.50 to 0.73 dSm1. The potassium level varied from 125.31 to 630.15 kg/ha, whereas the sodium content ranged from 0.52 to 0.97 meq%. The available nitrogen was determined to be between 140.01 and 252.68 kg/ha, whereas the available phosphorus was between 15.11 and 54.13 kg/ha. Farmers may find this information useful as it gives them an understanding of the nutrient levels in the soil and aids in deciding how much fertiliser to use to increase crop yield.

- **Deoli et al. (2020)** Conducted research on the significance of soil in plant growth and development. Soil testing, a chemical process, is crucial for assessing the availability of essential nutrients before crop cultivation. This helps determine the remaining nutrient requirements, which can be supplemented through the application of fertilizers. The goal of this study was to evaluate the compatibility of the soil for farming medicinal plant species in the study region by analysing macronutrients (phosphorus, potassium, sulphur) and micronutrients (manganese, iron, copper, and zinc). The results of a physiochemical analysis, which took into account variables including pH, organic carbon, phosphorus, potassium, sulphur, zinc, iron, manganese, and copper, were analysed. In Dehradun's Saheshpur block, a total of 24 soil samples were taken throughout the winter months of November and December. These samples were contrasted with results for typical soil quality. Atomic absorption spectrometer measurements of micronutrients (iron, copper, manganese, and zinc) were made. With a mean pH value of 7.1, the research area's organic carbon content ranged from 0.34% to 0.94%, suggesting its alkaline soil character. Spatial variation was examined using one-way ANOVA, revealing that certain sampling locations exhibited higher variability in soil quality parameters such as sulphur, zinc, and moisture content compared to others. Correlation analysis was conducted among various soil quality parameters, highlighting a strong correlation between manganese and iron, sulfur, zinc, and copper. With the exception of potash, which was found to be below the minimum need (> 140 kg/hectare), all the metrics were within the range allowed by the soil quality guidelines.

- **Koda et al. (2019)** found bentonite vertical barriers can be used as a remedial measure to lessen the environmental risks connected to landfills and waste management facilities. This essay focuses on engineering strategies for cleaning up an old municipal dump in Warsaw's northeast. A groundwater protection system's potential to improve groundwater quality in the research area and its surrounds was given particular consideration. Using information from a 20-year monitoring network, the water quality was assessed. Pollutant indicators including chloride concentration and electrical conductivity are reduced as shown on isoline maps. The outcomes show that the soil-water environment has been significantly improved by the containment system's adoption. The monitoring information provided in this research makes it abundantly evident how well vertical barriers work and how important a role they play in protecting the soil-water environment from contamination.

- **Bouzayani et al. (2014)** researched landfills' generation of leachate and its migration through waste materials cause groundwater and soil pollution. The Jebel Chakir landfill, which is located in Tunis City, Tunisia, was the subject of this study's assessment of the extent of soil pollution. The Jebel Chakir landfill, which is southwest of Tunis in Northern Tunisia, contains high concentrations of heavy metals, hence the main goal was to characterise soil samples taken from an unlined storage basin in relation to those concentrations. The amounts of Cr, Cu, Ni, Pb, and Zn in a total of twenty-four soil samples that were taken from various areas near the storage basin were examined using atomic absorption spectrophotometry. The results showed increased levels of Cr, Zn, Ni, Pb, and Cu. These findings imply that the active clay layer, which serves as an insulator within the landfill, has an impact on the migration of contaminants. In order to lessen the potential of pollution, it is judged necessary to develop a system for treating landfill leachates and to install a liner beneath the storage basin.

- **Bini et al. (2014)** researched about the physicochemical characteristics of soil in the Jaisamand lake area of Alwar were examined by Bini et al. (2014). Aspects including pH, EC, moisture content, organic matter, nitrogen, potassium, and phosphorus were the main focus of the study. The outcomes were noted, tabulated, and summarised. The Jaisamand region's soil is categorised as black cotton soil and is reddish-brown in hue. When compared to the typical agricultural field average of 32.27%, the moisture content of the soil in Jaisamand was found to be high at 72.41%. The presence of soil contamination coming from home and agricultural sewage sources is indicated by the colour, alkalinity, low phosphorus levels, and organic carbon content. Based on the data obtained, it can be concluded that the lake has oligotrophic characteristics, and the area is suitable for agricultural cultivation of crops such as wheat, gram, mustard, zea maize, cotton, and others.

- **Amponsah et al. (2014)** researched to analyze the soil samples from different crop-growing areas. The soil test results revealed phosphate levels ranging from 12 to 20ppm, which is considered adequate for plant establishment and production. The experimental results for sulphate content were as follows: virgin land (14.8ppm), tomato (20.9ppm), and cassava (43.3ppm). According to the results of the soil test, the typical sulphate values required for the best growth are between 15 and 40 ppm. These concentrations of sulphate, expressed in parts per million (ppm), are sufficient for supporting plant growth.

- **Shaikh et al. (2012)** conducted research next to a municipal solid waste disposal site in Nanded, Maharastra. The study's objectives included assessing and contrasting the physical, chemical, and biological characteristics of soil and groundwater samples, as well as looking into the effects of dumping on their quality. Leachate from waste disposal facilities can damage soil and groundwater because it contains a variety of different chemicals. pH, EC, total hardness, chlorides, salinity, Phenolphthalein alkalinity, fluoride, chromium, carbon dioxide, sulphate, phosphate, total solids (TS), total alkalinity, iron, magnesium, sodium, potassium, and calcium were all measured in the water samples. The exchangeable cations (Ca, Mg, K, and Na) as well as soil moisture, electrical conductivity (EC), water-holding capacity (WHC), pH, chloride, and organic carbon (OC) were all measured in the field. For every metric examined, significant differences were found between the various sampling sites.

- **Feng et al. (2010)** concentrated on the geological environment's contamination due to landfills. In addition to the characteristics of municipal solid waste (MSW), which are influenced by the geological environment, the type of landfill also plays a significant role in this problem's causes. Following field observations, a thorough literature study and experimental data analysis were carried out in order to comprehend the effects of MSW dumps on the nearby geological environment, including the atmosphere, groundwater, and soil. The results show that landfill leachate has a substantial impact on the local geological environment, which makes it necessary to investigate processes and implement control measures to address leachate contamination in surface water and groundwater channels. The concentration of heavy metals generally decreases with increasing depth in the soil profile, and leachate also conveys heavy metals that contaminate the soil. Heavy metal pollution in soil shows accumulation and lag patterns, with pollution levels getting worse with time. This study suggests particular pollution-control techniques that are adapted to various pollution types and pollution trends.

