STUDY OF GROUND WATER CONTAMINATION DUE TO LANDFILLS IN DELHI

A Dissertation Submitted in Partial Fulfillment for the Award

of the Degree of

MASTER OF ENGINEERING

IN

CIVIL ENGINEERING

(ENVIRONMENTAL ENGINEERING)

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CANDIDATE'S DECLARATION

I hereby certify that the work presented in this dissertation entitled **"STUDY OF GROUND WATER CONTAMINATION DUE TO LANDFILLS IN DELHI"** in partial fulfillment of the requirements for the award of the degree of **MASTER OF ENGINEERING** in Civil Engineering, with specialization in **ENVIRONMENTAL ENGINEERING**, submitted to the Department of Civil and Environmental Engineering, Delhi Technical University, Delhi (Formerly Delhi College of Engineering) is an authentic record of my own work, under the supervision of **Dr. S.K.SINGH**, Professor & Head, Department of Environmental Engineering, Delhi Technical University, Delhi (Formerly Delhi College of Engineering).

I have not submitted the matter embodied in this dissertation for the award of any other degree.

Date: 10.02.2012 (KALYAN SAGAR SINGHAL)

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CERTIFICATE

Certified that the work presented in this dissertation entitled **"STUDY OF GROUND WATER CONTAMINATION DUE TO LANDFILLS IN DELHI"** in partial fulfillment of the requirements for the award of the degree of **MASTER OF ENGINEERING** in Civil Engineering, with specialization in **ENVIRONMENTAL ENGINEERING**, submitted to the Department of Civil and Environmental Engineering, Delhi Technical University, Delhi (Formerly Delhi College of Engineering) is an authentic record of the work done by **Mr. KALYAN SAGAR SINGHAL (R.No.13992)**, under my supervision.

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ABSTRACT

The Solid waste is unwanted & discarded solid fractions, arising from domestic, industrial, commercial, institutional, and agricultural & horticultural purposes, mainly due to human activities. With fast urban growth and increasing standard of living the waste collection has steeply increased in Delhi from 5711 TPD in 2004 to 7400 TPD in 2011 and is projected to increase to 12446 TPD in 2021 mainly due to ever increasing population .

Leachate which is a result of Solid waste deposition is the one factor that has endangered the human health and environment. It is an established fact that leachate contaminates the ground water which is a major source of drinking water, with varying degree of toxicity. Some contaminants may be Carcinogenic, Mutagenic or Teratogenic. Contaminants like Metals, Alcohals, Synthetic organic compounds (SOCs), Volatile Organic Chemicals (VOC's) adversely affects the human health. Groundwater contamination is resulting in outbreak of several diseases like Gaestro-intestinal problems, diarrhea, stomach ache, vomiting, skin infection, eye irritation and hair loss etc

During the present study it has been found that Leachate Characteristics vary from place to place and time to time. The concentration of Chlorides, Nitrates, Fluorides, Iron, Cadmium, Lead, Copper & Zinc are found to be above the permissible standards for drinking. Underground water samples near the Landfill sites at Okhla, Ghazipur and Bhalaswa have been checked and found to be unfit for drinking purposes.

Municipal Authorities have addressed the problem of Ground water contamination due to Leachate. An Engineered sanitary landfill site has recently been developed and made operational at Narela-Bawana.

To address the problem of land scarcity for landfilling purpose efforts are being made to reduce the quantity of waste to be landfilled, Power Plants are being set up to generate green energy using Refused Derived Fuel and are expected to be operational in 2012. Compost Plants have been set up at all the three present Landfills. A 500TPD C&D Waste processing facility has been set up at Burari.

This study focuses on Leachate characteristics & effects of the Leachate generating from the existing SLF's on Ground water and to explore the remedial measures to this problem. The study also highlights the present status of Solid Waste Management in Delhi.

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ABBREVATIONS

SLF	Sanitary Land Fill
MSW	Municipal Solid Waste
MCD	Municipal Corporation of Delhi
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
TOC	Total Organic Carbon
TDS	Total Dissolve Solids
TPD	Ton per Day
Cl	Chlorides
Ca	Calcium
As	Arsenic
Pb	Lead
Zn	Zinc
Cd	Cadmiun
Cr	Chromium

CHAPTER 1

INTRODUCTION

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INTRODUCTION

1.1 Introduction

Solid waste is unwanted & discarded solid fractions, arising mainly due to human activities. Since the evolution of civilization humans have always generated solid waste. During the earlier part of civilization the nature of solid waste generated was mainly organic and was mostly scattered. With the concept of community living gaining popularity, the quantity of solid waste generated had increased but was more localized. With the development, Industrialization took place resulting in change in characteristics of solid waste generated as more and more inorganic waste was being generated.

The characteristics of MSW vary from place to place & season to season. Presently Delhi does not have any engineered disposal site for disposal of MSW. This is resulting in Contamination of ground water due to Leachate generating at the dumping site, foul smell emanating to nearby areas & aesthetically unpleasant scene for the people living in the neighborhood & also for the passer-by. This is also resulting in outbreak of several diseases like Cholera, Diahorrea, and Typhoid, Yellow fever, Encephalitis, Plague, etc. As per Master plan, the population of Delhi is likely to increase to 230 Lacs in 2021. The Quantity of the MSW generated is also likely to increase substantially by then. Presently in spite of vigorous efforts to reduce, recycle and reuse the solid waste, about 80% of the waste collected is landfilled (MCD). The organic portion of landfilled waste decomposes first by aerobic and then by anaerobic process resulting in generation of landfill gases, acid and water. When this water generated by decomposition of organic waste, moisture due to consolidation or water from rainfall/runoff passes through the landfill, it dissolves metallic and other non-desirable ions /trace particles of heavy metals present in the landfill due to presence of industrial waste or Phenol, hydrocarbons etc that may form part of domestic solid waste or other Toxic materials that may be present in solid waste. If Leachate is not contained, it migrates from site. If it reaches ground water, it contaminates the water supply wells. The extent of contamination depends on various factors like porosity, coefficient of permeability, grain size of soil, concentration and quantity of waste generated and composition of solid waste. A large portion of drinking water needs of residents of Delhi is being met by ground water. The Leachate from the SLF's contaminates the Ground water resources. Leachate alters the PH and increases the Turbidity, BOD, COD, TDS content and also concentration of Fe, F ,Cl, SO_4, Pb, Cd, Cu etc.

Dumps and landfills are not entirely synonymous and a distinction should be made. A dump is defined as, "a site used to dispose off the solid waste without environmental controls." The term landfill is replacing 'dump' due to modernization of our solid waste facilities. Landfill is defined as "a facility in which residual solid waste is disposed in the surface soil of the earth", and a sanitary landfill is defined as "a facility where solid waste is disposed and facility is designed and operated to minimize public health and environmental impacts in accordance with Environmental protection standards." Well-designed landfills should not cause water quality problems because Leachate Problems are anticipated and controlled. Delhi being capital of the country reflects the state of Economical, Social & Industrial status of the country to the visiting foreign delegates & Investors. The government is determined to make Delhi a world-class city.

Most of the areas in Delhi, which have not seen planned development, are plagued by acute problems related to MSW, resulting in unhygienic living conditions for inhabitants. The areas that have been developed as per plans are also facing additional load due to increase in population density.

With rapid influx of population in Delhi, the waste collection is likely to be 15750 TPD by 2021 (MPD 2021). Even with the best efforts to minimize the waste by composting and recycling, there would still remain 6000 TPD of residue for land filling (MPD 2021).

1.2 Profile of Delhi

Delhi, the capital city of India, is the second largest Municipal Corporation in the world after Tokyo. The growth of population has been 1.47 million in 1951 to 13.8 millions in 2001 (CENSUS 2001,MPD 2021)with annual growth of 3.80%.Presently the population is estimated at 18 million.(MCD 2011) Being the capital city of the country with vibrant trade, commerce and employment opportunities, lot of migration takes places from different parts of the country.

Business and Commercial activities:

To have effective administrative control, the MCD is divided into 12 zones, each zone headed by Deputy Commissioners. Each zone is looking after 4 to 12 Wards depending upon the area and population of the city.

Most of the areas in Delhi, which have not seen planned development, are plagued by acute problems related to MSW, resulting in unhygienic living conditions for inhabitants. The areas that have been developed as per plans are also facing additional load due to increase in population density.

At present Delhi's garbage is being dumped at three landfill sites -- Ghazipur in East Delhi, Bhalswa-Jehangirpuri in North Delhi and Okhla in South Delhi. All the three sites have already crossed their capacity.

Hon'ble Supreme Court of India has directed the MCD to develop at least ten new Garbage processing facilities as quickly as possible. Municipal Corporation of Delhi (MCD) is in the process of developing new sites for Engineered Sanitary Landfill Facility (SLF). Based on preliminary identification of possible sites and feasibility study, MCD proposed three new sites for purpose of sanitary land filling at Bhatti mines Jaitpur and, Narela-Bawana ,but due to litigations and resistance from local people, plan for first two sites have been shelved. The Narela-Bawana landfill has been constructed and landfilling has started from January 2012.
The city has already filled up 16 landfill sites covering an area of 180 hectares (MPD 2021) and occupying a volume of 10 million cum. The filled up sites are 1. Kailash Nagar ,East Delhi 2. Tilak Nagar 3. Subroto Park 4. Purana Quila/ Bhairon road 5. Timarpur 6. Sarai Kale Khan 7.

Gopal pur 8. Chatterpur 9. S.G.T Nagar 10.I.P. Depot 11.Sunder Nagar 12. Tuglakabad Extension 13. Haiderpur 14. Mandawali Fazilpur 15. Rohini Phase-III 16. Near Hastsal Village in West Delhi. The three active landfill sites cover an area of additional 60 hectares occupying a volume of 6 million cum.

With no Leachate collection and treatment system available, these landfill sites always pose a potential threat for surface water and ground water contamination.
This study focuses on effects of the Leachate from the existing SLF's on Ground water and solution to this problem. The study also highlights the status of SWM in Delhi.

1.3 Objective of Present Study

(i) To assess the status of Solid Waste Management in Delhi.

(iii)To Study the characteristics of leachate & its effect on ground water quality. Present study involved collection of leachate samples from the landfill and carrying out its analysis for the existing Landfills in Delhi viz, Okhla , Ghazipur & Bhalaswa at four different stages with a gap of two months period between each collection.

(ii) To study the Ground Water Quality against any possible contamination involving collection of ground water samples from or around the landfills and followed by its analysis.

1.4 Organization of the Dissertation

The present study has been divided into seven chapters. The first chapter gives introduction about the evolution of landfills, the potential threat to ground water due to landfills. The second chapter gives detailed literature review on the generation of Solid waste in Delhi and its Characteristics. The third chapter describes the Problems in managing solid waste in Delhi. Fourth chapter deals with study of existing landfill sites in Delhi at Okhla SLF, Ghazipur SLF & Bhalaswa SLF involving solid waste quantification. Fifth chapter deals with health aspect related to landfill sites. The sixth chapter involves Analysis of Leachate from Okhla, Ghazipur & Bhalaswa Landfills and Ground Water samples around these Landfill Sites for Physico-Chemical Characteristics and to study the problem of drinking water contamination. Seventh and the last chapter conclude the study with conclusions.

CHAPTER 2

GENERATION OF SOLID WASTE IN DELHI

CHAPTER- 2
GENERATION OF SOLID WASTE IN DELHI

2.1 Introduction

Solid waste consists of the heterogeneous mass of throwaways from residents and commercial activities as well as the more homogeneous accumulations of single industrial activity.

2.2 Types of solid wastes

The various types of solid waste are:

- Municipal wastes
- Industrial wastes
- Hazardous wastes

These are being briefly described below.

2.2.1 Municipal Wastes: -

Municipal solid waste (MSW) refers to the materials discarded in the urban areas for which municipalities are usually held responsible for collection, transport and final disposal. MSW encompasses household refuse, institutional wastes, street sweepings, commercial wastes, as well as construction and demolition debris.

Municipal Solid Waste (MSW) is heterogeneous in nature and consists of a number of different materials derived from various types of activities. The major constituents are paper and putrescible organic matter. Metal, glass, ceramics, plastics, textiles, dirt and wood are also generally present, the relative proportions depending on local factors. Waste composition is also influenced by external factors such as geographical location, the standard of living, energy source and weather. The composition and characteristics of municipal solid wastes vary throughout the world. Even in the same country it changes from place to place. Generally, all low and middle income countries have a high percentage of compostable organic matter in the urban waste stream, ranging from 40-85% of the total.

The materials comprising municipal solid waste are:

- **Food waste**
  The wastes resulting from handling, preparation, cooking, and eating of food materials because food wastes are putrescible, they decompose rapidly, especially in warm weather.
- **Rubbish**
  These comprise of combustible and non-combustible solid wastes, excluding food wastes or other putrescible materials. They typically include combustible plastics, textiles, rubber, leather, wood, furniture, and garden trimmings. Non-combustible rubbish

consists of items such as glass, crockery, tin cans, aluminum cans, ferrous and nonferrous metals, dirt, and construction materials.

- **Ashes and residues**
  These include materials remaining from the burning of wood, coal, coke, and other combustible wastes. Residues from power plants normally are not considered in this category.
- **Demolition and construction wastes**
  Wastes from razed buildings and other structures are classified as demolition wastes. Wastes from the construction, remodeling and repairing of residential, commercial and industrial buildings and similar structures are classified as construction wastes. These wastes may include dirt, stones, concrete, bricks, plaster, lumber, shingles, and plumbing, heating and electrical parts.
- **Special wastes**
  Wastes such as street sweepings, roadside litter, catch- basin debris, dead animals, and abandoned vehicles are classified as special wastes.
- **Treatment-plant wastes**
  The solid and semisolid wastes from water, wastewater, and industrial waste treatment facilities are included in this classification

2.2.2 Industrial Wastes:-

Industrial wastes are those wastes arising from industrial activities and typically include rubbish, ashes, demolition and construction wastes, special wastes and hazardous wastes.

2.2.3 Hazardous Wastes:-

Wastes that pose a substantial danger immediately or over a period of time to human, plant, or animal life are classified as hazardous wastes. A waste is classified as hazardous if it exhibits any of the following characteristics.

- Ignitability
- Corrosivity
- Reactivity
- Toxicity

Hazardous Waste in Delhi is composed of Cyanide, Paint/ Pigment waste, Oil waste, Effluent Treatment Plant Sludge, Insecticide, Acidic/alkaline Slurry. Presently facilities for its safe disposal are not available in Delhi.

2.3 Waste Collection in Delhi

Following are the quantities of MSW collected in Delhi (2010-11-MCD):

- MCD Controlled Area – 7000 M.T. per day.
- NDMC Controlled Area – 350 M.T. per day.

- DCB Controlled Area – 60 M.T. per day.

2.4 Characteristics of Solid Waste

2.4.1 Physical Characteristics

The physical characteristics include density of the waste and percentage of different constituents such as paper, plastics, inert materials, ashes and metal. Information on the chemical composition of solid wastes is important in evaluating alternative processing and energy recovery options.

Following are the Physical Characteristics of MSW in Delhi:

Table 2.1 Physical Characteristics of MSW in Delhi

Component	Percentage
Bio- degradable	62.5
Recyclable	3.84
Inert	2.75
Others	2.45
Density(mt/cum)	0.35667
Ash and fine earth	28.46

Source: (http://ccs.in/ccsindia/pdf/Ch12_Solid%20Waste%20Management.pdf)

The lower value of metal, plastic and paper is due to the segregation of these quantities by rag pickers.

2.4.2 Chemical Characteristics

The four important chemical properties of wastes are:

(i) Proximate analysis

- Moisture (loss at 105°C for 1h)
- Volatile matter (additional loss on ignition at 950°C)
- Ash (residue after burning)
- Fixed carbon (remainder)

(ii) Flushing point of ash.

(iii) Ultimate analysis, percent of C (carbon), H(hydrogen), O(oxygen), N(Nitrogen), S(Sulphur), and ash.

(iv) Heating value (energy value)

Following are the Chemical Characteristics of MSW in Delhi:

Table 2.2 Chemical Characteristics of MSW in Delhi

Component	Percentage
pH	8.2
Volatile	28
Nitrogen	0.94
Carbon	8.35
Hydrogen	1.16
Phosphorous	0.62
Potassium	1.01
Sulphur	<0.01
Organic Carbon	20.47
Moisture	40.10

Source: (https://uhra.herts.ac.uk/dspace/bitstream/2299/2031/1/902012.pdf)

CHAPTER- 3

CHAPTER 3

PROBLEMS IN MANAGING SOLID WASTE

PROBLEMS IN MANAGING SOLID WASTE

3.1 Introduction

Collecting, transporting and disposing of Municipal Solid Waste (MSW) represent a large expenditure for urban cities as waste management usually accounts for 30-50 percent of municipal operational budgets. Despite these high expenses, cities collect only 50-80 percent of the refuse generated. In India only about 50 percent of the refuse generated is collected.

3.2 Environmental Problems Caused by Municipal Solid Waste

Uncollected wastes often end up in drains, causing blockages that result in flooding and in-sanitary conditions.

Flies breed in some constituents of solid wastes, and flies are very effective vectors that spread disease and it has spread cholera in Delhi in last many years.

Rats find shelter and food in waste dumps. Rats consume and spoil food, spread diseases, damage electrical cable and other materials and inflict unpleasant bites.

Plastic bags are a particular aesthetic nuisance and they cause the death of grazing animals, which eat them.

Waste collection workers face particular occupational hazards, including strains from lifting, injuries from sharp objects and traffic accidents.

Dangerous items (such as broken glass, razor blades, hypodermic needles and other healthcare wastes, aerosol cans and potentially explosive containers and chemicals from industries) may pose risks of injury or poising, particularly to children and people who sort through the waste.

3.3 Solid waste management in Delhi

The task for solid waste management in Delhi is vested with three nodal Agencies:
Municipal Corporation of Delhi (MCD), New Delhi Municipal Committee (NDMC) and the Cantonment Board (CB). The Conservancy and Sanitation Engineering (CSE) Department of the MCD is responsible for solid waste management within the jurisdiction of the MCD including rural and urban villages, slum clusters, regularized (previously) unauthorized colonies, roads, streets and public conveniences. NDMC carries out sanitation operations including primary collection, transportation and disposal of municipal solid waste in the centrally administered areas of the city. The Cantonment Board looks after the areas of Delhi Cantonment. MCD, NDMC and CB are helped by various agents in the private sector such as private sweepers and garbage collectors employed by residents to clean private premises, rag pickers, junk dealers and industries that use scrap to produce recycled products. At present the entire city is not provided with waste management facilities. There are virtually no arrangements for waste management in squatter settlements, slums and illegal colonies, which comprise around 50% of the urban population in Delhi. As a result, waste is littered in open spaces and drains.

The Municipal Corporation of Delhi (MCD) is among the largest municipal bodies in the world, providing civic services to most of the 18 million citizens in the capital city of India. Within its jurisdiction are some of the most densely populated areas in the world. The average daily waste collection in Delhi during the year 2010-11 was 7,400 tons (MCD). Waste management has thus become a perpetual problem in the city. So far it has remained highly inefficient, outdated and lacking in public participation. The per capita expenditure in waste management in Delhi estimated in 2003-04 is Rs. 268.1, whereas it should not be more than Rs 259. To reduce this cost 30 mechanical sweepers have been inducted in the city in Jul 2011.To achieve environmental friendly waste management goals, MCD is preparing to attain maximum recycling of waste to attain economic viability; enhance environmental quality by achieving best sanitation standards; promote a culture of 'waste not pollute not' by segregation at source; promote public and NGO participation, and promote energy recovery from waste by non-conventional methods. From January 2004, following a Supreme Court order, MCD has started to segregate garbage at source.