- **Ramesh et al. (2009)** researched on geohazards, encompassing a range of surface processes that have the potential to pose risks or cause harm to both communities and the environment. The resulting risks associated with these hazards are influenced by various factors. The introduction of synthetic chemicals or changes to the natural soil ecosystem are two major causes of soil contamination. It is well known that lime may efficiently improve expansive soil's engineering qualities. However, the presence of sulphate in lime-treated soils can lead to increased volumes of free swelling and oedometer swelling. The occurrence of ettringite (kind of Sulphate) and thaumasite (kind of Silicate), which are problematic substances in lime-treated soils containing sulphate, can be mitigated by the addition of barium chloride. By incorporating barium chloride, both the deviator stress and strength parameters can be restored to their original levels.

- **Chen et al. (2009)** Municipal solid waste (MSW) management in China continues to be a significant problem, which Chen et al. (2009) investigated in detail. Landfilling is still, for the most part, the most economical form of waste disposal. The goal of this paper is to present a thorough review of four geotechnical issues concerning MSW landfills: (1) the flow of water and leachate within landfills; (2) the production, transportation, and control of landfill gas; (3) landfill settlement and its effects; and (4) the stability of the waste mass. The review largely focuses on China-specific landfill practises and waste composition features. By identifying and evaluating the current state and major challenges associated with landfilling, this study also highlights areas that require further research and development in the future.

- **Richardson et al. (2009)** studied the development of modern design principles for lined landfills in the US, which began in the 1980s to deal with the disposal of hazardous waste and then expanded to include municipal solid waste in the 1990s. Design procedures have been improved over nearly 30 years of experience to guarantee lined landfills work as intended. Both the liners, which stop vertical liquid migration, and the drainage fields, which collect and regulate the flow of liquids to reduce the risk of leaks, both depend heavily on geosynthetic components. Geomembrane liners offer a highly stable barrier against liquid spread, but their construction must adhere to rigorous guidelines, they must be protected from harm both during construction and throughout the duration of their service life, and they may have stability problems due to their smooth surfaces. The drainage of accumulated liquids over a sizable portion of the liner surface is made easier by geosynthetic drainage composites. These drainage layers improve landfill stability when properly planned by reducing hydrostatic stresses brought on by amassed liquids. Failures of lined landfills in the past are a useful example of the effects of disregarding crucial design specifications for these components.

- **Kasassi et al. (2008)** characterised, with a focus on the presence of heavy metals, soil samples from a closed unlined landfill located northwest of Thessaloniki, North Greece. Drilling was used to extract the samples, which ranged in depth from 2.5 to 17.5 metres. The samples were then examined using atomic absorption spectrophotometry to determine their Cd, Cr, Cu, Ni, Pb, and Zn contents. The results of the chemical examination showed that the metal values ranged widely: Cd values ranged from 0.50 to 18.75 mg/kg, Cr values ranged from 3.88 to 171.88 mg/kg, Cu values ranged from 8.13 to 356.25 mg/kg, Ni values ranged from 5.63 to 63.75 mg/kg, Pb values ranged from 2.50 to 92.50 mg/kg, and Zn values ranged from 6.38 to 343.75 mg/kg. In three of the six drillings, the largest quantities were found, notably at depths more than 2.5 metres. Despite the region's massive industrialization, the study's findings imply that small-scale businesses have not considerably added to the site's vast metal contamination.

# CHAPTER 3 METHODOLOGY

## 3.1 Study Area

Delhi capital of India spread over area of 42.7 $km^2$ and Bhalswa Landfill is situated in North-East district of Delhi which exist since 1994 with coordinates 28°44'24.9"N, 77°09'28.2"E. It's greatest length from North to South is 730 m and greatest breadth is 580 m, its approximate area is around 31 hectares.

It is surrounded by Bhalswa village, Jahangirpuri junction which connects major Highway and also there is a Bhalswa horseshoe lake nearby with around area of 34 hectare. There are three large dumping sites in Delhi including this other two are located in Gazipur and Okhla, none of the landfill is Lined.

On a daily basis, Delhi produces over 11,000 tons of municipal solid waste (Annepu, 2012). Unfortunately, only 9% of the collected waste undergoes composting, which is currently the sole treatment method available, while the remainder is disposed of in unregulated open landfills. Among the landfill sites in operation in Delhi, namely Bhalswa, Ghazipur, Okhla, and Narela, the first three have already surpassed their expected lifespan and lack proper engineering, thereby presenting a significant environmental hazard

Fig 3.1 Showing village near Bhalswa Landfill

Fig 3.2 Showing Bhalswa Landfill from Samaypur Badli Metro station

The below Map shows the Soil Samples location collected at certain distances:

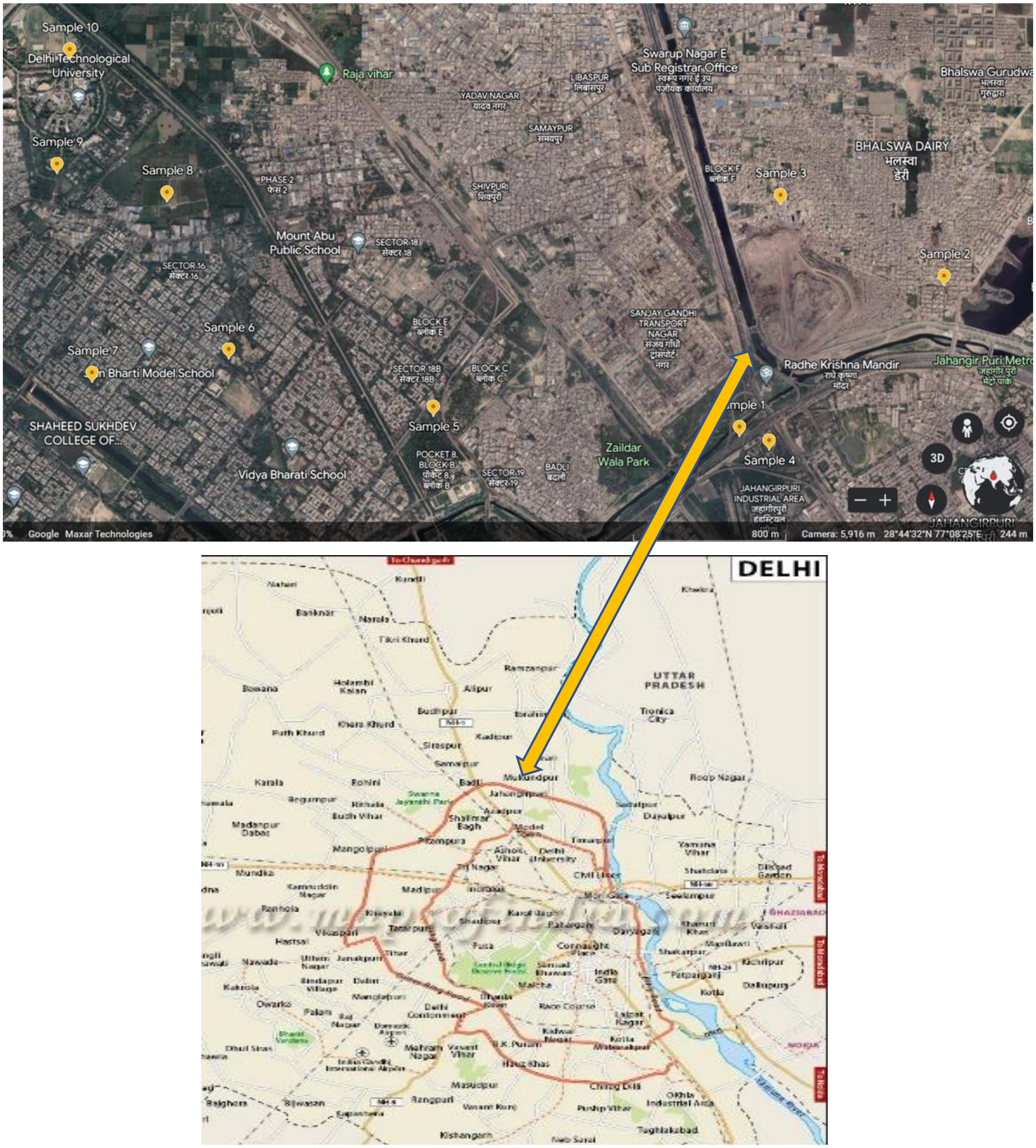



Fig 3.3 Map showing Soil sampling sites
Source: Google Earth

## 3.2 Collection of Samples

The current study examines the physiochemical examination of soil taken from various locations near the Bhalswa Landfill and close to the Delhi Technological University Campus, which is indicated on the map. The study primarily focussed on testing soil samples collected from 10 sites. The surface is cleaned with shovel and sample is collected with the help of core cutter up to depth of 13 cm. Samples were collected in plastic bags and lumps were broken manually and labelled for analysis. Some images of samples collection are shown.

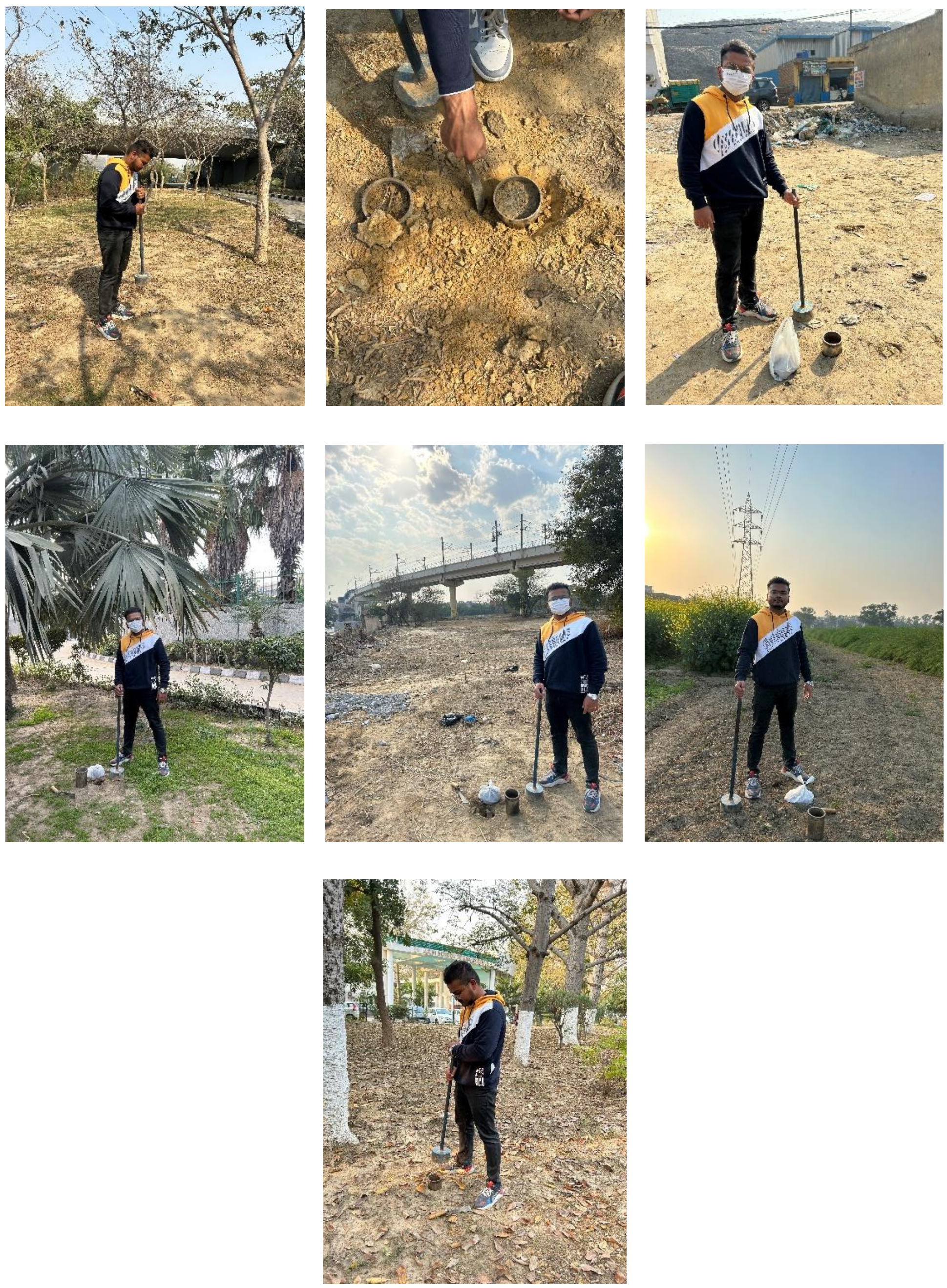


Fig 3.4 Collection of Soil samples around Bhalswa Landfill and coming towards DTU campus

**Table 3.1 Soil Sample collection distance variation from Landfill**

| Soil Sample No. | Distance from Bhalswa Landfill (approx.) |
|---|---|
| 1 | 865 m |
| 2 | 860 m |
| 3 | 393 m |
| 4 | 906 m |
| 5 | 1980 m |
| 6 | 2950 m |
| 7 | 3680 m |
| 8 | 3260 m |
| 9 | 3860 m |
| 10 | 3930 m |

## 3.3 Preparation of Samples for Testing

A 1:10 sample preparation ratio is used, involving the mixing of 10g of soil sample with 100 ml of distilled water for 5 hours with the aid of an orbital shaker.


Fig 3.5 Sample preparation and mixing with orbital shaker

For later tests centrifuge machine is used to derive water only from soil suspension for further investigation. A centrifuge is a tool used in science to separate fluids, gases, or liquids according to their densities. High-speed spinning of a container holding the material is required for this separation process. As a result, centrifugal forces are generated, causing the denser components to migrate towards the bottom of the container. Every soil suspension is kept in 4 test tubes each that is 3 samples i.e., 12x15 ml at a time in this machine for further tests rotated at max 16000 rpm, preparation of sample for spectrophotometer.

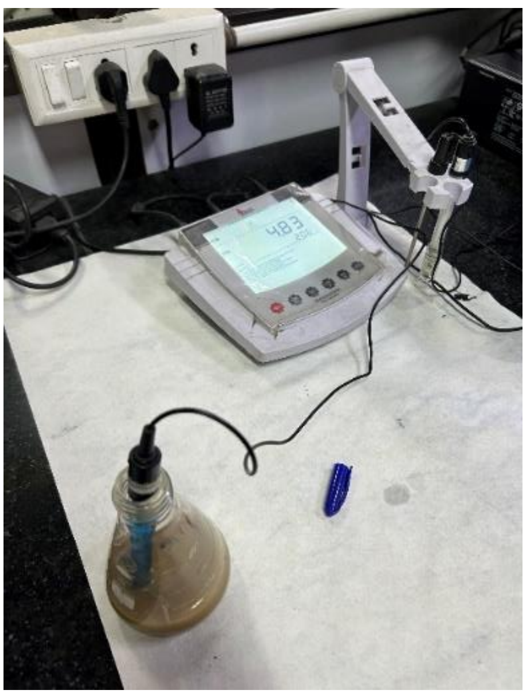

Fig 3.6 Sample preparation for spectrophotometer by using centrifuge machine

## 3.3 Estimation of pH, EC, Salinity and Resistance

The pH values were measured using a multiparameter water quality device. The electrode of the device was immersed into the soil suspension, and the pH reading was recorded. Prior to each new soil reading, the electrode was rinsed with distilled water.

The reading of EC is taken in similar way like pH where water quality multiparameter shows the reading. Greater is the conductivity lesser is resistivity (kΩ) so this parameter value is also observed to double check.

Salinity is found using the same procedure as above two parameters using electrode and multiparameter and washing it after every soil sample tests.



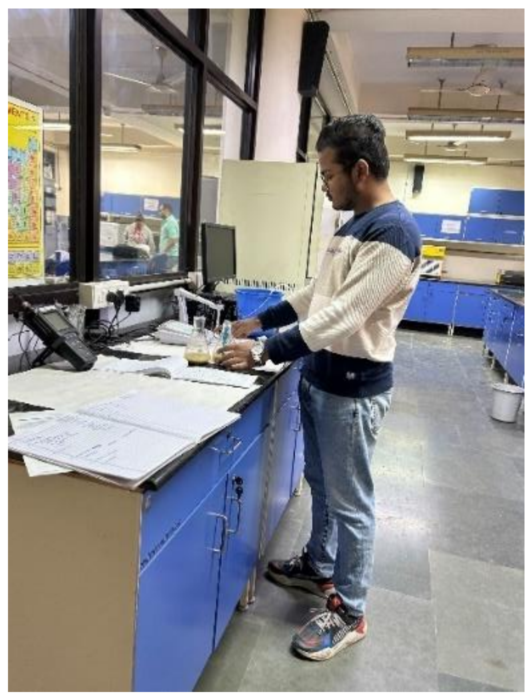


Fig 3.7 Use of Water quality Multiparameter to find parameters like pH, Conductivity, TDS etc.

All the analysis done is under provision of Central pollution control board (CPCB Manual)

## 3.4 Estimation of Calcium, Total Hardness, Magnesium, Chloride and Alkalinity

For determination of contents of next parameters soil samples are stored in test tubes and is centrifuged so as to get the water with contents of soil minerals and that water is used for titrations and determination of other parameters.

Fig 3.8 Use of Titration to find chemical contents

Calcium

Determination of calcium is done by titrating EDTA (Ethylenediamine tetra acetic acid) with 10 ml sample + 0.5 ml 1N NaOH + pinch of murexide where indicator changes colour from pink to violet which is endpoint this is done for all 10 soil samples and readings were noted.

Magnesium

For determination of Magnesium content Total hardness (mg/l as CaCO3) is found in centrifuged sample by titrating EDTA with 10 ml sample + 4-5 drop of Ammonia buffer + pinch of EBT (Eriochrome black T) where the colour changes from purple to blue.

Total Hardness = Calcium + Magnesium, so subtracting the calcium content from total hardness yields the magnesium amount (mg/l as CaCO3).

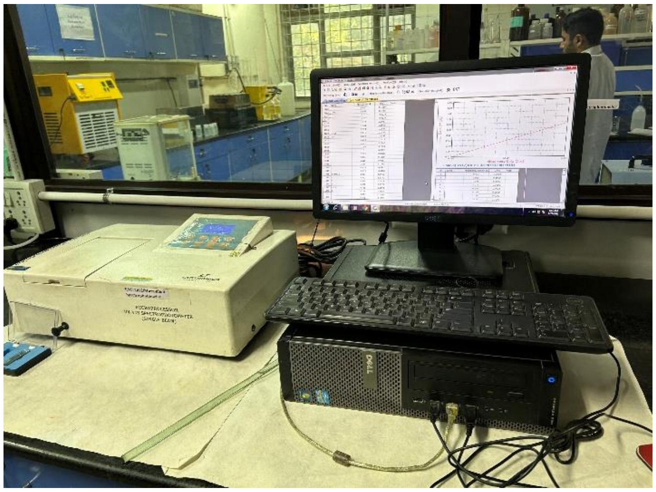
Chloride

For determining this titration of Silver Nitrate (N=0.01) with 10 ml sample + 2-3 drops of potassium chromate is performed where colour change is from yellow to brick red.