3.4 New Landfill site in Delhi

- SLF site has been developed at Bawana-Narela on an area of 112 Hectares and has become operational from January 2012.

3.4.1 Bawana -Narela SLF

Following are the salient features of the Landfill:

- Area of 112 hectares is being developed.
- Consist of 10 cells of 1.5 million tonne capacity each.
- Each cell life of 1-2 year.
- Operating life to be 20 years.
- Post closure care of 25 years.
- Leachate treatment facility proposed.
- Leachate collection capacity of 5 cum/hr proposed.
- Total capacity of SLF to be 15 million tonnes.
- Concentration of Methane gas generated at landfill site not to exceed 25% of Lower Explosive Limit.
- Bottom liner to consist of 1.5mm HDPE liner with 0.9m compacted low permeability soil ($k<1x10^{-7}$ cm/sec).
- Intermediate liner to be 600 mm thick compacted local soil.
- Final cover 40 microns LDPE liner with 750mm thick layer of compacted soil of hydraulic conductivity of $1x10^{-6}$ cm/sec or less.
- A 1000 TDP waste to energy plant to be upgraded to 4000TPD, which will use Refused Derived Fuel for power generation to generate 35 MW of power, is being set up by M/s DMSWSL and is expected to be operational in 2012.
- Work of setting up 450 TPD compost plant has been awarded. Expected to be operational in 2012.
- 350 TPD C&D Waste processing facility being set up by IL&FS.

3.4.2 Technical Aspects

- All the proposed new facilities in future will have liner system to protect contamination of sub-soil water.
- Leachate treatment facilities will be provided.
- Provision for Methane harvesting.
- 15 M height for landfills above ground level.

3.4.3 Modern Sanitary Landfill

Final disposal of wastes at sanitary landfills is given the lowest priority in an Integrated Waste Management approach. A sanitary landfill is a facility designed specifically for the final disposal of wastes that minimizes the risks to human health and the environment associated with solid wastes. Sanitary landfills commonly include one, two or three different liners at the bottom and sides of the disposal area, in order to prevent leachates from polluting nearby surface waters or aquifers. Liners also prevent the underground movement of methane. Waste arriving at landfills is compacted and then covered with a layer of earth, usually every day. This prevents animals from having access to the organic matter to feed. Sanitary landfills may also include other pollution control measures, such as collection and treatment of leachate, and venting or flaring of methane.

3.4.4 Essential Components

The seven essential components of a MSW landfill are:

- A liner system at the base and sides of the landfill which prevents migration of leachate or gas to the surrounding soil.
- A leachate collection and control facility which collects and extracts leachate from within and from the base of the landfill and then treats the leachate.
- A gas collection and control facility (optional for small landfills) which collects and extracts gas from within and from the top of the landfill and then treats it or uses it for energy recovery.
- A final cover system at the top of the landfill which enhances surface drainage, prevents infiltrating water and supports surface vegetation.
- A surface water drainage system which collects and removes all surface runoff from the landfill site.
- An environmental monitoring system which periodically collects and analyses air, surface water, soil-gas and ground water samples around the landfill site.
- A closure and post-closure plan which lists the steps that must be taken to close and secure a landfill site once the filling operation has been completed and the activities for long-term monitoring, operation and maintenance of the completed landfill.

3.4.5 Leachate Collection Systems

Integrated into all liner systems is a leachate collection system. This collection system is composed of sand and gravel or a geo-net. A geo-net is a plastic net-like drainage blanket. In this layer is a series of leachate collection pipes to drain the leachate from the landfill to holding tanks for storage and eventual treatment. In double-liner systems, the upper drainage layer is the leachate collection system, and the lower drainage layer is the leak detection system. The leak detection layer contains a second set of drainage pipes. The presence of leachate in these pipes serves to alert landfill management if the primary liner has a leak.

Components of the liner system are protected by a layer that minimizes the potential for materials in the landfill to puncture the liner. This protective layer was traditionally composed of soil, sand, and gravel, but many landfills now use a layer of soft refuse instead of soil. Soft refuse consists of paper, organic refuse, shredded tires, and rubber.

3.4.6 Liner Components

- **Clay**

To protect the ground water from landfill contaminants, clay liners are constructed as a simple liner that is two to five feet thick. The effectiveness of clay liners can be reduced by fractures induced by freeze-thaw cycles, drying out, and the presence of some chemicals. In theory, one foot of clay is enough to contain the leachate. The reason for the additional clay is to safeguard the environment in the event of some loss of effectiveness in part of the clay layer. The efficiency of clay liners can be maximized by laying the clay down in four to six inch layers and then compacting each layer with a heavy roller. The efficiency of clay liners is impaired if they are allowed to dry out during placement.

Desiccation of the clay during construction results in cracks that reduce the liner efficiency. In addition, clays compacted at low moisture contents are less effective barriers to contaminants than clays compacted at higher moisture contents. Liners that are made of a single type of clay perform better than liners constructed using several different types.

- **Geomembranes**

Geo-membranes are also called flexible membrane liners (FML). These liners are constructed from various plastic materials, including polyvinyl chloride (PVC) and high-density polyethylene (HDPE). The preferred material for use in MSW and secure landfills is HDPE. This material is strong, resistant to most chemicals, and is considered to be impermeable to water. Therefore, HDPE minimizes the transfer of leachate from the landfill to the environment.

- **Geotextiles**

In landfill liners, geotextiles are used to prevent the movement of small soil and refuse particles into the leachate collection layers and to protect geo-membranes from punctures. These materials allow the movement of water but trap particles to reduce clogging in the leachate collection system.

- **Geosynthetic Clay Liner (GCL)**

Geo=synthetic clay liners are becoming more common in landfill liner designs. These liners consist of a thin clay layer (four to six millimeters) between two layers of a geotextile. These liners can be installed more quickly than traditional compacted clay liners, and the efficiency of these liners is impacted less by freeze-thaw cycles.

- **Geonet**

A geo-net is a plastic net-like drainage blanket which may be used in landfill liners in place of sand or gravel for the leachate collection layer. Sand and gravel are usually used due to cost considerations, and because geo-nets are more susceptible to clogging by small particles. This clogging would impair the performance of the leachate collection system. Geo-nets do, however, convey liquid more rapidly than sand and gravel.

3.4.6.1 Minimum requirements

On a basis of review of liner systems adopted in different countries, it is recommended that for all MSW landfills the following single composite liner system be adopted (waste downwards) as the minimum requirement:

(a) A leachate drainage layer 30 cm thick made of granular soil having permeability (K) greater than 10-^{2} cm/sec.

(b) A protection layer (of silty soil) 20 cm to 30 cm thick.

(c) A geo-membrane of thickness 1.5 mm or more.

(d) A compacted clay barrier or amended soil barrier of 1 m thickness having permeability (K) of less than 10^{-7} cm/sec.

The liner system adopted at any landfill must satisfy the minimum requirements published by regulatory agencies (MOEF/ CPCB). It has to be more stringent in free draining alluvial soils at locations where water table level is close to the base of the landfill. The recommendations for the liner system are not expected to be reduced. However in circumstances where it can be proven by subsoil investigations as well as by hydrological investigations that the leachate will not cause harmful impact to the soil as well as ground water, the norms can be reduced after approval by the regulatory authority.

3.5 Leachate Generation

Leachates are defined as water that has percolated through the wastes (rainwater or groundwater seepage), a source of soil and groundwater contamination. The leachate consists of many different organic and inorganic compounds that may be either dissolved or suspended. Regardless of the nature of the compounds, they pose a potential pollution problem for local ground and surface waters. The leachate is a most toxic by-product of a solid waste decomposition. The chemicals within the leachate vary over time depending on the physical, chemical and biological activities occurring within the landfill. The leachate consists of solid metals, phenols, pesticides and other harmful substances.

Not-rarely, bacteria causing infection diseases can occur in the leachate. The pH value of the leachate vary between 6 and 9, while the values for BOD_5 can reach a value of up to 10000 mg/l and COD a value of 20000 mg/l in young leachate.

Many factors influence the production and composition of leachate. One major factor is the climate of the landfill. For example, where the climate is prone to higher levels of precipitation there will be more water entering the landfill and therefore more leachate generated. Another factor is the site topography of the landfill which influences the runoff patterns and again the water balance within the site.

The major environmental problems experienced at landfills have resulted from the loss of leachate from the site and the subsequent contamination of surrounding land and water. Improvements in landfill engineering have been aimed primarily at reducing leachate production, collecting and treating leachate prior to discharge, and limiting leachate discharge to the assimilative capacity of the surrounding soil. Whether leachate is to be collected and treated or is allowed to discharge to the soil, it is essential to have estimates of leachate flow and strength and the variation of these with time as the site develops, through closure and after closure.

3.5.1 Mechanisms of leachate formation

Leachate is produced when moisture enters the refuse in a landfill, extracts contaminants into the liquid phase, and produces moisture content sufficiently high to initiate liquid flow. Sources of moisture entering the landfill include liquid present in the refuse at placement, precipitation falling on refuse at placement and infiltrating after cover application, and intrusion of groundwater from outside into the landfill.

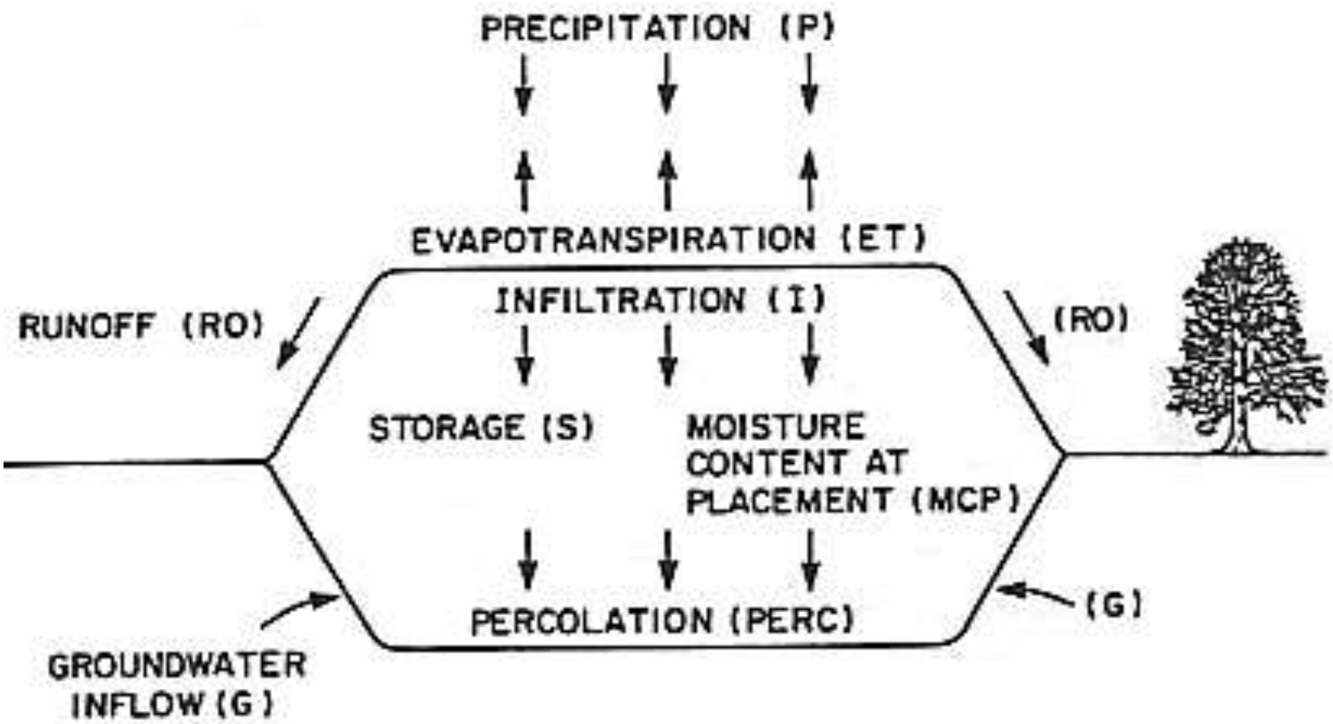
The formation includes the following steps:

(i) Precipitation falls on the landfill and some of it becomes runoff.

(ii) Some of the precipitation infiltrates the surface (uncovered refuse, intermediate cover, or final cover).

(iii) Some of the water infiltrated evaporates from the surface and (or) transpires through the vegetative cover if it exists. Some of the infiltrated water may make up a deficiency in soil moisture storage (the difference between field capacity (FC) and the existing moisture content (MC)).

Fig 3.1: Mechanism of Leachate formation



(iv) The remainder of water, after needs of evaporation, transpiration, and storage has been satisfied, moves downward forming percolate and eventually leachate as it reaches the base of the landfill.

(v) Percolation may be augmented by infiltration of groundwater. The procedure used to analyze these processes is referred to as a water balance, various forms of which are commonly used for the simulation of surface water hydrology.

3.5.2 Leachate Composition

The characteristics of leachate generated depend on the following factors

- Type of waste involved (industrial or municipal)
- Siting of the landfill
- The design and the mode of operation of the landfill
- Evolution through time

Organic and inorganic contaminants of landfill leachate are released from the waste due to successive biological, chemical and physical processes. Basically, three phases of decomposition are distinguished for domestic landfills occurring within twenty years.

In the first stage following waste deposit, initial aerobic phase rapidly consumes the confined oxygen and water infiltration enhances acetogenic fermentation producing leachate characterized by high BOD, COD and ammoniacal nitrogen contents. Volatile fatty acids (VFA) are the main components of the organic matter released; besides the lower pH solubilises metals.

Gradually, the methanogenic phase of decomposition starts and consumes the simple organic compounds resulting from acetogenic process to produce biogas. In that stage, the leachate composition represents the dynamic equilibrium between the two microbiological mechanisms with lower BOD and COD values while the ammonia concentration remains high. Dissolved inorganic materials are continuously released.

With landfill ageing, waste stabilization takes place. As the volatile fatty acids leachate content decreases parallel to the BOD/COD ratio, the leachate organic matter is made up of high molecular weight humic and fulvic-like material (HMW).

Table 3.1: Leachates classification

LEACHATE TYPE	YOUNG	INTERMEDIATE	STABILIZED
Landfill age yr	<5	5-10	>10
pH	<6.5	7	>7.5
COD g/l	>20	3-15	<2
BOD/COD	>0.3	0.1-0.3	<0.1
TOC/COD	0.3	-	0.4
Metals	2	<2	<2

Though leachate Composition may vary widely within these stages three types of leachates can be defined according to landfill age. Leachate flow changes literally with the weather, increasing during rainy periods and then decreasing during dry. Waste concentrations can change dramatically over the life of the landfill. Leachate from young landfills is high in biodegradable organics. But later on, as the landfill ages, contents degrade and produce concentrations of complex organics, which are not readily biodegradable.

3.6 Future Planning for SWM in Delhi

It is necessary to construct all the future Landfill sites with Liner systems to save the contamination of groundwater at those locations. Composting of organic waste should be encouraged in existing and future landfills to reduce the waste component to be landfilled. The People residing near the existing Landfill sites should be made aware of the consequences of using the groundwater for human consumption. Latest technologies should be adopted to reduce the final disposable inert product being produced from SWM.

3.6.1 Energy Recovery Technologies

Some of the possible methods of waste treatment are listed below:

a) Biomethanation

Anaerobic digestion is process used for biological decomposition of organic wastes. The organic wastes are hydrolyzed, liquified and gasified with the help of methanogenic bacteria. There is an appreciable saving in recurring costs in such processes because of the utilization of bio-gas.

b) Sanitary Land-fill Gas

Sanitary land filling is a process of dumping of solid waste in a scientifically designed land area spreading waste in thin layers, compacting to the smallest practicable volume and covering with soil on daily basis. The methane rich biogas is produced due to anaerobic decomposition of organic matters in solid wastes. Garbage has a potential to generate about 150-250 cubic metre biogas per tonne waste depending upon the quality.

c) Pelletisation

Fuel pellets also referred as refuse derived fuel (RDF) are small cubes/cylindrical pieces made out of garbage. Its calorific value, 4000 Kcal/kg of the product is quite close to the coal, therefore, it can be good substitute for coal, wood etc.

d) Pyrolysis/Gasification

In this process, combustible matter of garbage is allowed to dry/dewater and then is subjected to shredding. Incineration of waste under oxygen-deficient conditions is called pyrolysis. The objective of pyrolysis has generally been to produce gas, which would be stored and used when required.

e) Incineration

Incineration is a process of controlled combustion for burning of wastes and residue, containing combustible material. Carbon dioxide, water vapour, ash and non-combustibles are end products. The heat generated during incineration is recovered and utilized for the production of steam, heating water and generating electricity. Incineration is used to achieve maximum volume reduction of solid waste and when there is shortage of land filling facilities. It is usually cost effective method of disposal.

f) Composting

Composting is one of the methods of waste utilization. It is defined as the decomposition of heterogeneous organic matter by a mixed microbial population in the moist, warm and aerobic environment. These microorganisms convert organic wastes into humus, which has significant value to agriculture farming.

Merits of the composting process are:

1. Foul smells is quickly eliminated.
2. Processing site is made hygienic for workers.
3. Harmful pathogens are killed by exothermic heat. .
4. Waste becomes free from flies and vultures.
5. Chances of smoke and fire hazards are minimized.
6. Weed seeds, fruit nuts are made unviable.
7. Waste material becomes safe for re-transportation etc.
8. Value added matured organic manure is derived for use in agriculture, horticulture, landscaping etc.
9. Re-cyclable products like glass, metals; plastics are recovered at the end of the process.
10. Minimizes production and release of gases like methane, ammonia, hydrogen sulphide etc., in the environment.

g) Vermiculture

Vermiculture is an aspect of biotechnology involving the use of earthworms as natural and versatile bio-reactors for cleaning up the environment by adoption of cost-effective waste management technique. Vermiculture means culturing of earthworms in a scientific manner. It is a simple low-cost and appropriate biotechnology using earthworms systematically. By providing them with optimum conditions for rapid multiplication and conversion of farm wastes and bio-degradable urban wastes into bio-fertilizers, it can preserve and improve the soil fertility.