Alkalinity

Its content is measured in the centrifuged soil sample by preparing 10 ml of sample + 2 drops of phenolphthalein if this turns pink colour titrate with $H_2SO_4$ till it becomes colourless then add 2 drop of Methyl orange indicator and titrate with $H_2SO_4$ where colour changes to pinkish.

## 3.5 Estimation of Sulphate, Phosphate and Nitrate



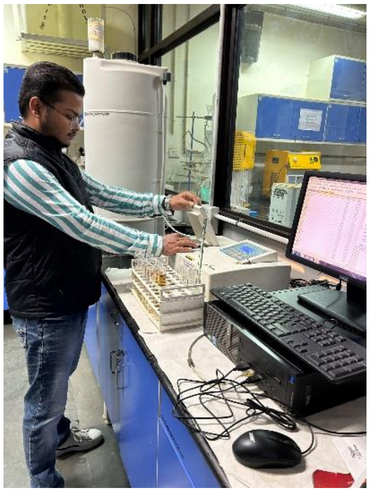


Fig 3.9 Use of Spectrophotometer for finding content of Sulphate Phosphate and Nitrate

These three parameters are found with the help of Spectrophotometer by preparing the samples with help reagents and chemicals. Only contents are measured with help of instrument rather than further research of different constituents.

Sulphates

For its determination a standard container used in spectrophotometer is filled with sample in which 0.4 ml of conditioning reagent + $BaCl_2$ pinch is added and is put for observation and results are found help of computer system and standard curve equation.

Phosphate

For finding its concentration standard container is filled with sample + 0.4 ml of Ammonium molybdate + 1 drop of $SnCl_2$, colour generated is blue which is observed with help of spectrophotometer instrument which gives out values with help of standard R equation in computer system.

Nitrate

Nitrate content is measured by filling standard container with sample + 0.2 ml 1N HCl and is observed with help of computer system and standard curve equation.

# CHAPTER 4 RESULT AND DISCUSSION

**Table 4.1: Comparison of different parameters after experimental analysis**

| **Parameters** | **Sample 1** | **Sample 2** | **Sample 3** | **Sample 4** | **Sample 5** | **Sample 6** | **Sample 7** | **Sample 8** | **Sample 9** | **Sample 10** |
|---|---|---|---|---|---|---|---|---|---|---|
| Water Content (%) | 3.16 | 11.64 | 2.75 | 9.88 | 8.93 | 5.36 | 9.57 | 3.91 | 4.19 | 7.99 |
| Conductivity, µS/cm | 1370 | 2423 | 12940 | 2133 | 2098 | 1793 | 2886 | 3038 | 4349 | 2948 |
| TDS, mg/l | 676.4 | 1192 | 6346 | 1050 | 1032 | 883.5 | 1419 | 1494 | 2135 | 1450 |
| Resistance, kΩ | 7.298 | 4.127 | 0.772 | 4.689 | 4.769 | 5.578 | 3.465 | 3.292 | 2.3 | 3.388 |
| Salinity, mg/l | 1180 | 1670 | 6930 | 1530 | 1520 | 1370 | 1890 | 1960 | 2590 | 1920 |
| pH | 8.13 | 7.77 | 7.81 | 8.06 | 7.88 | 8.10 | 7.95 | 6.61 | 7.59 | 7.8 |
| Chlorides, mg/l | 70.9 | 70.9 | 354.5 | 70.9 | 70.9 | 70.9 | 70.9 | 70.9 | 70.9 | 99.26 |
| Phosphate, mg per 1 lit | 3.74 | 23.03 | 1.85 | -0.18 | 17.26 | 0.16 | 6.30 | 65.83 | 2.70 | 3.50 |
| Nitrate, mg/l | 32.75 | 228.94 | 1708.75 | 130.67 | 180.75 | 120.93 | 1708.75 | 181.60 | 115.46 | 30.07 |
| Sulphate, mg/l | 1.83 | 48.07 | 686.38 | 22.01 | 35.73 | 313.65 | 433.48 | 625.04 | 745.74 | 17.79 |
| Total Hardness, mg/l as CaCo3 | 1400 | 1300 | 4900 | 1400 | 1300 | 900 | 1600 | 1400 | 3000 | 2800 |
| Conductivity, µS/cm | 1370 | 2423 | 12940 | 2133 | 2098 | 1793 | 2886 | 3038 | 4349 | 2948 |
| Calcium, mg/l equivalent to CaCo3 | 160.32 | 320.64 | 1362.72 | 400.8 | 320.64 | 360.72 | 360.72 | 320.64 | 761.52 | 617.23 |
| Magnesium, mg/l as CaCo3 | 1239.68 | 979.36 | 3537.28 | 999.2 | 979.36 | 539.28 | 1239.28 | 1079.36 | 2238.48 | 2182.77 |
| Alkalinity, mg/l as CaCo3 | 3000 | 3000 | 2000 | 4000 | 3000 | 3000 | 4000 | 1000 | 3000 | 2800 |

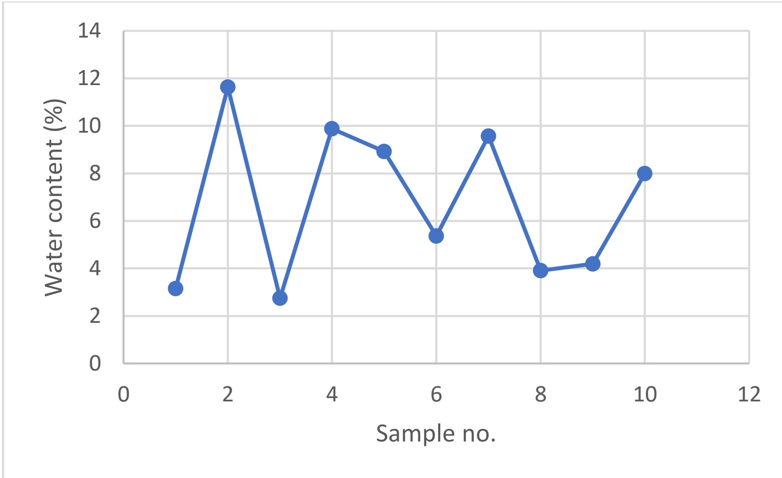



Fig 4.1 Water content varies for various soil samples.