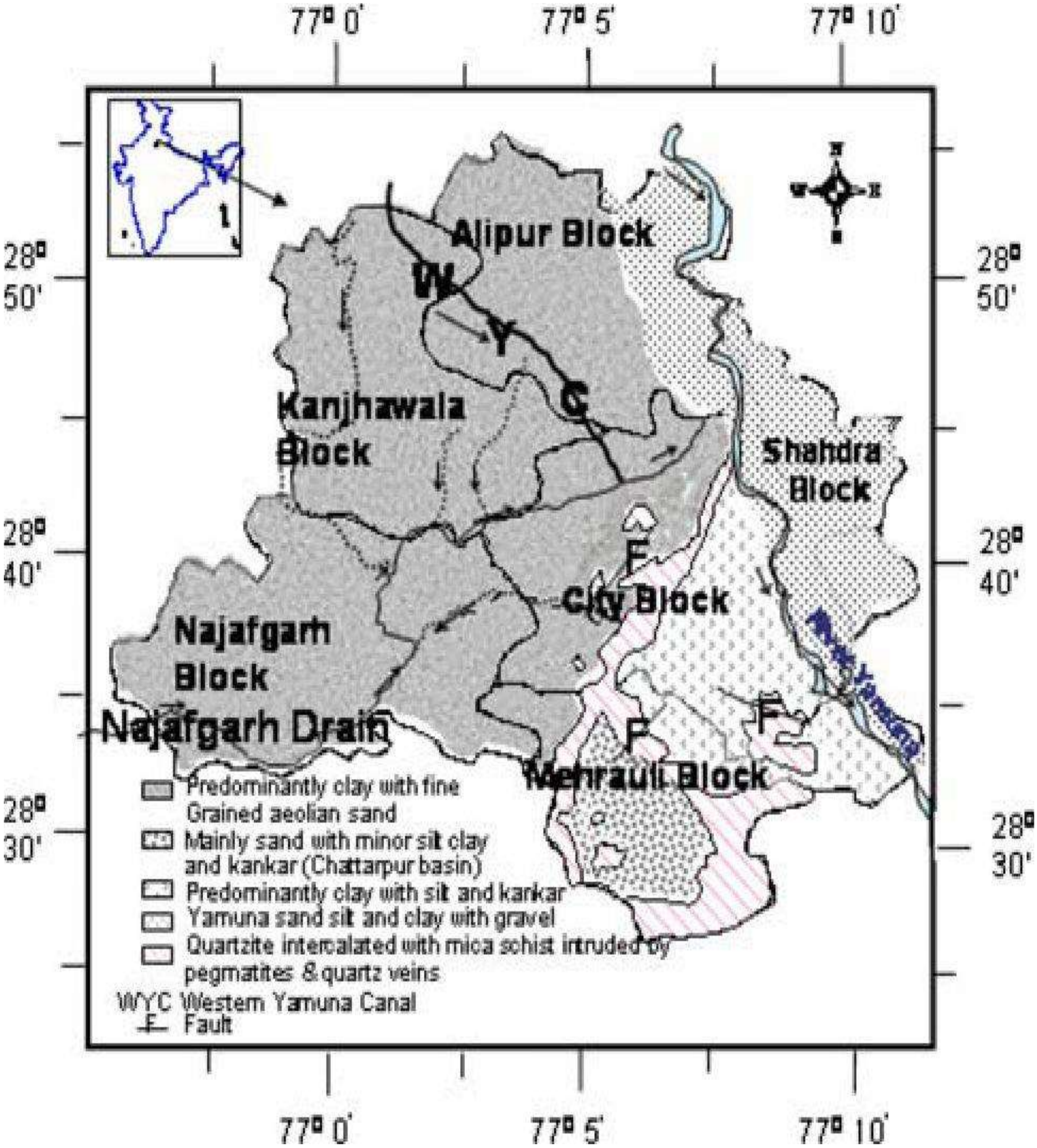
CHAPTER- 4
STUDY OF OPERATIONAL LANDFILLS IN DELHI

CHAPTER 4

STUDY OF OPERATIONAL LANDFILLS IN DELHI

4.1 Introduction

The geological composition of Delhi is shown in the map & table given below.

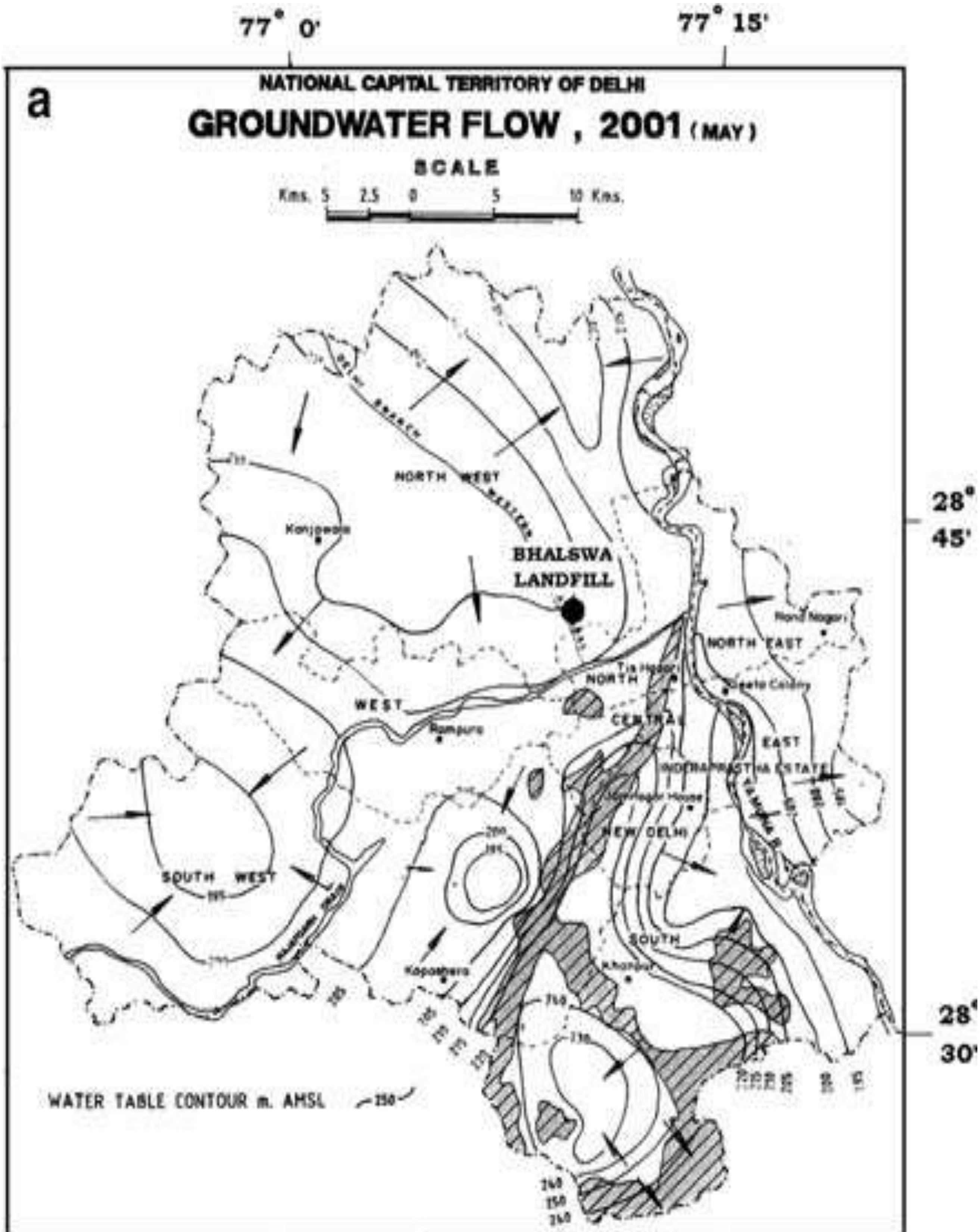


Map. 4.1 Geology of study area (source: CGWB 2001)

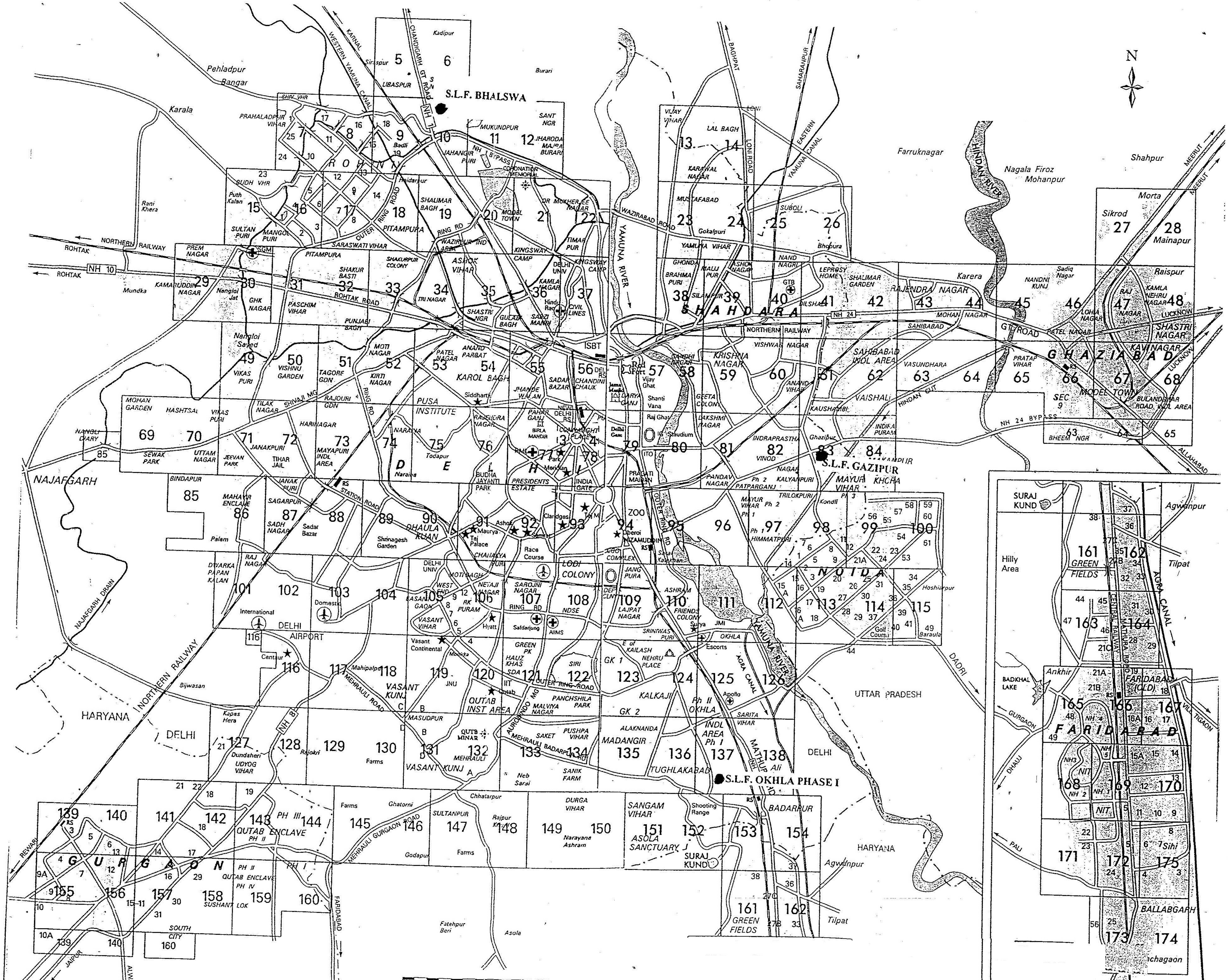
Table 4.1 Geology of study area

	Age Group	Lithology	Hydrological Condition	Groundwater Potential
Unconsolidated formation	**Newer Alluvium (Quarternary)**	Yamuna Sand, Silt and clay with gravel	30-40m thick unconfined to semi confined aquifers	Very large yield 100-280 m^3/hr
		Predominantly Clay associated with fine grained Aeolian deposit	Fairly thick regional extensive semi confined aquifers	Large yield prospects 30-100 m^3/hr
	Older Alluvium (Tertiary)	Predominantly Clay with silt and kankar	Local limited thick semi-confined aquifer	Moderate yield prospects 23-100 m3/hr
Consolidated formation	**Delhi super group (Precambrian)**	Mainly sand with minor clay and kankar (Chattarpur Bain)	Fairly thick, regionally extensive aquifers	Low yield prospects 10-30 m^3/hr
		Quartzite intercalated with mica schist ,intruded by pegmatite and quartz veins	Weathered, fractured quartzite highly jointed	Limited yield prospects 0-10 m^3/hr

(source: CGWB 2001)



Map 4.2 Groundwater flow direction (source: CGWB 2001)



Map 4.3 Showing Location of Solid Waste Disposal Sites in Delhi

SOURCE
EICHER CITY
MAP PAGES

Map 4.4 Satellite view of Bhalaswa SLF
(Source: Google Earth)

Map 4.5 Borehole Location at Bhalaswa SLF
(Source: Google Earth)

Map 4.6 Satellite view of Okhla SLF
(Source: Google Earth)

Map 4.7 Borehole Location at Okhla SLF
(Source: Google Earth)

4.2 Bhalaswa

4.2.1 Bhalaswa SLF – Facts & Figures

i. Bhalaswa SLF is located on National Highway 1, on the North West corner of Delhi on the Northern side of the G.T.K bypass.
ii. The landfill was established and commissioned in 1993. It has served well past its designed life. Its designed life ended in 2005.
iii. The Area of the landfill is around 21.06 Ha.
iv. The SLF receives around 2200 MT of Solid Waste daily.
v. There are about 80-90 personnel working at the Bhalaswa SLF.
vi. No Leachate pond existing at site, Leachate is discharged into Supplementary drain through lined drains.
vii. No Gas control equipment installed at site.
viii. A 300 TPD Compost plant is being operated by a private operator (Nature Waste Management India Limited).
ix. It has been proposed to reclaim the landfill by deploying a number of technologies to set up recycling plants, in a phased manner.
x. The weighing bridge is fully computerized at the landfill run by a private agency.
xi. The total estimate of fuel expenditure comes out to be around 500-600 liters of diesel per day.
xii. 14 machines are present on the SLF site. Most of them are out of order. Three to four machines are operated at a given time.
xiii. There is maximum load on the SLF is during the months of April-July.
xiv. Solid Waste is received from the zones – West, K.Bagh, Rohini, Najafgarh, Narela, Civil Lines, SP, City, Delhi APMC, DMRC and DDA.

4.3 Okhla

4.3.1 Okhla SLF – Facts & Figures

i. Okhla landfill site is located at Okhla Ph-I, which is about 2 km from National Highway- 2 on South East end of the city, Established in 1994.
ii. The Area of the landfill is around 16.20 Ha.
iii. Site serves for dumping of solid waste generated from South Delhi and Central Delhi.
iv. The SLF receives around 2000 MT of Solid Waste daily.
v. Compost plant with daily intake capacity of 200 MT, is operated by MCD.
vi. A 2050 TDP waste to energy plant which will use Refused Derived Fuel for power generation to generate 16 MW of power is being set up by M/S Jindal Urban Infrastructure Limited., expected to be operational in 2012.
vii. Does not have any liners at the base bulldozers.
viii. No arrangement for leachate collection and treatment. Leachate is being disposed into existing sewer through open drains.

The solid waste received at site is leveled and compacted with the help of hydraulic bulldozers. The solid waste so leveled is covered daily with daily cover with building

Map 4.8 Satellite view of Ghazipur SLF
(Source: Google Earth)

Map 4.9 Borehole Location at Ghazipur SLF
(Source: Google Earth)

rubbish and/or good earth. The site is divided into ten pockets and dumping is carried out in Onion Skin layer method with every refuse lift of 1 to 2 m covered with a daily cover of 0.15 m. The intermediate covers are made as per requirements. The site is finally covered with a soil cover of approximately 0.6 m (2ft). Also the top surface is given some slope to obtain better run off. The solid waste depth varies from 2 m on the western side of the landfill to approx. 15 m on the eastern side. The pockets, which have attained their final height, are covered with soil cover and vegetation process has been started. At present ten numbers gas wells have been provided at the landfill site and the gas so collected is flared out.

4.4 Ghazipur

4.4.1 Ghazipur SLF – Facts & Figures

i. Ghazipur SLF is located on National highway 24 Bypass at the eastern border of Delhi
ii. Established and commissioned in 1984
iii. The Area of the landfill is around 29.16 Ha.
iv. Quantity of waste already deposited is estimated at 5.0 million cum.
v. There are 10 cells in the Gazipur SLF with bottom slope of 1:200
vi. The landfill handles about 3000 MT of Solid Waste daily
vii. No Leachate pond existing at the SLF site. Leachate is being disposed through brick lined drains.
viii. The weighing bridge is fully computerized at the landfill and is run by a private agency
ix. This SLF also caters to the Slaughter House Waste
x. This SLF caters to these zones/areas/agencies – Shahdara (North, South), Central, S.P, Delhi Cantt, NDMC, etc.
xi. Large numbers of birds and stray animals can be sighted due to unregulated Slaughter house & Bio-medical waste.
xii. A 1300 TDP waste to energy plant which will use Refused Derived Fuel for power generation to generate 10 MW of power is being set up by M/s DIAL and is expected to be operational in 2012.
xiii. No Gas Collection Equipments installed at site. However feasibility studies have been carried out with World Bank assistance for gas recovery and reuse and MOU has been signed with GAIL.
xiv. A proposal to process waste lying at Ghazipur, has been approved by the planning commission at a total cost of 30.19 crore including Machinery installation & O&M cost to process 2000TPD of solid waste. It has been proposed to reclaim the landfill.

CHAPTER 5

EFFECT OF LANDFILL ON HUMAN HEALTH

CHAPTER- 5
EFFECT OF LANDFILL ON HUMAN HEALTH

5.1 Introduction

Landfills pose many threats to public health, safety, and the environment. Some of these are enlisted below:

Table 5.1 Potential Health Hazards due to Landfills

THREAT	HAZARD
Failure of liner & leachate containment system	Public health, Environmental
Runoff of sediment & leachate	Wetlands damage, wildlife habitat
Illegal roadside dumping and litter near landfill	Aesthetics, Public health, Economics
Truck traffic	Congestion, air pollution, aesthetics, public health and safety
Noise	Aesthetics, public health
Odours	dumping and landfill gas ,aesthetics, public health
Dust and wind blown litter	Aesthetics, public health
Vectors, insects, rodents, birds	Public health, nuisance, aircraft hazard
Impaired view/view shed	Aesthetics

All municipal solid waste (MSW) landfills, even with modem "state of the art" landfill construction that includes liners, leachate collection system, relatively impervious landfill "caps", and gas collection & treatment systems, are dangerous to the environment and a threat to public health. In this chapter the health aspects related to leachate are discussed in length.

5.2 The Chemical Composition of Leachate and its Related Aspects

Containing hundreds of different chemicals, the quality of municipal landfill leachate varies greatly within individual landfills over time and space as well as among different landfills. Many factors influence leachate composition including the types of wastes deposited in the landfill, the amount of precipitation in the area and other site specific conditions. The rates of biological and chemical activity taking place in a specific landfill or landfill cell can also affect leachate quality by altering the way that waste dissolves in or migrates with leachate (US EPA Landfill Manual).

Pathogenic microorganisms do not usually appear in landfill leachate at concentrations high enough to cause public health concern, but other substances found in leachate and its groundwater mixtures may adversely affect human health (Barlaz, Morton A., et aI., 1990). Many of the numerous studies conducted on the chemical quality of leachate have shown that samples of leachate as well as samples of leachate mixed with underlying groundwater often contain toxic chemicals in excess of standards for drinking water quality.

Incomplete knowledge of characteristics of landfill leachate makes it difficult to determine its overall toxicity. Although standards have been developed for some of the chemicals present in leachate that have been proven to have toxic effects, other leachate chemicals have neither been studied nor regulated. In addition, the mix of different chemicals contained in leachate may result in chemical combinations that are more harmful than the individual leachate chemicals. Table 5.2 defines various terms associated with human health and their effect on humans.

Laboratory tests can determine whether groundwater samples contain some of the deleterious substances that can be present in leachate, indicating that leachate contamination may have occurred. Three specific categories of substances are often analyzed in these tests: volatile organic compounds, metals, and general water quality parameters. The following sections describe these indicators of leachate contamination.

Table 5.2 Terms Defining the Health Effects of Chemicals

Term	Health Effects
Toxic	Upon exposure, toxic chemicals produce detrimental ill effects on living organisms
Acute Toxicity	An immediate effect from a short-term exposure to a Chemical Substance. Some of these effects include injury to the lungs, liver, Kidneys or immune system, and neurological damage
Chronic	An effect from a prolonged but time-limited exposure to a chemical substance. The effects are the same as those incurred from exposure to acutely toxic chemicals.
Sub Chronic Toxicity	An effect produced by a prolonged and continuing exposure to Toxicity a chemical substance. Such effects include delayed toxic reactions, Progressive degeneration, and tissue damage.
Environmental Toxicity	A toxic effect on fish, birds or other non-human organisms.