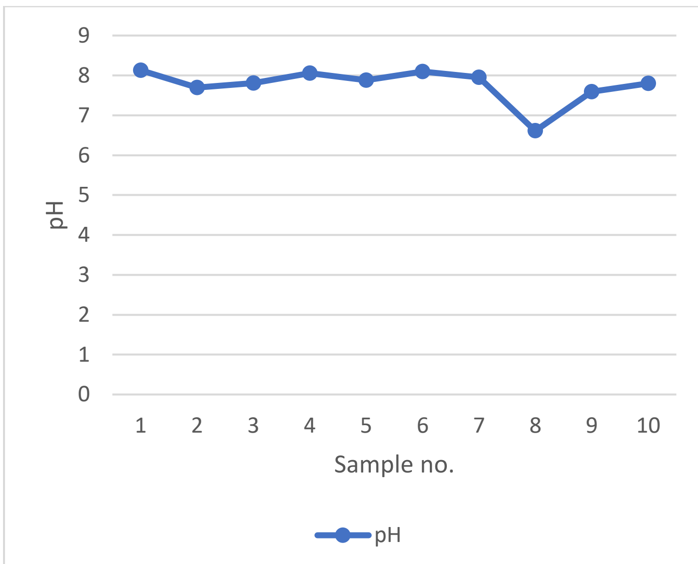



Fig 4.2 Variation of pH in different soil samples

- The pH value represents the level of hydrogen ions in the soil water system and indicates the soil's acidity or alkalinity. It plays a crucial role in determining nutrient availability, microbial activity, and the physical state of the soil.

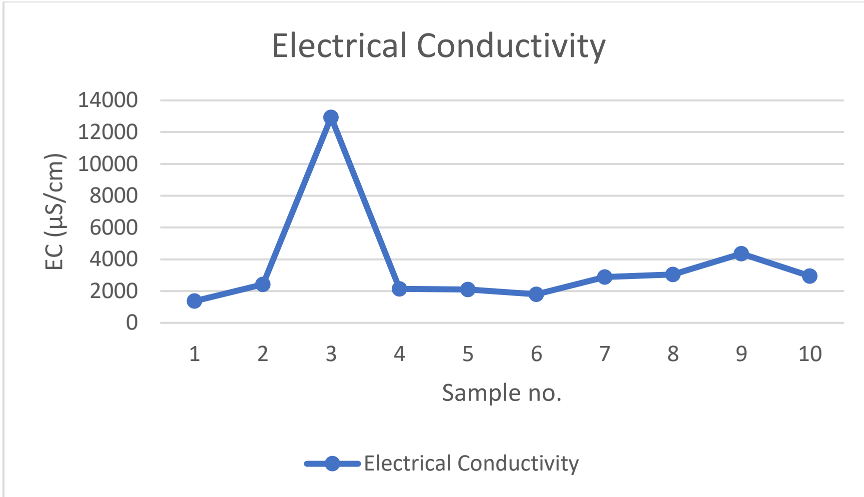



Fig 4.3 Variation of Electrical Conductivity for different soil samples

- Electrical conductivity (EC, µS/cm) indicates the level of ion concentration in a solution, providing information about the soil's ability to conduct electrical current. This measurement provides valuable insights into the presence of soluble salts within the soil.

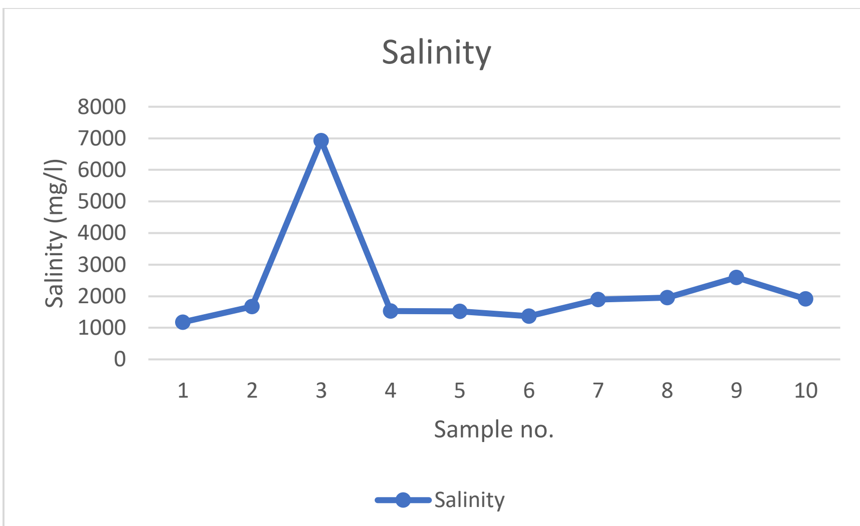



Fig 4.4 Variation of Salinity in different soil samples

- Soil salinity (mg/l) becomes problematic when there is an accumulation of salts in the root zone that adversely affects plant growth and creates engineering challenges.

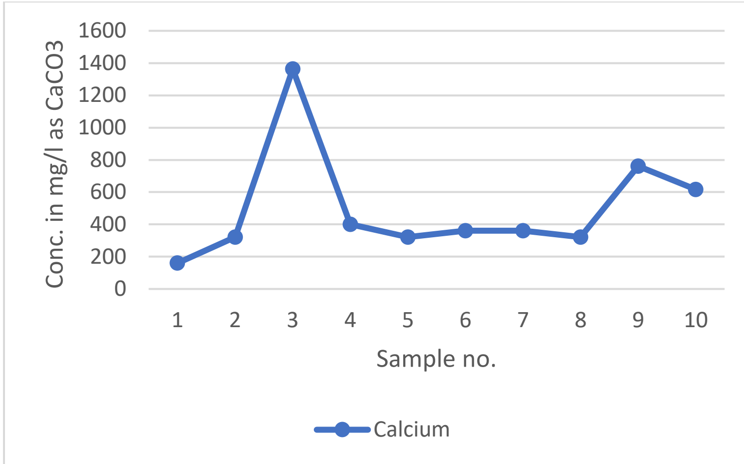



Fig 4.5 Variation of Calcium content for different soil samples

- Calcium (mg/l as CaCO3) is a vital nutrient that plants extract from the soil to support cell wall formation. Additionally, it acts as a binding agent in soil particle aggregation, facilitating the cohesion of organic and inorganic materials. This plays a good role in the establishment of a healthy soil structure.