Carcinogenic	Upon exposure, carcinogenic chemicals can cause uncontrolled cell growth, producing tumors, leukemia's and other forms of cancer. initial exposure to a carcinogenic chemical may slightly alter the genetic structure of a cell yet begin the sequence of events leading to cancer. Many experts believe there is no threshold or safe level of exposure to a carcinogen. Since the length of time between exposure to a carcinogenic chemical and the diagnosis of cancer in humans may be 20-40 years, it may be impossible to link the cancer to a specific chemical.
Mutagenic	Upon exposure, mutagens can permanently change an organism's genetic material, or DNA. If reproductive organs are exposed, the damaged genes may then be passed on to the person's offspring.
Teratogenic	Upon exposure to the mother, teratogens can cause Non-hereditary birth defects in the unborn fetus.

(Source: Sierra Club Legal Defense Fund, 1989).

In the 1980's, when EPA was preparing a new rule for municipal waste disposal, the agency conducted numerous studies of existing landfills, considering leachate and other associated environmental problems

Table 5.3 Health Effects of Selected Volatile Organic Chemicals (VOC's) Found in Landfill Leachate

Type of VOC	Effects
Benzene	Human carcinogen, mutagen, and possible teratogen; central Nervous system (CNS), peripheral nervous system, Immunological and gastrointestinal effects; blood cell disorders; allergic sensitization; eye and skin irritation.
Chloroform	Probable human carcinogen and possible teratogen; CNS and gastrointestinal effects; kidney and liver damage; embryo toxic; eye and skin irritation
I, I-dichlorethane	Embryotoxic; CNS effects; kidney and liver damage.
Ethyl benzene	CNS effects; kidney and liver damage; upper respiratory system, eye and skin irritation.

Methylene Chloride	Possible carcinogen; CNS, lung/respiratory system, and Cardiovascular effects; blood disorders; eye and skin irritation.
Tetrachloroethylene	Probable carcinogen; CNS and lung / respiratory effects; embryotoxic; kidney and liver damage; upper respiratory tract and eye irritation.
Toluene	Possible mutagen and carcinogen; CNS and cardiovascular effects; kidney and liver damage; upper respiratory tract, eye and skin irritation; and allergic sensitization.
Trichloroethylene	Probable carcinogen; CNS and lung / respiratory effects; embryotoxic; kidney and liver damage; upper respiratory tract and eye irritation.
1,1,1-trichloroethylene	Carcinogenic; mutagenic; CNS and lung/respiratory effects; kidney and liver damage; eye and skin irritation.
Vinyl Chloride	Carcinogenic; mutagenic; possible teratogen; CNS effects; Kidney and liver damage; blood cell disorders; and skin irritation.
Xylene	CNS and cardiovascular effects; kidney and liver damage; Upper respiratory and eye irritation.

(Source: Sierra Club Legal Defense Fund, 1989).

5.3 The Effect of Metals on Human Health

Metals occur naturally in the environment along with nutrients, minerals, and salts. Metals are termed "inorganic" chemicals since they are not based on carbon and hydrogen structures. Metals are used in many industrial and manufacturing processes, such as the making of alloys and metal products; in electroplating; and in products like paint, glass, plastic, and pesticides. Common items made of metal include cans, appliances, aluminum foil and other household goods. Most metals are not carcinogenic when consumed in drinking water, but they produce other serious toxic effects.

When deposited into the ground, metal particles frequently bind to the soil and do not easily dissolve or migrate with water. In the acidic conditions of a landfill, however, metals such as cadmium, copper, iron, manganese, and lead can dissolve and migrate with leachate. Other chemical reactions in a landfill can also change the state of metals, allowing them to attach to other particles and travel with leachate.

The 1988 U.S. EPA study that consolidated leachate data from 70 municipal landfills calculated median values for metals in the samples (US EPA 1988, Report Volume II). Several metals that

cause a variety of health effects exceeded drinking water standards, including antimony, beryllium, cadmium, lead, mercury, nickel and thallium.
Table 5.4 presents the health effects of some of the metals found in landfill leachate.

Table 5.4 Health Effects of Selected Metals Found in Landfill Leachate

METAL	HEALTH EFFECT
Arsenic	Carcinogenic; potential teratogen; cardiovascular, peripheral nervous system, reproductive and lung/respiratory effects; liver and skin damage.
Cadmium	Probable carcinogen and teratogen; embryotoxic; CNS, reproductive and lung/respiratory effects; kidney damage.
Chromium	Carcinogenic, probable mutagen, lung/respiratory effects, allergic sensitization, eye irritation.
Mercury	Teratogenic (organic mercury substances); CNS, cardiovascular and lung/respiratory effects; kidney and visual damage.
Nickel	Probable carcinogen, possible teratogen, lung/respiratory effects, allergic sensitization, eye and skin irritation, liver and kidney damage.

(Source: US EPA Landfill Manual).

5.4 Other Chemicals Found in Leachate

Leachate and groundwater samples taken near landfills are frequently tested for volatile organic compounds, metals and general water quality parameters. Other chemicals found in landfill leachates include synthetic organic compounds (SOCs), and alcohols.

5.4.1 The Effect of Synthetic Organic Compounds (SOC's) on Human Health

Synthetic Organic Compounds (SOC's) may also pose threats to human and environmental health. SOCs are human-made chemicals based on a carbon and hydrogen structure that, unlike VOCs, do not volatilize in the air. These chemicals are common in agricultural applications such as pesticides, herbicides and fungicides. Many sacs are probable or known carcinogens, and some cause toxic effects to the liver, lungs and kidneys, central nervous system or reproductive system. Drinking water standards have been created for only a small nun1ber of SOCs, including 2,4-D, endrin, lindane, pentachlorophenol and toxaphene. Table 5.5 summarizes the health effects of some common SOCs.

Table 5.5 Health Effects of Selected Synthetic Organic Compounds Found In Landfill Leachate

Synthetic Organic Compounds	Effect on Human Health
2,4-D	Mutagenic; possible carcinogen and teratogen; reproductive, nerve, liver and kidney damage; lung/respiratory effects; skin and eye irritation.
Lindane	Reproductive, nerve and liver damage; possible carcinogen.
Pentachlorophenol	Possible mutagen and teratogen; eye, skin and lung/respiratory irritation; liver and kidney damage.

(Source: US EPA Landfill Manual).

In the 1988 EPA consolidation of leachate data from 70 municipal landfills, some studies analyzed five synthetic organics. In these studies, researchers found that the average concentrations of two SOCs, pentachlorophenol and 2,4-D, exceeded federal drinking water standards (US EPA 1988, Report Volume II). The studies also indicated that SOCs might be found most often in landfill leachate originating from agricultural areas, since these landfills are likely to contain equipment coated with pesticide residues or the empty containers of SOC-containing agricultural chemicals.

5.4.2 The Effect of Alcohols on Human Health

Alcohols are other contaminants found in landfill leachate. Some alcohols, including methanol and ethanol, are produced by biological activities in the landfill. Others, such as butanol, ethanol, propanol, and phenols, are found in industrial solvents and household products. Though they are usually volatile organic compounds, alcohols are not often listed with the other VOCs because different laboratory tests are used to determine their presence and concentration.

One study of leachate from two municipal landfills concluded that alcohols posed a greater health risk than any other leachate chemicals (Brown, K. W., and Donnelly K. c., 1988). The health effects associated with some of the alcohols found in landfill leachate are presented in Table 5.6.

Table 5.6 Health Effects of Selected Alcohols Found in Landfill Leachate

Alcohols	Effect on Human Health

Ethanol	Mutagenic, carcinogenic, causes birth defects
I-propanol	Possible carcinogen
(propyl alcohol)	
2-propanoll	Possible carcinogen; eye, skin and upper respiratory irritation; possible CNS effects
(isopropyl alcohol)	
4-nitrophenol	Possible mutagen and carcinogen, blood cell disorders, skin and upper respiratory irritation, CNS effects

(Source: Brown, K.W., and K.C. Donnelly, 1988).

5.5 Health Studies of People Residing Near Landfill Sites

5.5.1 Study in Delhi

A study has revealed that use of ground water has caused rashes on the skin, hair loss and other skin diseases in the residents of Bhalaswa colony located adjacent to Bhalaswa sanitary landfill.

People living in surrounding areas are suffering from problems including Gaestro-intestinal problems, diarrhea, stomach ache, vomiting, skin infection, eye irritation and hair loss. In a survey conducted in the area 70% people reported gastro-intestinal irritation, 20.4% people complained skin infection, rashes or allergy, 19.8 % people reported diarrhea and vomiting, 17.9% people had burning sensation in eyes and 9.7% people suffered breathlessness.

A study conducted by Bhalaswa Lokshakti Manch revealed high concentration of TDS .In all the 15 samples tested, TDS was found to be above permissible limit of 500ppm. In 8 samples it varied up to 2000 ppm and in another 7 samples was found to be varying from 2373 to 5846 ppm. Of the 15 samples 7 tested positive for faecal contamination**. (Source HT dt. 16.01.2012)**

5.5.2 Study in US

Studies in US have shown that people living near landfills have increased incidences of cancer. A 1998 study by the New York State Department of Health reports that women living near solid waste landfills where gas is escaping have a four-fold increased chance of bladder cancer or leukemia (cancer of the blood-forming cells) (Trashing the Solid Waste Master Plan).

This New York study examined the occurrence of seven kinds of cancer among men and women living near 38 landfills where naturally occurring landfill gas is thought to be escaping into the surrounding air. Of the 14 kinds of cancer studied (7 each in men and women), 10 (or 71%) were found to be elevated but only two (bladder and leukemia in women) achieved statistical significance at the 5% level. The seven cancers studied were leukemia, non-Hodgkin's lymphoma, liver, lung, kidney, bladder, and brain cancer. In women living near landfills, the incidence of all seven kinds of cancer was elevated. In men, the study found elevated (though not statistically significant) incidence of lung cancer, bladder cancer, and leukemia.

A 1995 study of families living near a large municipal solid waste landfill (the Miron Quarry) in Montreal, Quebec reported an elevated incidence of cancers of the stomach, liver, prostate, and lung among men, and stomach and cervix/uterus among women. Also it found a 20% increased likelihood of low birth weight among those most heavily exposed to gases from the landfill.
A 1990 study found an increased incidence of bladder cancers in northwestern Illinois where a landfill had contaminated a municipal water supply with trichloroethylene (TCE), tetrachloroethylene (PERC), and other chlorinated solvents.

A study of families living near the Lipari landfill in New Jersey reported low birth weight among babies born during 1971-1975, when the landfill was thought to have leaked the greatest quantity of toxic materials into the local environment.

A study of people living near the BKK landfill in Los Angeles County, California in 1997 reported significantly reduced birth weight among children born during the period of heaviest dumping at the site.

In one other study of 58 landfills, 113 toxic chemicals were in leachate from municipal landfills and 72 toxic chemicals in leachate from hazardous waste landfills. In municipal landfill leachate, 32 of the chemicals cause cancer, 13 cause birth defects, and 22-cause genetic damage; in industrial landfill leachate, 32 of the chemicals cause cancer, 10 cause birth defects, and 21-cause genetic damage.

Ammonia and a variety of organic nitrogen compounds are conventional contaminants that are also of great concern in MSW landfill leachate. Oxic ground waters contaminated by ammonia can have greatly elevated concentrations of nitrate. Nitrate above 10 mglL as N is a public health hazard in groundwater; it causes methemoglobinemia (blue baby disease).

Gintautas et al. (1992) reported finding a phenoxyalkanoic acid herbicide in municipal landfill leachate that had not been previously reported. They concluded that the chlorinate 2-phenoxypropionic herbicides are ubiquitous in MSW landfill leachates in the US. There are likely to be many other potentially hazardous or otherwise deleterious chemicals yet to be identified in MSW landfill leachate. It is clear that today's society has not found all of the highly hazardous chemicals that can cause cancer (carcinogens), birth defects (teratogens), and mutations (mutagens). It is highly likely that hazardous chemicals or hazardous transformation products that are now part of the non-conventional contaminants in MSW landfill leachate will be found in the future.

5.6 Expenditure incurred on Solid Waste Management by MCD

CHAPTER 6

ANALYSIS OF LEACHATE AND GROUND WATER FROM OKHLA, GHAZIPUR & BHALASWA LANDFILLS

A study by Macfarlane in 2000 looked at the capital expenditure on 25 major landfill sites throughout the world(mixed income) and concluded that upper tolerable limit of public expenditure in management of solid waste should not exceed 0.5% of GDP. Average GDP of Delhi in 2004 was INR 51728/-.The cap would be INR 259, while The per capita expenditure in waste management in Delhi in 2003-04 was Rs.268.1(MCD) .To reduce this cost to below 0.50% of GDP around 30 Mechanical Sweepers were inducted in the City in July 2011. (COWI report 2004).

5.7 Green House Gas Generation from Municipal Solid Waste in Delhi

Solid waste received at Landfills in Delhi (in 2011 MCD) – 7410 MT/day
Carbon contents in waste – 8.35% by weight
Generally 50% gas is converted into carbon dioxide (CO_2) and rest in methane (CH_4).Due to lack of arrangement for Methane harvesting methane is also released into the atmosphere.
Total quantity of Green House Gas Generation – 7410 x (8.35/100) x (12/16) =464.05 MT/day

5.8 Necessity of Checking Water Quality at SLF sites

Analysis of the Physical, Chemical and Biological characteristics of waste water is essential for the following reasons:
It provides the basic data on which the planning, designing and operation feasibilities of SLFs is based.
The changes/trend in composition and quantity of waste water over a period of time helps adopting suitable technologies for solid waste management.
This also helps in selection of equipment and appropriate technology
The time variation in these characteristics helps in the deployment of vehicles, equipments and machinery.
This can also be used as guideline for usage of water for drinking and other purpose.

CHAPTER- 6
ANALYSIS OF LEACHATE AND GROUND WATER FROM OKHLA,GHAZIPUR & BHALASWA LANDFILLS

6.1 Introduction

Water is one of the most important raw materials for the survival of living beings covering over 71% of the earth's surface.
Groundwater is historically being considered as reliable and safe source of water protected from surface contamination by natural filtration through geological ions present in soil. The ground water is however contaminated with varying degree of contamination from place to place resulting in various water borne diseases. Pollution of fresh water occurs due to many reasons, prominent being excess nutrients from sewage, industrial wastes, surface runoff from fields, leachate generated from solid waste at garbage/refuse dumping sites. The problem of drinking water contamination has assumed a lot of significance as it has far reaching effect on human health. The Quality of water is described by its physical, chemical and microbiological characteristics.

6.2 Study Area

In this section samples of leachate from Okhla ,Gazipur and Bhalaswa landfill sites and water from bore well located in surrounding areas have been taken to carry out the case study.

6.3 Methodology

The sample of leachate was collected from the landfill site on four different dates from same location. Similarly sample of water was taken from bore well located in surrounding area of the same landfill on the corresponding date. The leachate and water sample were tested for physical and chemical properties and results were collected. The process was repeated on four different dates with a gap of around two months between each collection date. The results were compiled to draw inferences. The process was repeated for other landfill.

6.4 Results and Discussion

6.4.1 Okhla Leachate

Table 6.1 Characteristics of Leachate from Okhla SLF

S. No	Characteristics	08-08-2008	10-10-2008	09-12-2008	04-02-2009
1	pH	8.36	8.34	8.29	8.32
2	Conductivity (mMhosl)	22240	21600	19400	20900
3	Turbidity (NTU)	690	720	710	705
4	Temperature (˚C)	46	42	39	41
5	Total dissolved solids	12600	11880	11680	11740
6	Chlorides	4424	5709	4614	4528
7	Nitrates	86	102	98	92
8	Sulphates	3976	3840	3470	3766
9	BOD	1208	1280	1248	1104
10	COD	11886	12608	12242	10680

11	TOC	5615	6400	6345	5980
12	Zn	4.158	3.586	3.924	4.206
13	Cd	Nil	Nil	Nil	Nil
14	Pb	Nil	0.012	Nil	Nil
15	Cu	Nil	Nil	Nil	0.028
16	Fluoride	31	41	39	36
17	Fe	21	22	19	23

(All units are in mg/l, except for turbidity, conductivity & temp)

6.4.1.1. pH

The pH values in the monitoring period of 186 days varied from 8.29 to 8.36 and fluctuated as shown in Figure 6.1. At a given temperature the intensity of the acidic or basic character of a solution in indicated by pH or hydrogen iron activity. pH variation not only depends on the concentration of the acids that are present but also on the partial pressure of carbon dioxide in the landfill gas that is in contact with leachate.

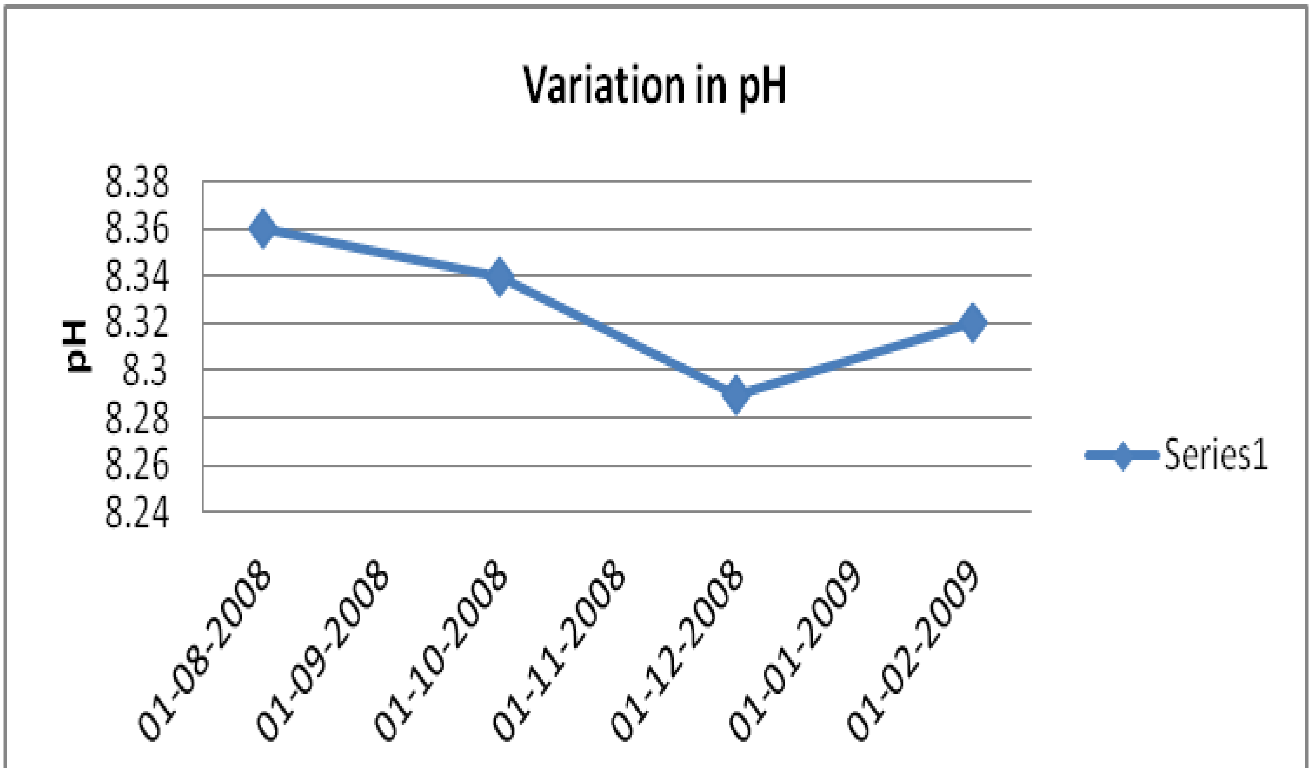


Fig 6.1 variation in pH

(The relationship between pH value and refuse age may be roughly categorized into two phases. In the initial phase (0 to 4 month) pH values decreases from 8.36 to 8.29, which may indicate that the refuse may be undergoing aerobic degradation, and then pH value increases to 8.32 in the following 2 months, which may be classified as the phase, where the facultative biodegradation may be predominant.