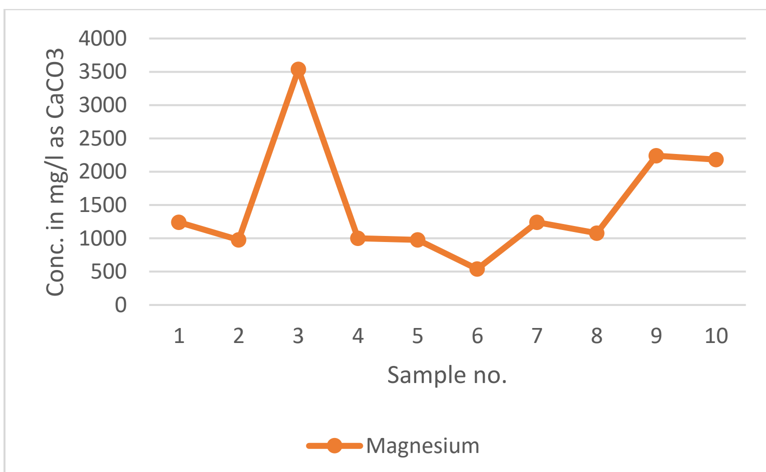



Fig 4.6 Variation of Magnesium content for different soil samples

- Magnesium serves as the central component of the chlorophyll molecule within plant tissue. Consequently, a deficiency in magnesium leads to insufficient chlorophyll levels, resulting in weak and stunted plant growth. Additionally, magnesium plays a crucial role in activating specific enzyme systems. Enzymes are intricate substances that facilitate the construction, modification, or breakdown of compounds as part of a plant's natural metabolic processes.

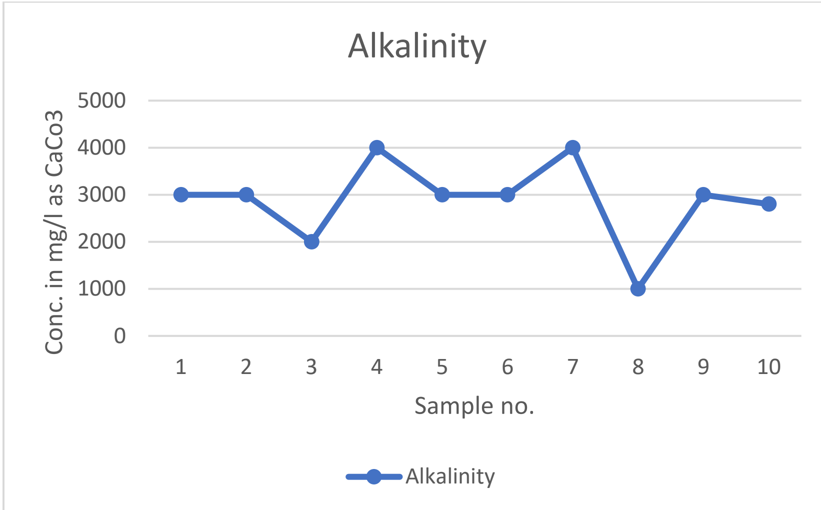



Fig 4.7 Variation of Alkalinity in different soil samples

- When minerals like calcium and magnesium are present dissolved in liquids, it is said to have an alkalinity. These alkali metals are naturally occurring and are widely distributed in the crust of the earth.

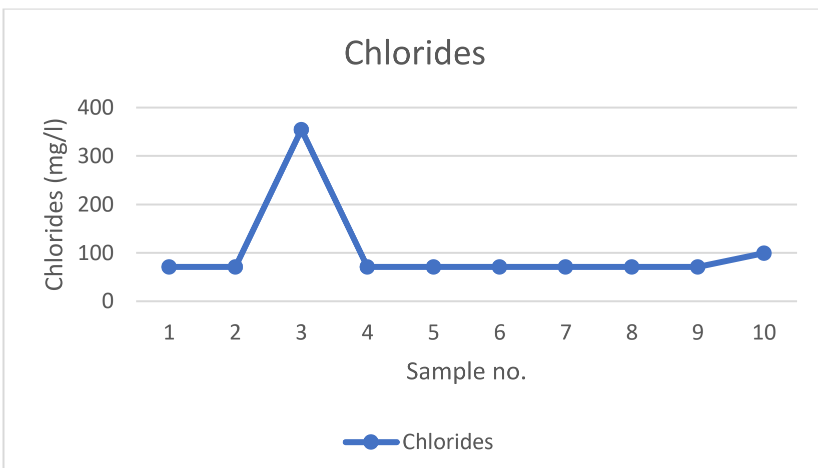



Fig 4.8 Variation of Chlorides for different soil samples

- The chloride (mg/l) content in soil is not an inherent characteristic of the soil itself but rather a consequence of soil management practices. This is due to the mobility of chloride within the soil, as it tends to move along with water within the soil profile.

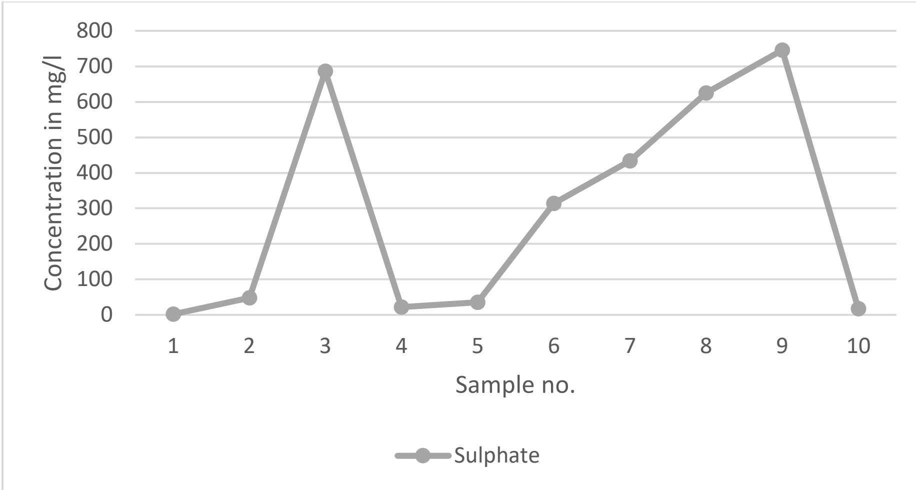



Fig 4.9 Variation of Sulphate content for
different soil samples

- The presence of sulphate has a significant impact on the physical and engineering properties of lime treated soils. The extent of these effects depends on the concentration, form of sulphate, and duration of curing. One notable effect is the abnormal increase in the liquid limit of lime treated soils when exposed to sulphate during the curing process.