6.4.1.2 Conductivity

The conductivity of the leachate samples varied .In the initial phase (0 to 4 month) conductivity decreased from 22.4 to 19.40 to mMhosl. In the following 2 months Conductivity increased to 20.9 mMhosl. The Figure 6.2 shows the periodic variation of leachate during the study period. All the electrolytes or charged ions largely comprising of cations and anions of inorganic matter which remain prevalent in the sample in the dissociated form have ability to carry electric current and they, depending on their charges, move towards the oppositely charged electrodes.

However organic constituents, particularly those, which exist in un-dissociated form, are not found good for carrying the electric current.

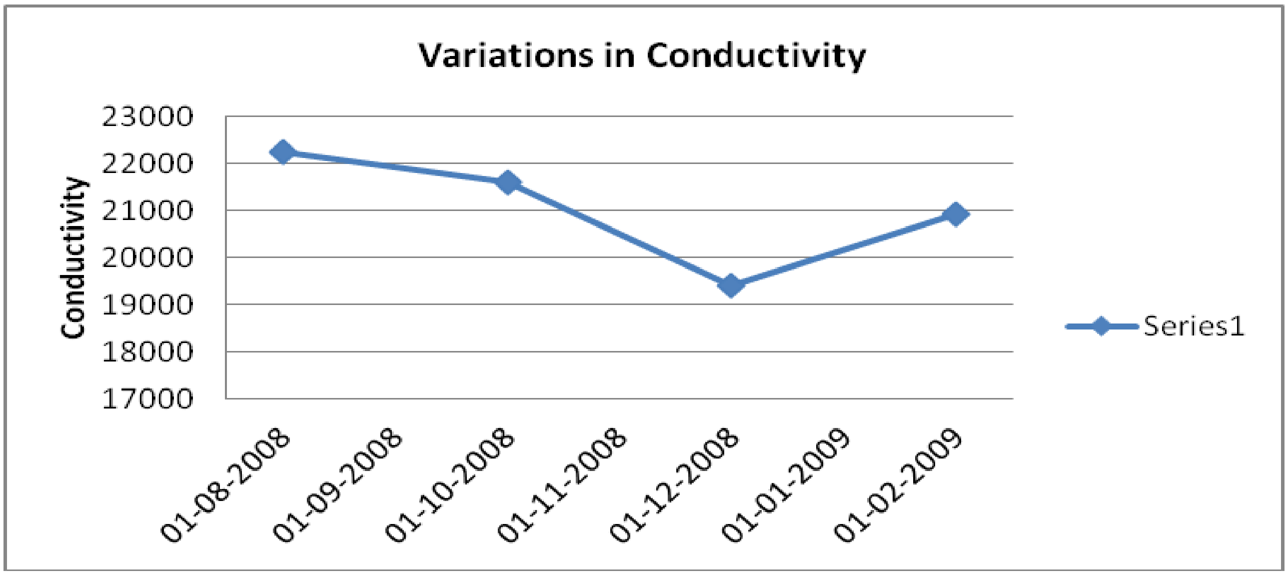


Fig 6.2 variation in conductivity

6.4.1.3 Temperature

Interesting phenomenon was noticed about the variation in temperature. Temperature of the leachate was quite high about 46°C following a rain, but on the normal day. Without any precipitation, the temperature was just normal and was found to be quite low upto 39°C. Figure 6.3 shows the variation of the water temperature and leachate temperature. The landfill site is acting as a large bioreactor and the physical, chemical and biological processes are being carried out slowly inside the reactor and the temperature difference between the leachate and the water temperature outside indicates the strength of the process undergoing change.

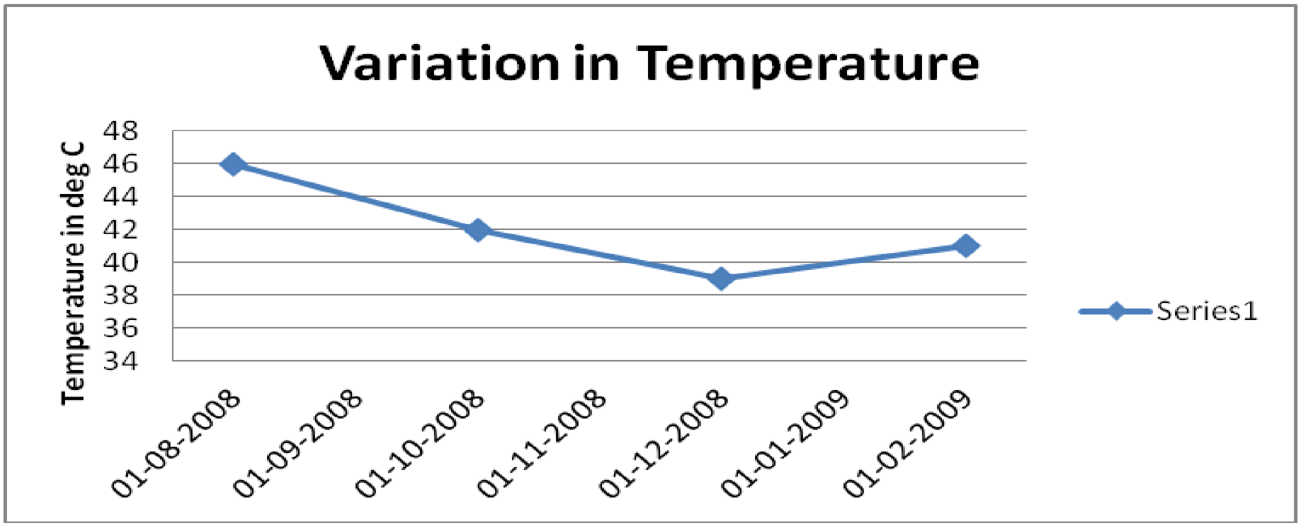


Fig 6.3 variation in temperature

6.4.1.4 Total Solids

Total solids showed a downward trend and then increased marginally at the end of study period. Total solids were found to be as high as 12600 mg/L and then decreased to a value of 11740 mg/L. Decreasing trend of total solids may be attributed to the aspect that at there are larger number of loose particles at the initial stage which are carried away with the percolating water and subsequently there is decrease in the solids which can be easily carried away. Figure 6.4 indicates the variation in total solids concentration.

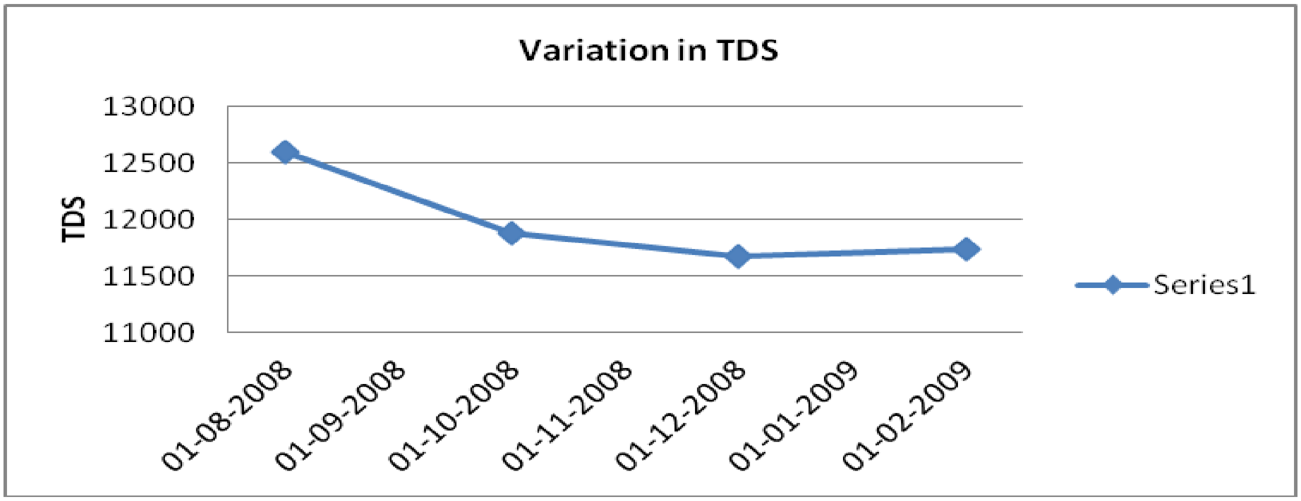


Fig 6.4 variation in TDS

6.4.1.5 Chlorides

Chlorides were found in high concentration. Chlorides concentration varied from 5709 mg/L to 4424 mg/L. Chloride in the form of chloride ions is one of the major inorganic anions in leachate. High chloride content may harm metallic pipes and other equipments therefore due care shall be taken before selecting materials for leachate collection, recycling and treatment. The chlorides variation is shown in Figure 6.5

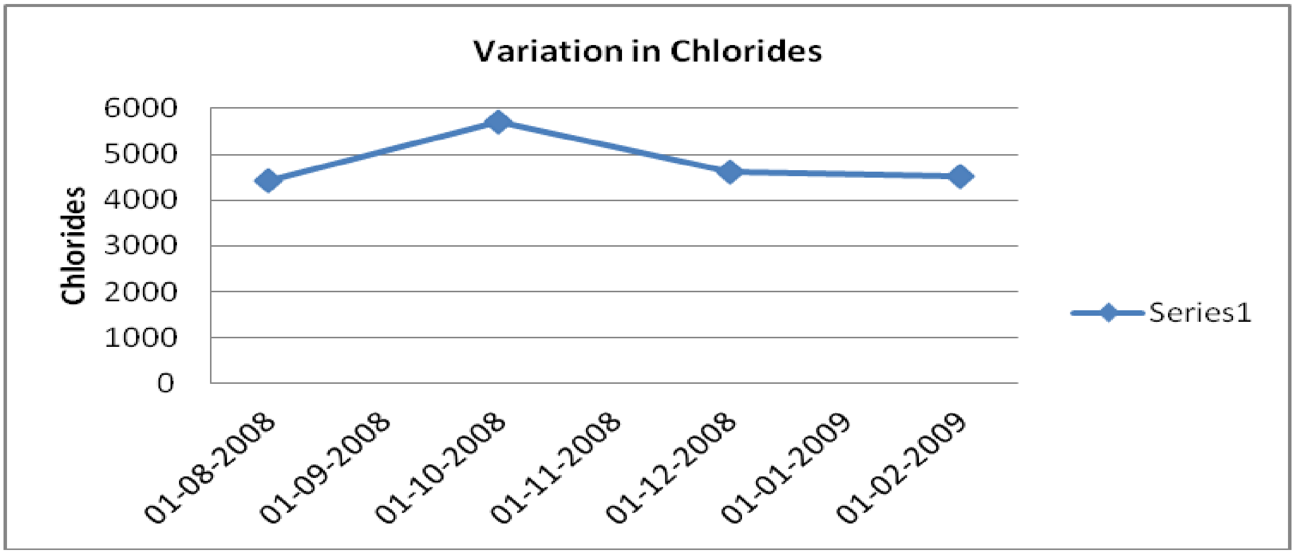


Fig 6.5 variation in chlorides

6.4.1.6 Nitrates

Presence of too much nitrates in water may adversely affect the health of infants, causing a disease technically called "mathemoglobinemia"(commonly called "blue baby disease"). Children suffering from this disease may vomit, their skin colour may become dark, and may die in extreme cases. Nitrate contents in present samples vary from 86 to 102 mg/l.

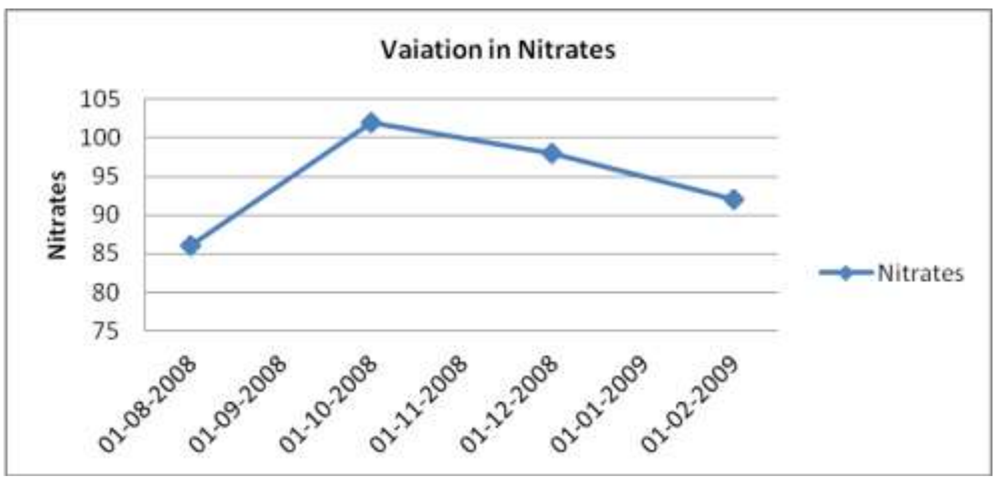


Fig 6.6 variation in nitrates

6.4.1.7 BOD

Aerobic bacteria production flourishes if oxygen is present in water & causes biological decomposition of waste and organic matter. The amount of oxygen required in the process is known as BOD. The BOD of drinking water must be zero. The sample contains high BOD that varies from 1104 to 1280 mg/l.

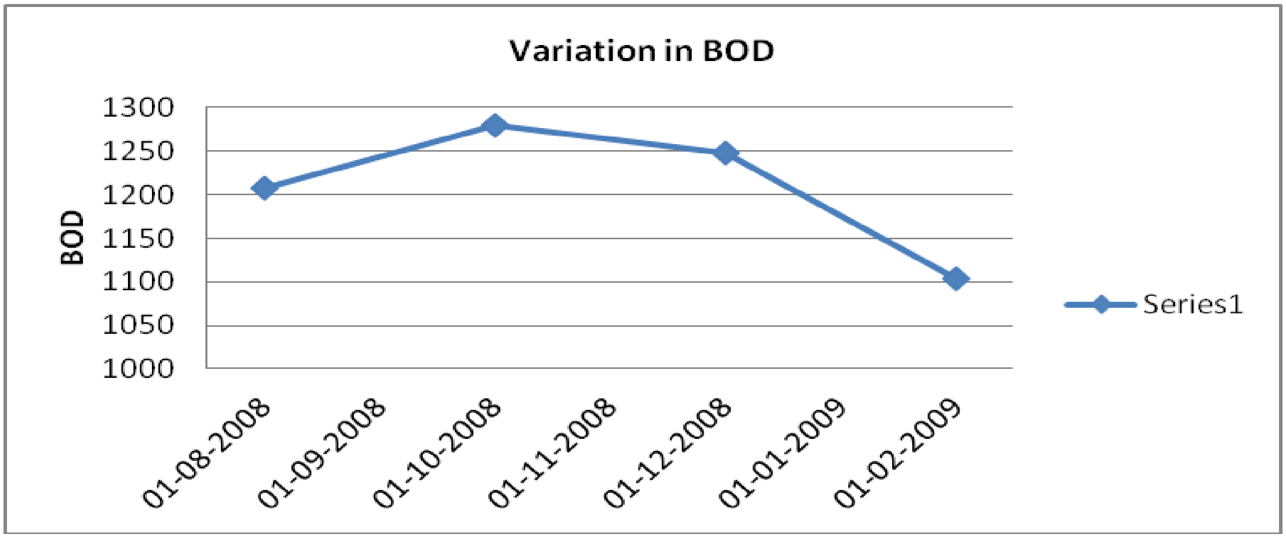


Fig 6.7 variation in BOD

6.4.1.8 COD

Chemical oxygen demand of the leachate samples varied rather arbitrarily. No clear trends about the COD can be indicated with this study. Chemical Oxygen Demand varied from 11886 mg/l to as high as 12,608 mg/l and then dropping to as low as 10680 mg/l. So the variation in Chemical Oxygen Demand could not be concluded. For drawing any definite conclusions, study for a longer period has to be carried out.

Chemical Oxygen Demand is the measure of oxygen required in oxidizing the organic compounds present in water by means of chemical reactions involving oxidizing Substances such as potassium dichromate. The estimation of COD is of importance for samples having unfavorable conditions for the growth of microorganisms, such as presence of toxic chemicals and in such cases BOD cannot be determined accurately, which is very true in the case of leachate, as leachate is expected to contain the toxic chemicals which had not been analyzed ever before. The variation in COD is shown in Figure 6.8

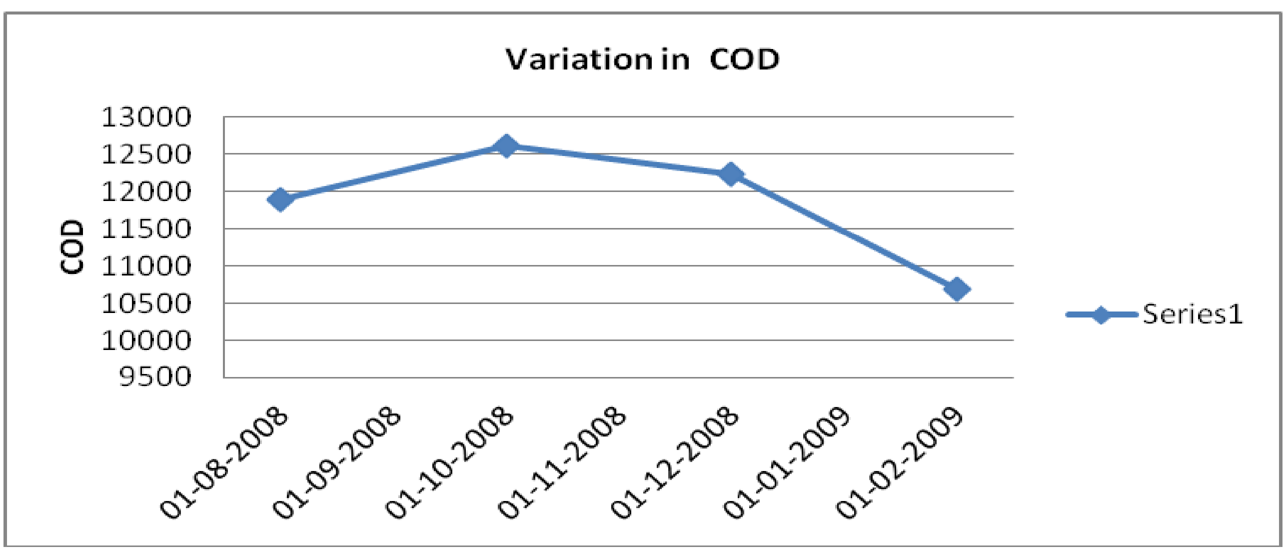


Fig 6.8 variation in COD

6.4.1.9 Sulphates

Variation in Sulphate content during study period is shown in Figure 6.9.