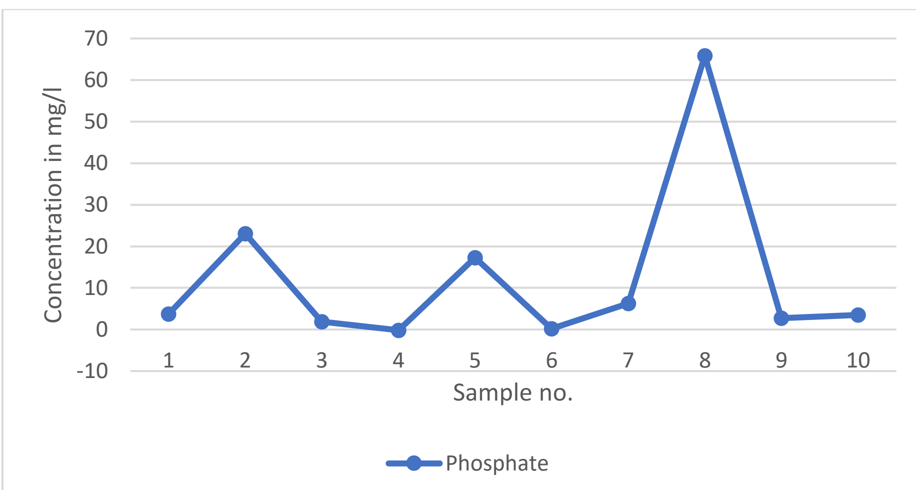



Fig 4.10 Variation of Phosphate content in
different soil samples

- The second most important nutrient for plants in the soil after nitrogen is phosphorus. Phosphate, often known as inorganic phosphate, can be found in biological systems as a free phosphate ion in solution.

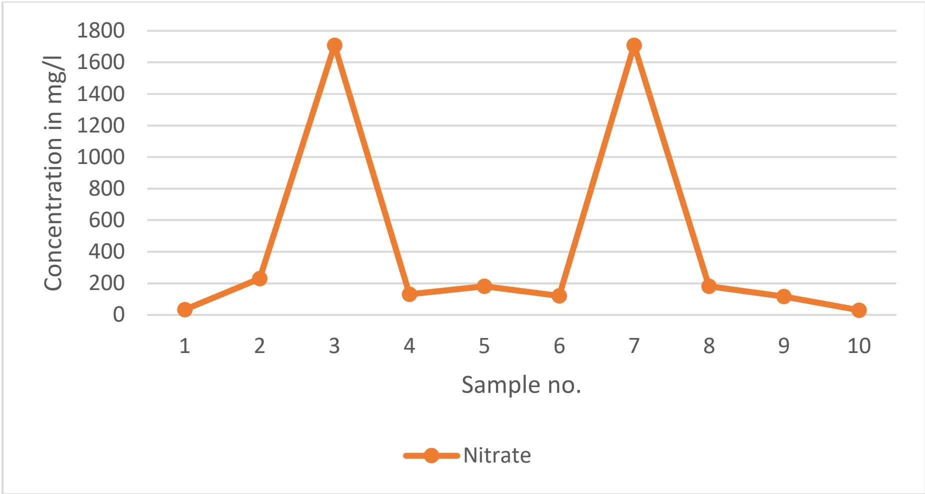



Fig 4.11 Variation of Nitrate content for different soil samples

- Natural nitrogen loads encompass nitrogen compounds originating from microorganisms in aquatic environments, atmospheric precipitation, and geological substances. Nitrate-nitrogen (NO3-N) quantifies the readily available nitrogen content in the soil that plants can readily absorb.

# CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

## 5.1 CONCLUSIONS

This research highlights that improper waste management from its generation to disposal leads to soil contamination. Soil quality assessment can be conducted using various parameters, many of which exceed the acceptable limits. The study examines the impact of soil compaction on soil properties such as pH, chloride, electrical conductivity (EC), phosphate, nitrate, sulfate, and others at different distances from the Bhalswa Landfill.

It is crucial to understand that if materials with different chemical, mineralogical, physical, and structural qualities are utilised, the results of soil characteristics may change. Changes in behaviour will depend on the particular polluted material as well as the type of leachate and length of exposure. This study can be further investigated if we go vertically in depth which will need machinery work that can increase the research scope laterally and vertically in soil sites. The study comes with number of conclusions:

- Idea pH range for soil sample is crossed at some locations seems like basic soil in nature except at one place which is slightly acidic
- If we overlook the values of Electronic conductivity and Salinity it shows higher value at location 3$^{rd}$ which is near Bhalswa Landfill
- There are around 5 locations with Sulphate more than 40 ppm which is found to be contaminated and thus not suitable for plant growth
- As we move far away from Landfill the values comes under standard range according to ICAR (Indian Council of Agricultural Research)

This study was limited to soil sample on surface or at depth of 13 cm to assess the contamination but this can be further enhanced by taking soil samples at certain depths of around 2.5 m and more to find further study and metallic contaminants.

## 5.2 RECOMMENDATIONS

Based on this analysis, addressing the primary pollution issues associated with waste disposal sites should involve preventive measures and careful site selection. Given the significant number of municipal garbage sites that are not safeguarded, dump sites in many Indian cities contribute to environmental degradation and groundwater contamination, which could pose a threat to our nation's future social and economic growth. The following approaches are recommended to tackle these challenges:

- Pre-treatment of municipal solid waste (MSW) should be implemented.
- Sites for landfills should be remote from water sources and places where the soil permeability is low. They should also be free of significant cracks or flaws. A layer of suitable water-resistant materials should be incorporated into the soil that lies beneath the landfill to make it thicker and more compact.
- Geologically impermeable liners, such as geomembranes, should be used during landfill construction to prevent leachate seepage and groundwater contamination.
- In order to prevent pollution from spreading further, contaminated sites should be managed to keep the contamination footprint as small as possible.
- The practice of storing leachate in earth basins should be discontinued, and instead, a concrete basin should be constructed to store leachate, ensuring the protection of the underlying substrate.
- An effective leachate treatment system should be established for landfill leachates.
- The biological degradation of organic components causes changes in the hydraulic and mechanical properties of MSWs over time. When evaluating the effectiveness of MSW landfills, the ageing effect should be taken into account.

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**May 27th 2023 Delhi, India**

## *Acceptance Letter*

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*Authors:* **Chirag, Ashok Kumar Gupta**

*Paper ID:* ***ITAR_28710***

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