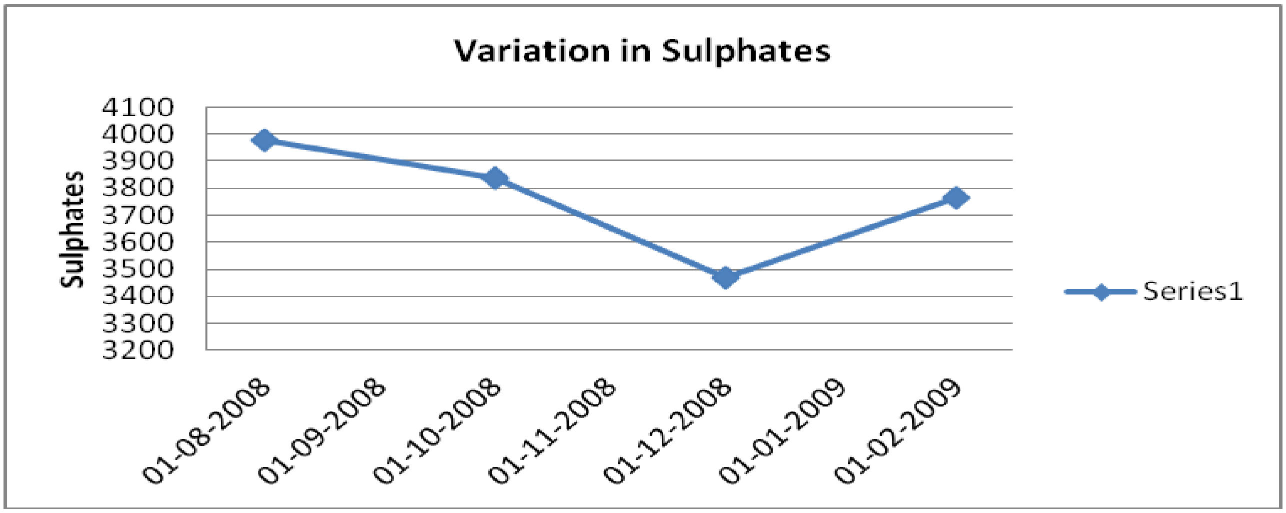


Fig 6.9 variation in sulphates

6.4.1.10 Zinc

It is relatively non–toxic for humans and animals. It is acutely toxic for aquatic animals and plants. Concentrations of more than 5mg/l is undesirable for drinking purposes. In the present study the concentration is found to be between 3.58 to 4.20mg/l.

6.4.1.11 Cadmium

This metal is highly toxic to humans and livestock. It deposits in the body cumulatively. Traces not found in the samples.

6.4.1.12 Copper

It is Essential for humans and animals in small quantities. At higher concentrations it is acutely toxic for aquatic animals and plants. Presence makes the water distasteful. Concentrations of more than 1.5mg/l is undesirable for drinking purposes. In the present study the concentration is found to be around 0.03mg/l.

6.4.1.13 Lead

This metal is highly toxic to humans and livestock. It deposits in the body cumulatively. Not desirable in drinking water. Permissible higher limit is 0.05mg/l .Traces found in the samples but is within permissible limits.

6.4.1.14 Turbidity

It is due to presence of suspended matter like clay, silt or some other suspended organic matter. It depends upon the fineness and concentration of the particles present in the water. Although it may not be harmful but is to be removed for aesthetic or psychological reasons. In the present case the turbidity is found to be varying between 690 and 720 NTU.

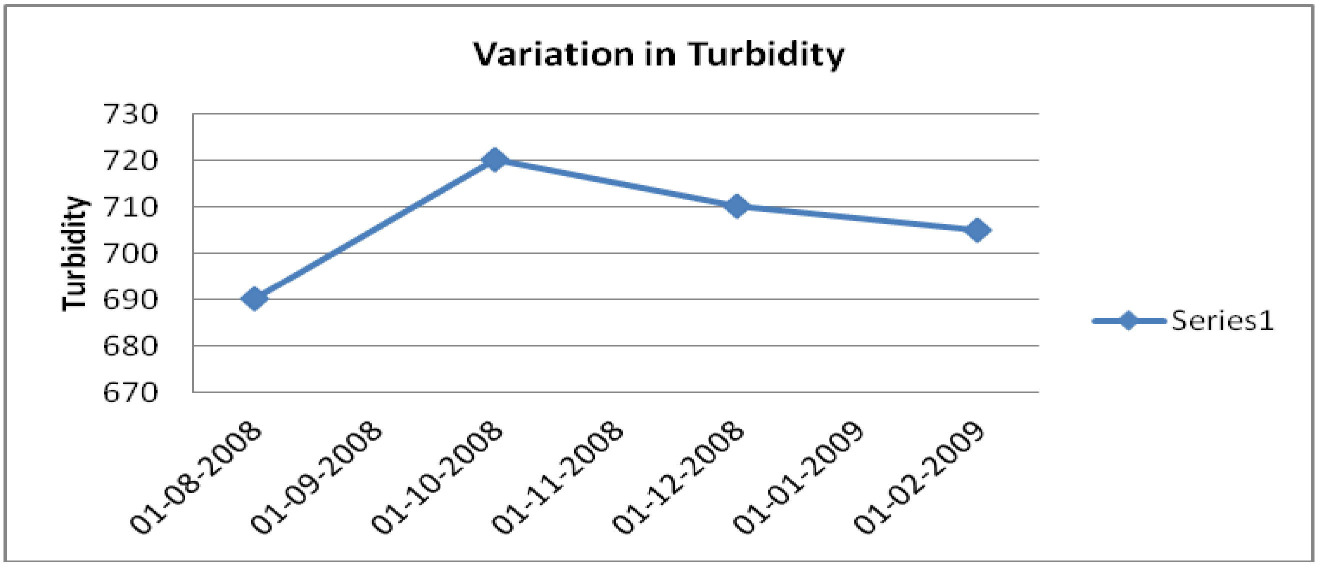


Fig 6.10 variation in turbidity

6.4.1.15 Fluoride

If fluoride concentration of less than 0.8 mg/l may cause tooth decay due to formation of excessive cavities in teeth of young children during calcination of their permanent teeth. Higher Fluoride concentrations, greater than 1.5mg/l or so may again be harmful, causing spotting & discolouration of teeth called fluorosis. Continued consumption of excessive fluorides may even cause deformation of bones.

In the present case the fluoride content is found to be varying between 31 mg/l and 41mg/l.

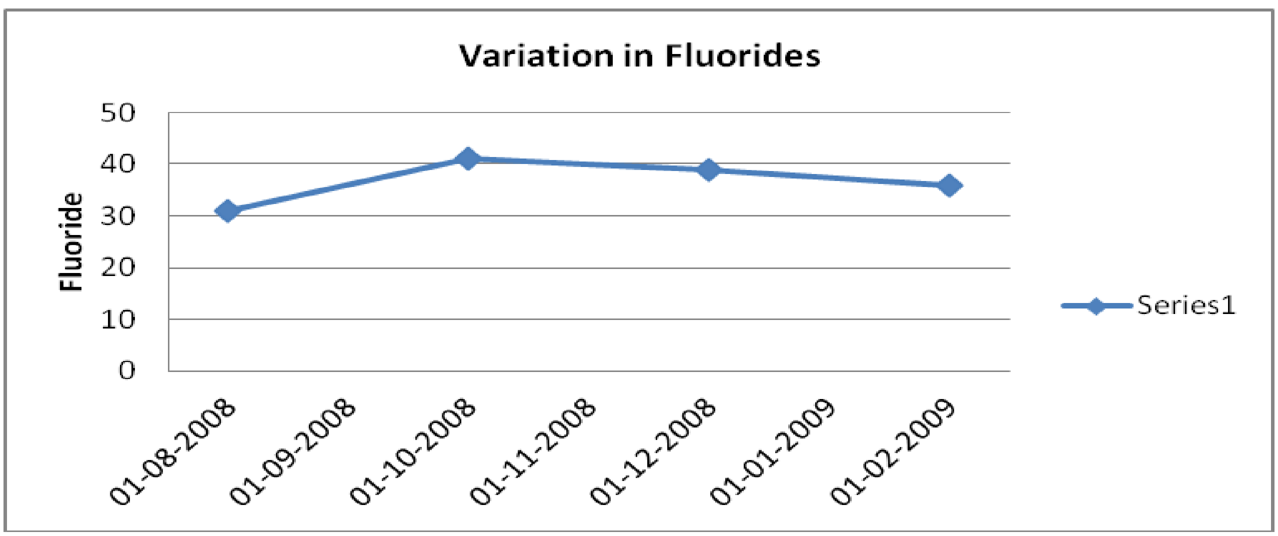


Fig 6.11 variation in fluorides

6.4.1.16 Iron

It imparts colour to the water. In the present case the Iron content is found to be varying between 19 mg/l and 23mg/l.

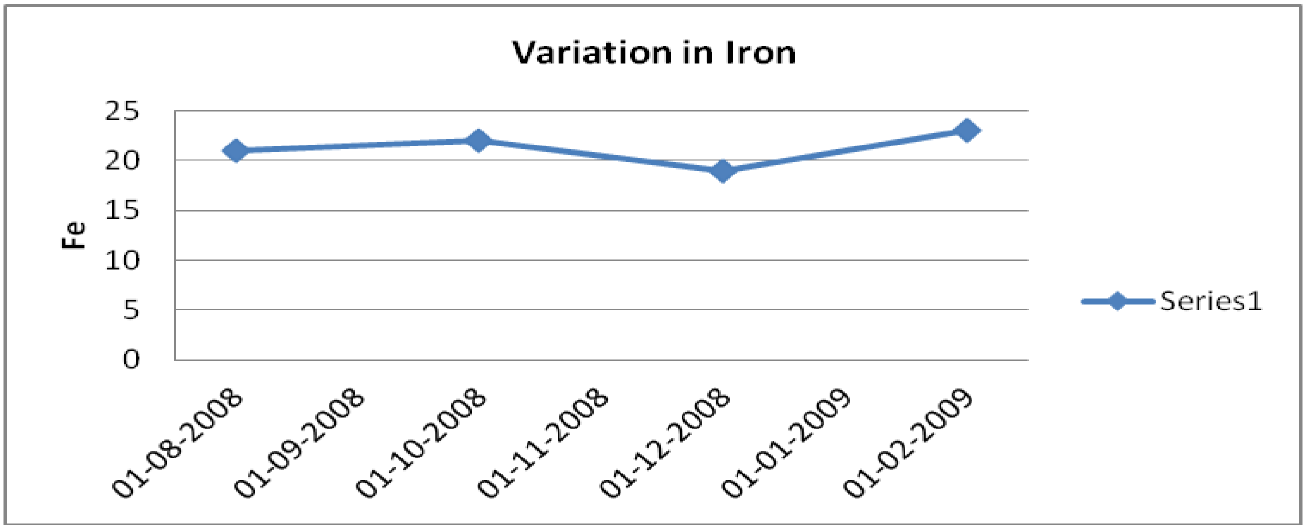


Fig 6.12 variation in iron

6.4.2 Okhla Ground Water Samples

Table 6.2 Characteristics of Ground Water Samples from Okhla SLF

S. No	Characteristics	08-08-2008	10-10-2008	09-12-2008	04-02-2009
1	pH	6.54	6.45	6.34	6.34
2	Conductivity (mMhosl)	1132	1126	1103	1073
3	Turbidity (NTU)	43	45	42	44
4	Temperature (˚C)	29	27	28	29
5	Total dissolved solids(mg/l)	871	859	843	827
6	Chlorides	348	402	342	390
7	Nitrates	15	14	16	15
8	Sulphates	392	398	396	402
9	COD	184	178	186	194
10	TOC	124	127	131	133
11	Zn	0.005	0.022	0.008	0.027
12	Cd	0.014	0.01	Nil	0.016
13	Pb	0.004	0.012	Nil	0.014
14	Cu	0.064	0.049	Nil	0.028
15	Fe	5.7	6.2	6.9	6.4
16	Fluorides	3.1	2.9	3.3	2.8

(All units are in mg/l, except for turbidity, conductivity & temp)

6.4.3 Ghazipur Leachate Samples

Table 6.3 Characteristics of Leachate Samples from Ghazipur SLF

		Sample Collection Date (D/M/Y)			
S. No	**Characteristics**	**08-08-2008**	**10-10-2008**	**09-12-2008**	**04-02-2009**
1	pH	8.52	8.39	8.28	8.27
2	Conductivity (mMhosl)	20900	20700	19520	19300
3	Turbidity (NTU)	740	790	755	730
4	Temperature (˚C)	42	37	34	36
5	Total dissolved solids(mg/l)	28420	25420	23860	23540
6	Chlorides	5320	5700	5274	5257
7	Nitrates	96	108	105	102
8	Sulphates	2970	2862	2794	2655
9	BOD	2470	2534	2252	2366
10	COD	29670	30268	26860	28240
11	TOC	3586	4134	3956	3844
12	Zn	Nil	0.057	Nil	Nil
13	Cd	Nil	Nil	Nil	0.014
14	Pb	Nil	Nil	0.046	Nil
15	Cu	Nil	Nil	0.015	Nil
16	Fe	20	17	19	18
17	Fluoride	26	29	31	28

(All units are in mg/l, except for turbidity, conductivity & temp)

6.4.3.1 pH

The pH values in the monitoring period of 186 days varied from 8.52 to 8.27 and fluctuated as shown in Figure.

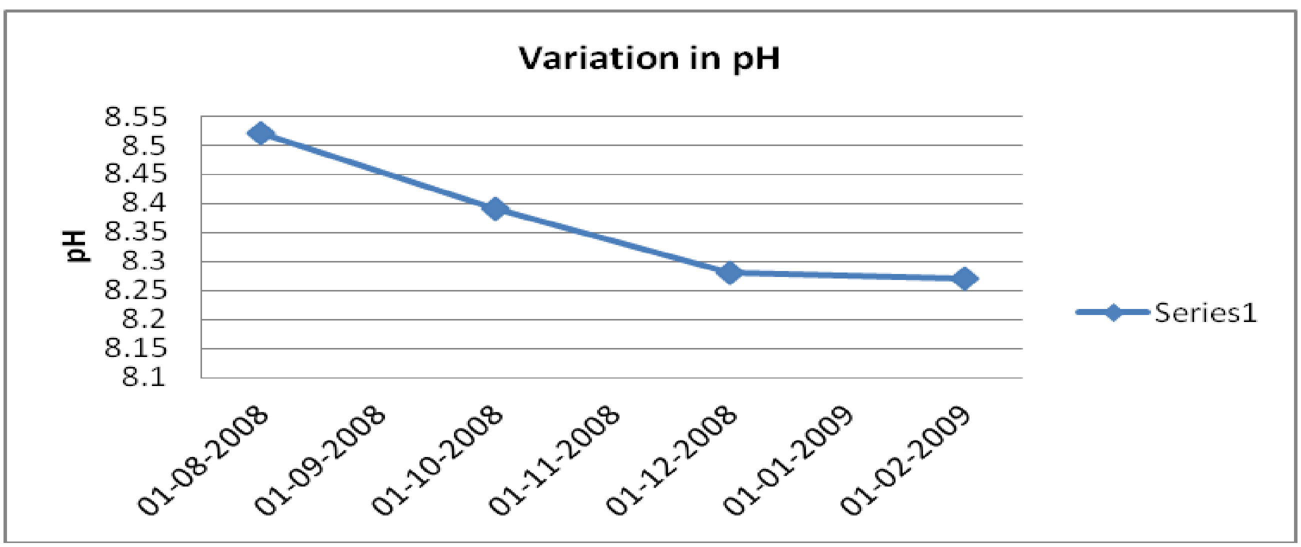


Fig 6.13 variation in pH

6.4.3.2 Conductivity

The conductivity of the leachate samples varied from 19.30 to 20.9 mMhosl, but a concluding trend could not be evaluated. The Figure 6.14 shows the periodic variation of leachate during the study period.

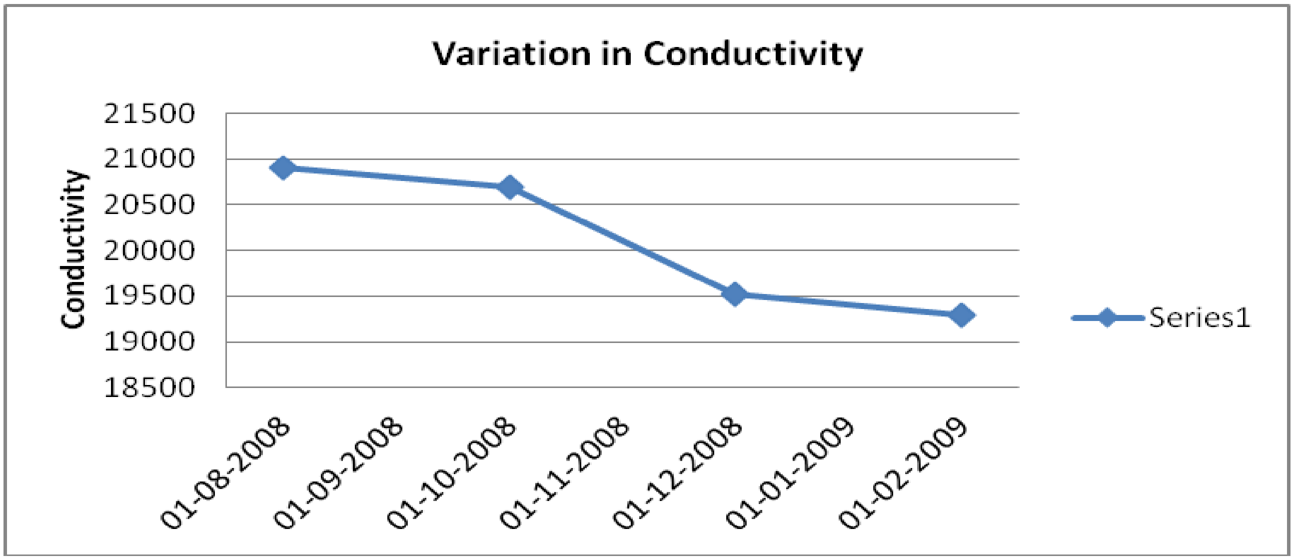


Fig 6.14 variation in conductivity

6.4.3.3 Temperature

Interesting phenomenon was noticed about the variation in temperature. Temperature of the leachate was quite high about 45°C following a rain, but on the normal day the temperature was just normal and was found to be quite low up to 39 °C .Figure 6.15 shows the variation of the leachate temperature.

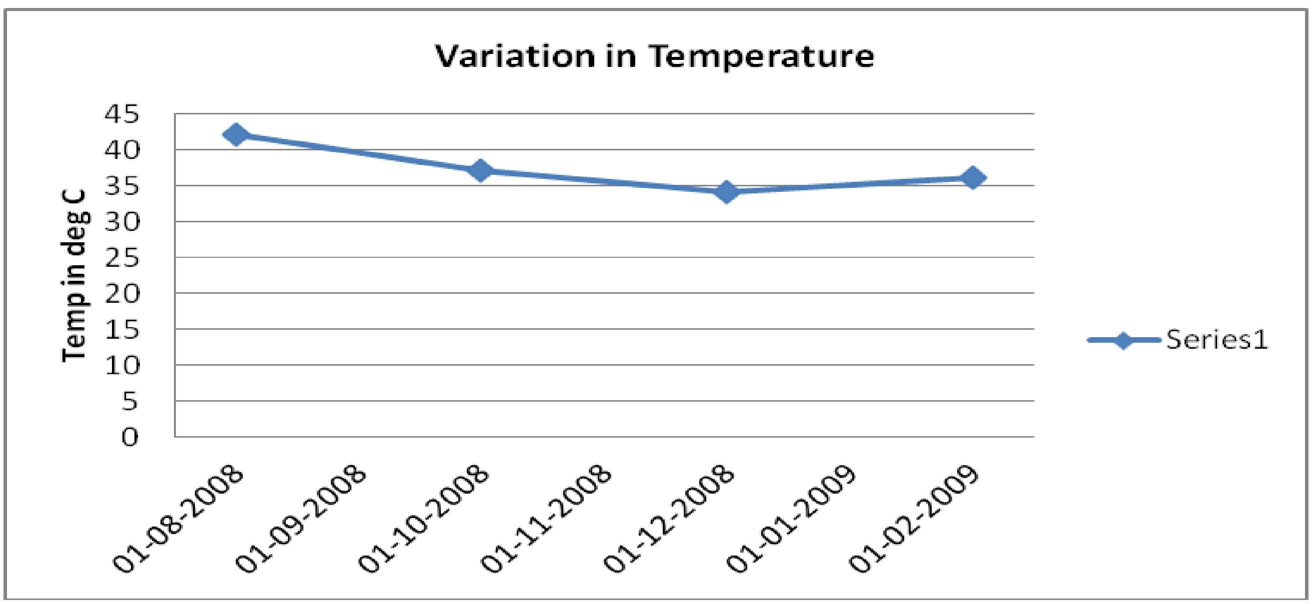


Fig 6.15 variation in temperature

6.4.3.4 Total Solids

Total solids showed a slight upward trend and then decreased marginally at the end of study period. Total solids were found to be as high as 28420 mg/l and then decreased to a value of 23540 mg/l. Figure 6.16 indicates the variation in total solids concentration.

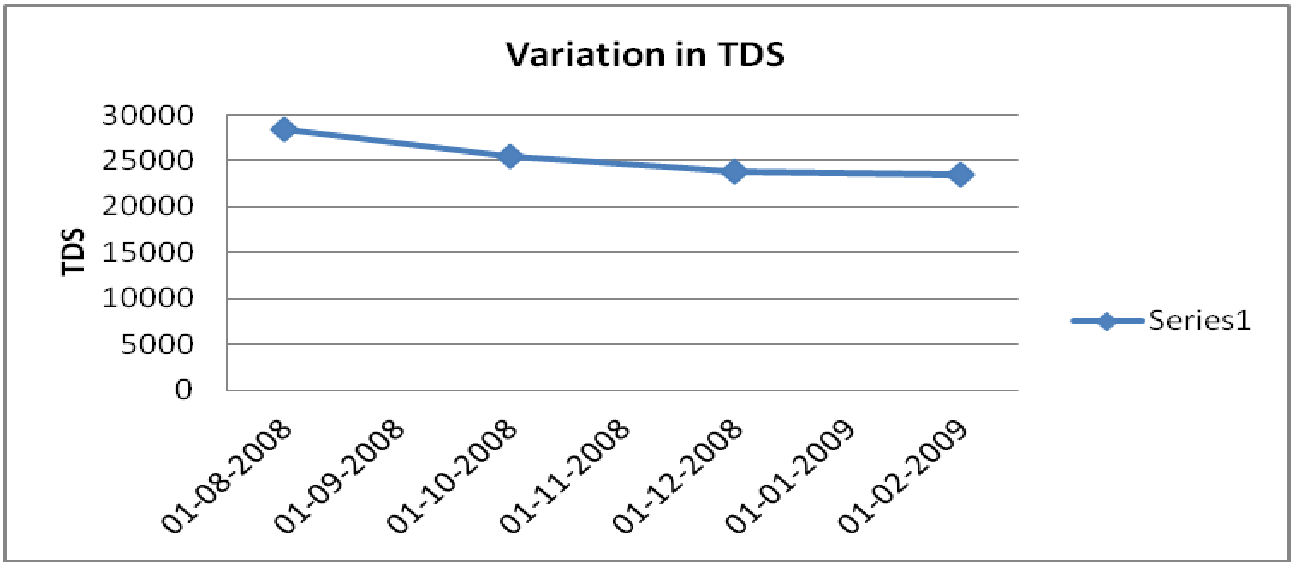


Fig 6.16 variation in TDS

6.4.3.5 Chlorides

Chlorides were found in high concentration. Chlorides concentration varied from 5700 mg/l to 5257 mg/l. The chlorides variation is shown in Figure 6.17

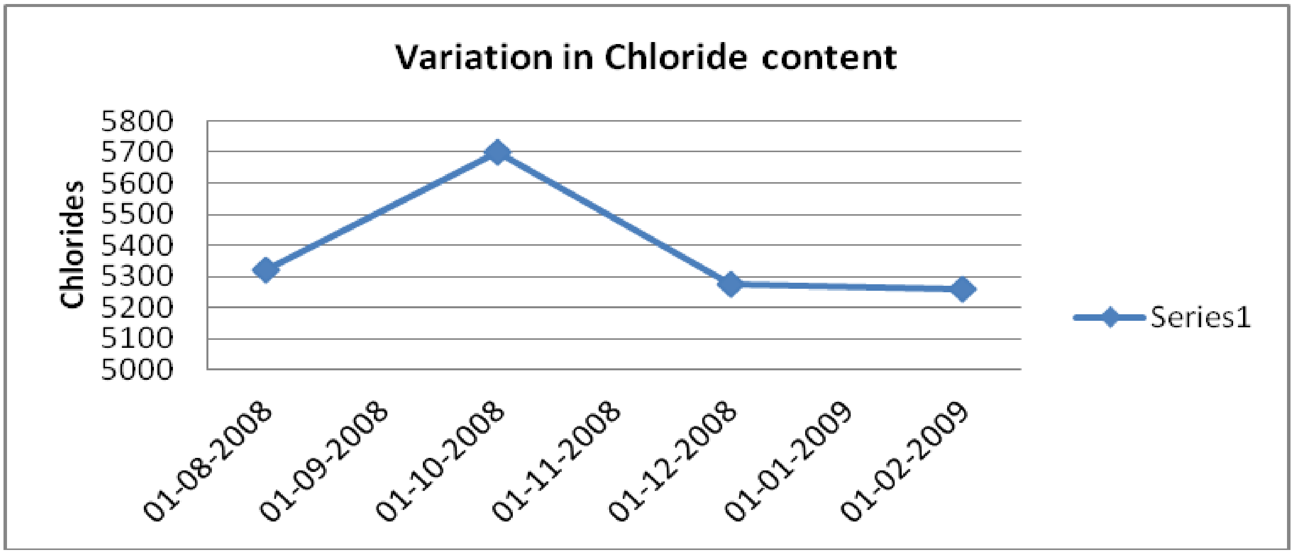


Fig 6.17 variation in chloride content

6.4.3.6 Nitrates

Nitrate contents in present samples vary from 96 to 108 mg/l. Variation is shown in Figure 6.18

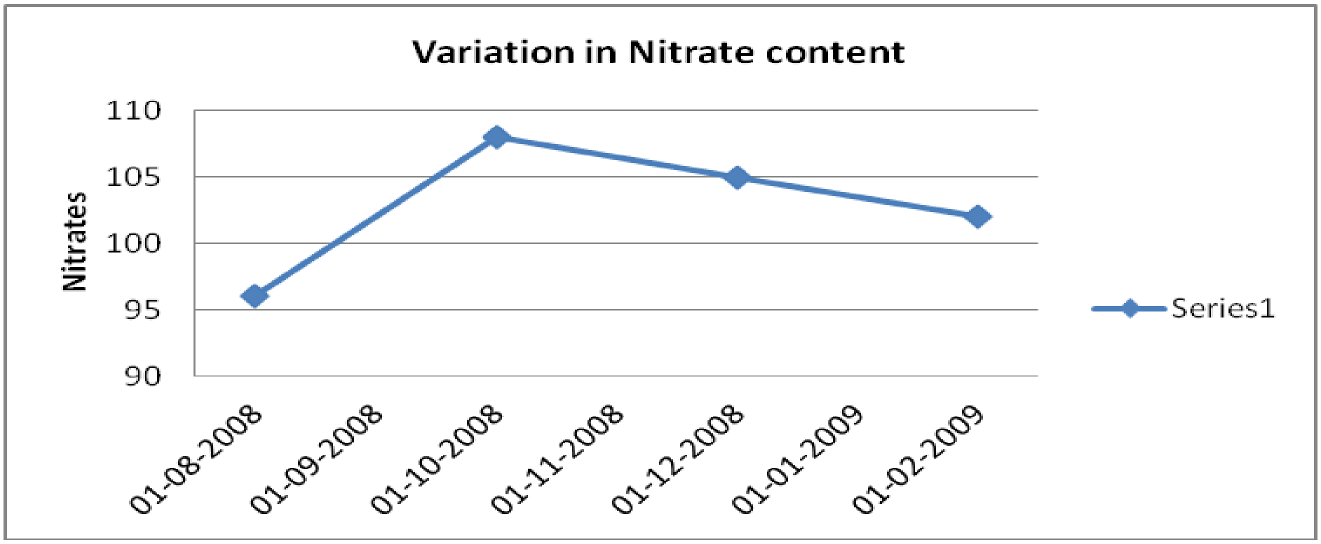


Fig 6.18 variation in nitrate content

6.4.3.7 BOD

BOD in the samples in present study varies from 2252 to 2534 mg/l.

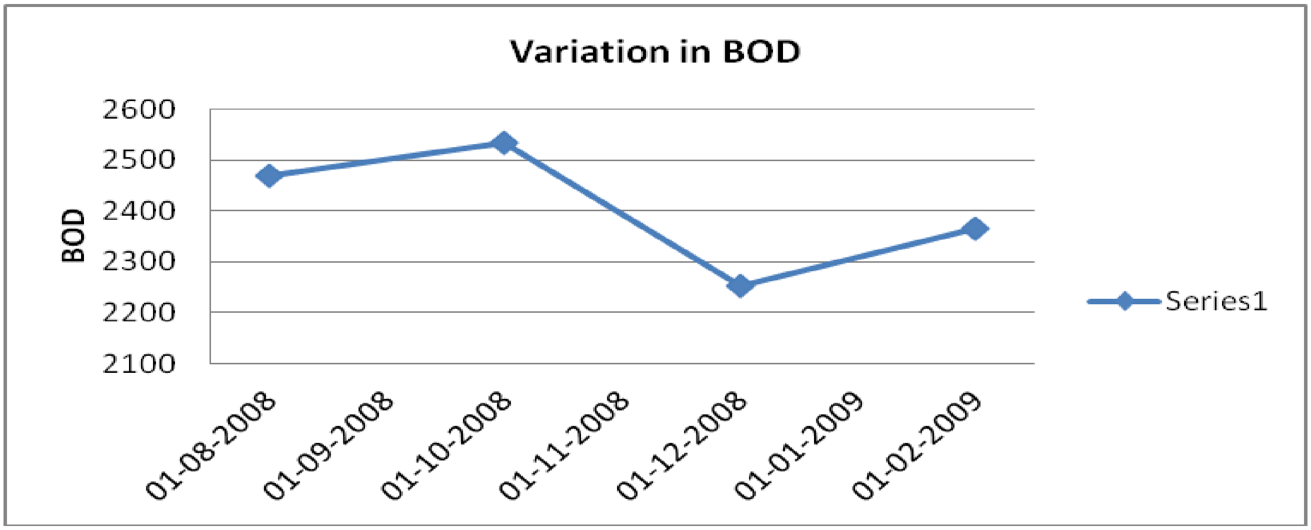


Fig 6.19 variation in BOD

6.4.3.8 COD

Chemical oxygen demand of the leachate samples varied rather arbitrarily. No clear trends about the COD can be indicated with this study. Chemical Oxygen Demand varied from 29670 mg/l to as high as 30268 mg/l and then dropping to as low as 26860 mg/l. The variation in COD is shown in Figure 6.20 .

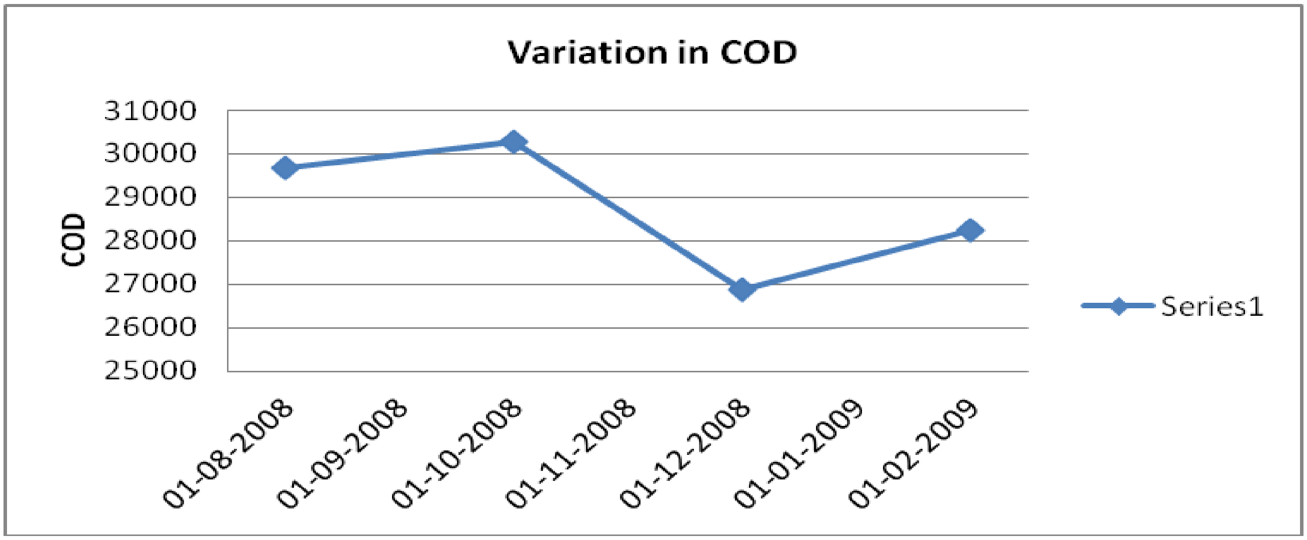


Fig 6.20 variation in COD

6.4.3.9 Sulphates

Sulphate concentration in present study varies from 2970 to 2655 mg/l. Variation is shown in Figure 6.21

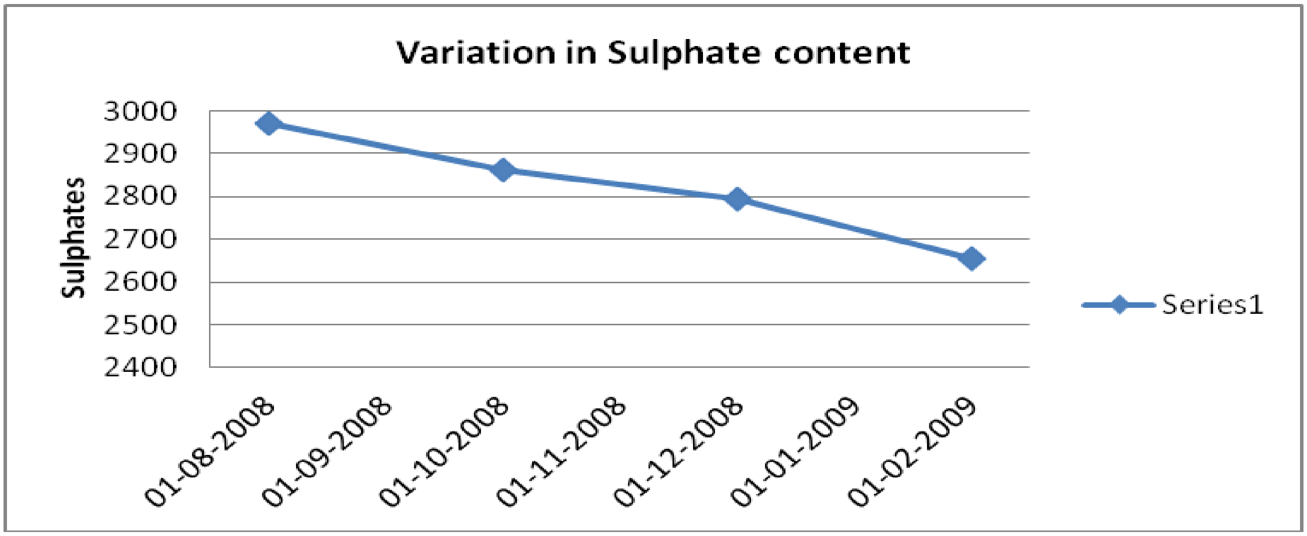


Fig 6.21 variation in sulphate content

6.4.3.10 Zinc

It is relatively non–toxic for humans and animals. It is acutely toxic for aquatic animals and plants. Concentrations of more than 5mg/l is undesirable for drinking purposes. In the present study the concentration is found to be around 0.06 mg/l.

6.4.3.11 Cadmium

This metal is highly toxic to humans and livestock. It deposits in the body cumulatively. Traces are found in the samples. In the present study the concentration is found to be 0.014mg/l.

6.4.3.12 Copper

In the present study the concentration is found to be around 0.015mg/l.

6.4.3.13 Lead

Traces have been found in the samples but are within permissible limits. Concentration is found to be around 0.046mg/l.

6.4.3.14 Turbidity

It is due to presence of suspended matter like clay, silt or some other suspended organic matter. It depends upon the fineness and concentration of the particles present in the water. Although it may not be harmful but is to be removed for aesthetic or psychological reasons. In the present case the turbidity is found to be varying between 730 and 790 NTU.

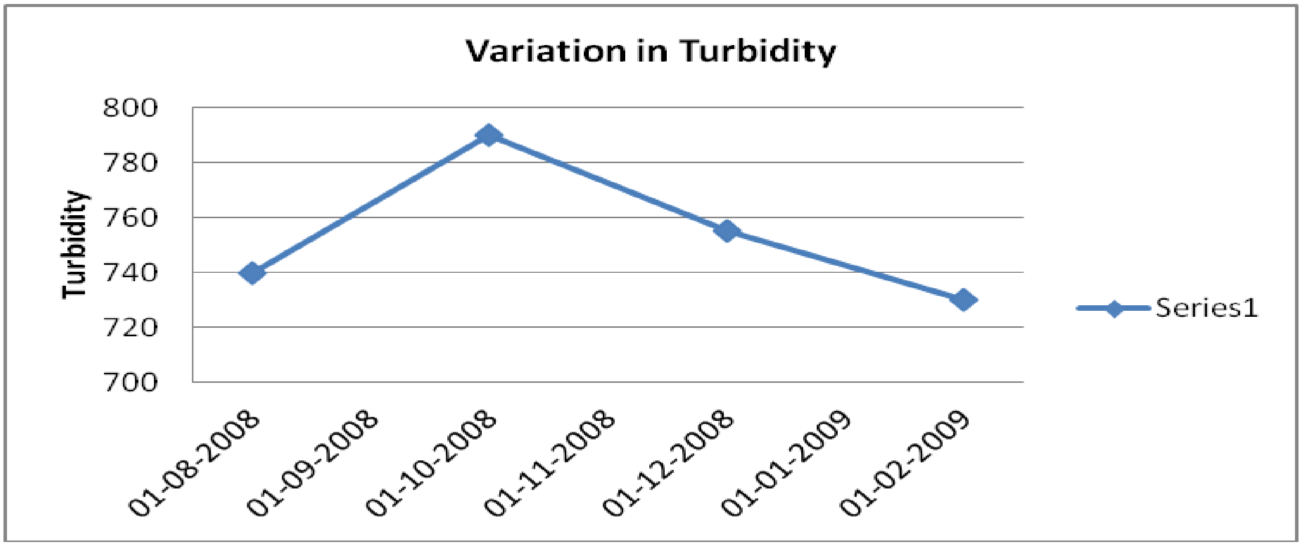


Fig 6.22 variation in turbidity

6.4.3.15 Iron

Iron content in present study varies from 17 to 20 mg/l.

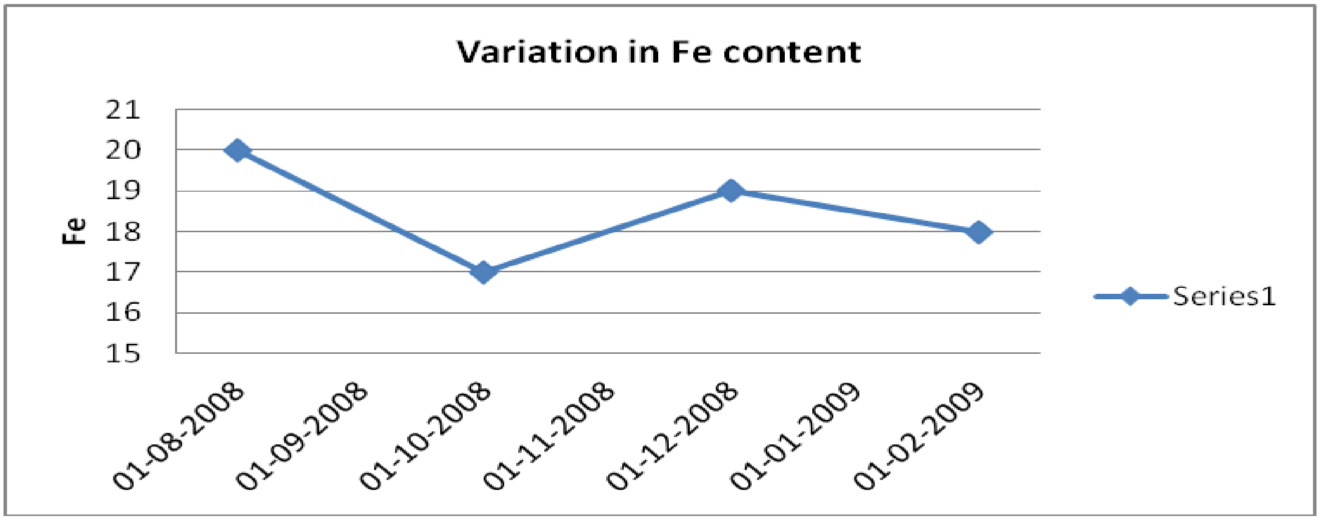


Fig 6.23 variation in iron content

6.4.3.16 Fluorides

Fluoride content in the present study varies from 26 to 31 mg/l.

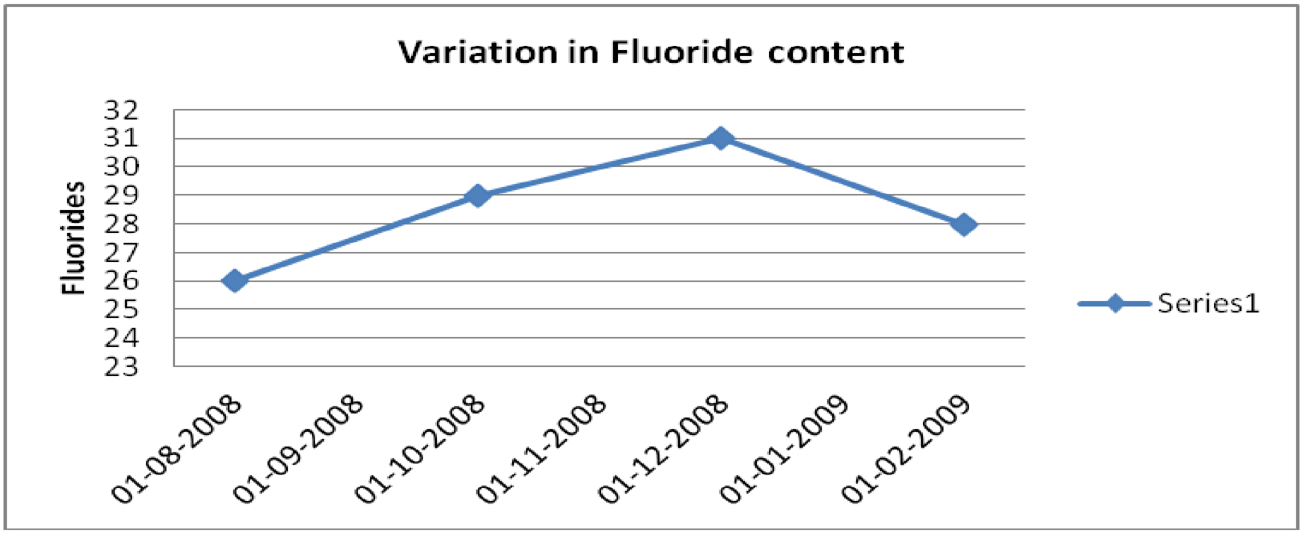


Fig 6.24 variation in fluoride content

6.4.4 Ghazipur water samples

Table 6.4 Characteristics of Ground Water Samples from Ghazipur SLF

		Sample Collection Date(D/M/Y)			
S. No	**Characteristics**	**08-08-2008**	**10-10-2008**	**09-12-2008**	**04-02-2009**
1	pH	7.68	7.71	7.79	7.75
2	Conductivity (mMhosl)	479	559	721	648
3	Turbidity (NTU)	45	48	39	47
4	Temperature (˚C)	29	27	27	28
5	Total dissolved solids(mg/l)	749	771	852	742
6	Chlorides	309	368	357	342
7	Nitrates	13	14	12	14
8	Sulphates	188	193	198	194
9	COD	85	87	89	73
10	TOC	70	79	78	73
11	Zn	0.012	0.037	0.019	0.027
12	Cd	Nil	0.01	Nil	0.014
13	Pb	0.056	Nil	0.046	0.027
14	Cu	0.05	Nil	0.015	0.024
15	Fe	3.8	3.7	3.9	4.2
16	Fluorides	2.9	2.8	3.1	3

(All units are in mg/l, except for turbidity, conductivity & temp)

6.4.5 Bhalaswa leachate samples

Table 6.5 Characteristics of Leachate Samples from Bhalaswa SLF

		Sample Collection Date(D/M/Y)			
S. No	**Characteristics**	**08-08-2008**	**10-10-2008**	**09-12-2008**	**04-02-2009**
1	pH	8.31	8.34	8.29	8.21
2	Conductivity (mMhosl)	19520	20018	19316	19637
3	Turbidity (NTU)	890	916	869	892
4	Temperature (˚C)	42	37	34	35
5	Total dissolved solids(mg/l)	20420	20844	20147	19976
6	Chlorides	6480	7219	6614	5648
7	Nitrates	56	62	43	41
8	Sulphates	3318	2862	2914	2763
9	COD	14670	15268	18860	17240
10	TOC	4586	4162	4857	4848
11	Zn	6.95	6.01	6.34	7.88
12	Cd	0.2	0.19	0.16	0.14
13	Pb	1.03	0.96	0.63	0.81
14	Cu	0.96	0.66	0.7	0.81
15	Fe	19	17	16	18
16	Fluoride	36	43	48	35

(All units are in mg/l, except for turbidity, conductivity & temp)

6.4.6 Bhalaswa water samples

Table 6.6 Characteristics of Ground Water Samples from Bhalaswa SLF

		Sample Collection Date(D/M/Y)			
S. No	**Characteristics**	**08-08-2008**	**10-10-2008**	**09-12-2008**	**04-02-2009**
1	pH	7.59	7.48	7.63	7.53
2	Conductivity (mMhosl)	1132	1116	1067	1083
3	Turbidity (NTU)	44	41	40	41
4	Temperature (˚C)	30	27	28	29
5	Total dissolved solids	1162	1141	1087	1119
6	Chlorides	948	911	908	856
7	Nitrates	38	41	37	36
8	Sulphates	524	533	502	495
9	COD	179	167	174	180
10	TOC	119	122	128	125
11	Zn	0.89	0.87	1.24	1.16
12	Cd	0.02	0.019	0.017	0.021
13	Pb	0.014	0.016	0.019	0.02
14	Cu	0.064	0.059	0.067	0.074
15	Fe	2.1	1.95	1.74	1.59
16	Fluoride	7.1	6.9	6.7	7.8

(All units are in mg/l, except for turbidity, conductivity & temp)

Pursuant to an order of the Hon'ble High Court of Delhi, dated 828.04.1999, the Central Board is carrying out inspection and monitoring of MSW management in NCT-Delhi. During the year

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

2001, three rounds of inspection were carried out and reports submitted to the Hon'ble Court. Salient recommendations made in these reports are:

Ø A Master Plan for Improvement of MSW Management in accordance with the guidelines prescribed in the Municipal Solid Waste (Management & Handling) Rules, 2000, should be prepared; and,

Ø The Master Plan has to take into account all the aspects of MSW management including primary collection, storage, transfer, transport and disposal, as recommended by the Central Board in their inspection reports. Implementation of the Master Plan should be carried out in a phased manner with time targets. Measurable indicators to evaluate the improvements achieved by the civic authorities should be identified.

Ø Around **30% of leachate infiltrates into groundwater regime** below the dumpsite. The groundwater sample analysis and the leachate chemistry indicate seepage of leachate into groundwater;

Ø Electrical conductivity, total dissolved solids, nitrates and hardness values of groundwater samples in the downstrean area of dumpsites are higher compared to upstream areas, indicating possible contamination due to leachate from the dumpsite; and,

Ø Other sources like human and animal wastes, agricultural activities may also be contributing to the higher concentration of nitrate in the downstream of dumpsite.

CHAPTER- 7
CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

From the present study, following conclusions are drawn:

1. With fast urban growth and increasing standard of living the waste collection has steeply increased in Delhi from 5711 TPD in 2004(MCD) to 7400 TPD in 2011(MCD) and is projected to increase to 15750 TPD in 2021 (MPD 2021)mainly due to ever increasing population .

2. Studies have revealed that leachates contaminate the ground water which is a major source of drinking water, with varying degree of toxicity. Some contaminants may be Carcinogenic, Mutagenic or Teratogenic. Contaminants like Metals, Alcohals, Synthetic organic compounds (SOCs), Volatile Organic Chemicals (VOC's) adversely affects the human health. Groundwater contamination is resulting in outbreak of several diseases like Gaestro-intestinal problems, diarrhea, stomach ache, vomiting, skin infection, eye irritation and hair loss etc

3. Of late efforts have been made on the part of the Municipal Authorities to improve the facilities for SWM in Delhi. An Engineered sanitary landfill site has recently been developed at Narela-Bawana .To reduce the quantity of waste to be landfilled, Power Plants are being set up to generate green energy using Refused Derived Fuel and are expected to be operational in 2012. Compost Plants are working at all the three present Landfills. A 500TPD C&D Waste processing facility is functional at Burari.

4. Revealed that concentration of TDS, Turbidity, Sulphate ,Chlorides, Fluorides, Iron, Cadmium, Lead, & Copper are above the Acceptable standards for drinking. Around Okhla SLF, pH is found to be below 6.5 indicating that the underground water has turned acidic. Underground water samples near the Landfill sites at Okhla, Ghazipur and Bhalaswa have been checked and found to be unfit for drinking purposes. Groundwater near the Landfill sites is unfit for human consumption mainly due to contamination by Leachate.

7.2 Recommendations

Following recommendations may prove to be helpful in improving the present state of SWM and in controlling further ground water contamination due to Leachate:

1. Engineered Landfills should be provided in future, in which Leachate collection and treatment facilities should be made available.

2. Awareness should be spread in the area to discourage the people from using the groundwater for drinking purposes. Municipal water supply should be made available.

3. Zero Landfill Concept-involving Gasification; RDF powered green energy plants, composting facilities and Construction & Demolition waste processing facility should be adopted.

4. Keeping in view Paucity of Land and its high cost in Delhi, all out efforts should be made to reclaim the land of filled up/closed landfills by treating the solid waste dumped there.

5. New technologies like Arrow Biotechnology, Plasma technology, Zero Landfill Concept, and Other biological, mechanical processing technologies should be explored & adopted for processing of MSW.

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REFERANCES

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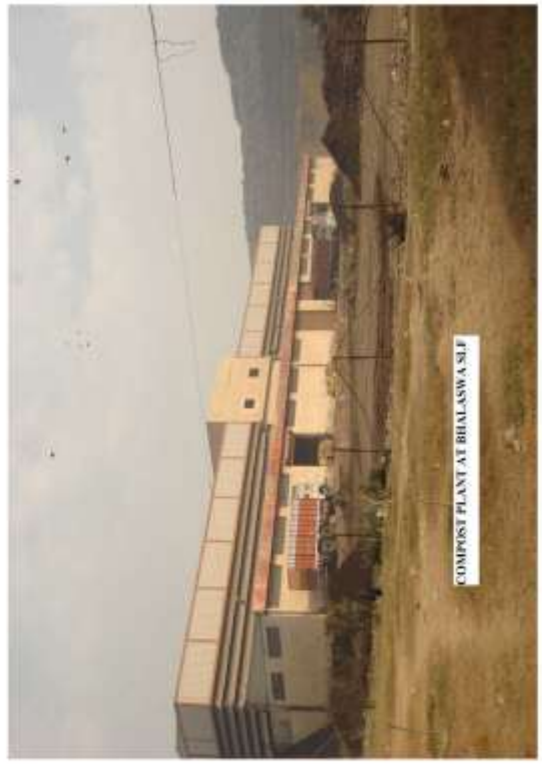
APPENDICES

APPENDIX I

PHOTOGRAPHS

Collection of Ground Water Sample at Bhalaswa SLF



COMPOST PLANT AT BHALASWA SLF

COLLECTION OF LEACHATE AT BHALASWA SLF

LINED DRAIN FOR DISPOSAL OF LEACHATE AT BHALASWA SLF


TESTING OF
LEACHATE AT
DCE LAB


TESTING OF LEACHATE AT DCE LAB


TESTING OF LEACHATE AT DCE LAB


TESTING OF GROUND WATER AT
ENVIRONMENTAL LAB, DCE

TESTING OF SAMPLES FOR TRACE METALS AT ENVIRONMENTAL LAB, DCE

TESTING OF SAMPLES FOR TRACE METALS AT ENVIRONMENTAL LAB, DCE

TESTING OF SAMPLES FOR TOC

TESTING OF SAMPLES FOR BOD


TESTING OF SAMPLES FOR COD


TESTING OF SAMPLES FOR pH VALUE.


TESTING OF LEACHATE FOR pH VALUE.


COLLECTION OF LEACHATE AT BHALASWA SLF

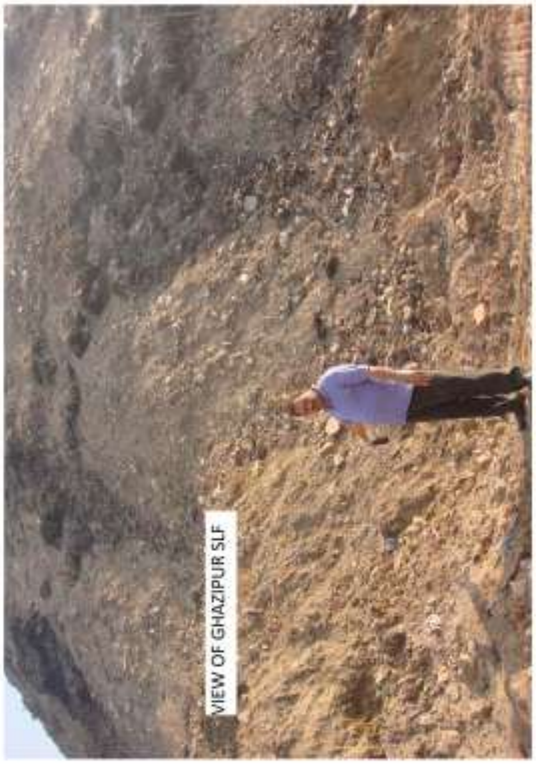

COLLECTION OF LEACHATE AT BHALASWA SLF


VIEW OF OKHLA SLF


COLLECTION OF LEACHATE AT OKHLA SLF


COLLECTION OF LEACHATE AT OKHLA SLF


VIEW OF OKHLA SLF


VIEW OF GHAZIPUR SLF


WEIGH BRIDGE AT OKHLA BRIDGE

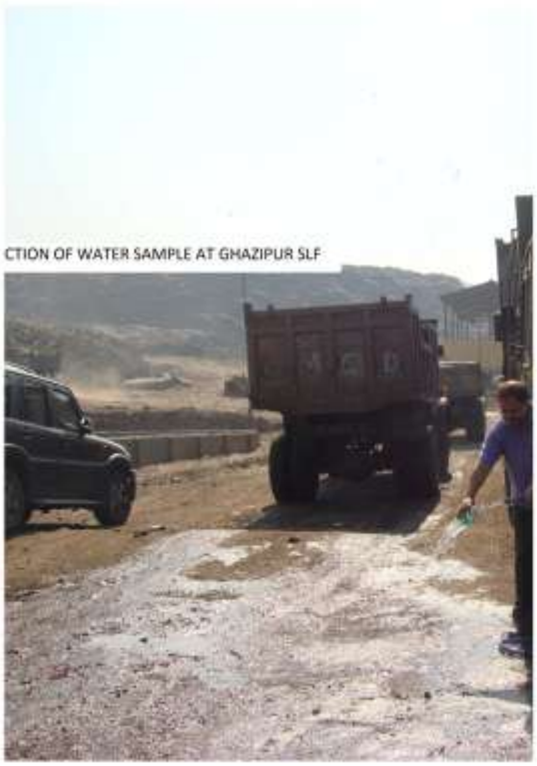

REDUNDENT MACHINERIES AT OKHLA SLF


VIEW OF GHAZIPUR SLF


LINED DRAIN FOR LEACHATE DISPOSAL AT OKHLA SLF


LINED DRAIN FOR DISPOSAL OF LEACHATE AT GHAZIPUR SLF

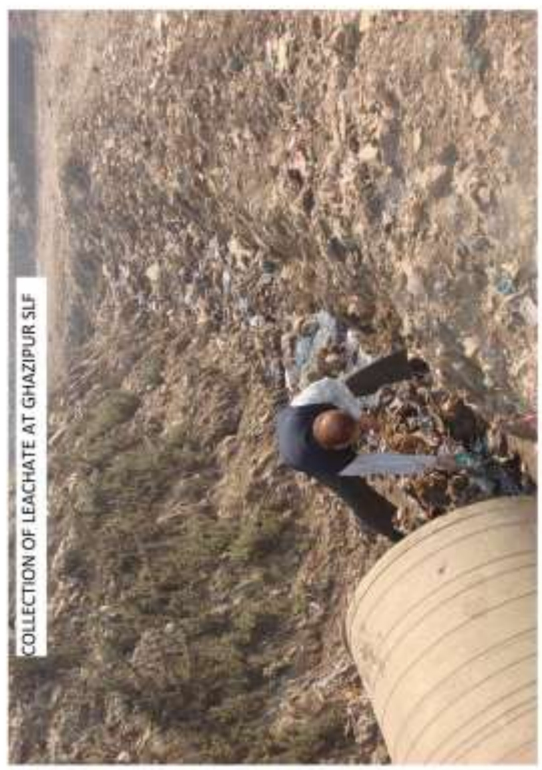

COLLECTION OF GROUND WATER SAMPLE AT OKHLA SLF


CTION OF WATER SAMPLE AT GHAZIPUR SLF


SMOKE ENAMATING FROM SOLID WASTE PILE AT GHAZIPUR SLF


VIEW OF GHAZIPUR SLF

COLLECTION OF LEACHATE AT GHAZIPUR SLF



COLLECTION OF LEACHATE AT GHAZIPUR SLF


COLLECTION OF LEACHATE AT GHAZIPUR SLF


COLLECTION OF GROUND WATER SAMPLE AT GHAZIPUR SLF

COLLECTION OF GROUND WATER SAMPLE AT GHAZIPUR SLF


WEIGH BRIDGE AT GHAZIPUR SLF

APPENDIX II

NEWS PAPER CLIPPINGS

metro

Meetings of th
already taken
KIRAN WALI

.iving next to landfill, they ;eek freedom from disease

NKING SHAME Contaminated ground water has led to gastroenteritis, skin infection among residents of Bhalaswa colony

n out of the 15 water samples collected from areas near the landfill site tested positive for faecal coliform. VIRENDRA SINGH GOSAIN/HT

a Khandekar

LHI: Salma Khatun's hus- barely manages to earn) a month by preparing r bindis. And she spends pping 12 per cent of it to rinking water for her fam- lve.

ma's colony has hand s and taps and sometimes is brought in rs. B... three sources ter show traces of con- ation.

26 year old said ever she moved to Bhalaswa four years ago, she start- icing rashes on her face. ust this, using this water hing has resulted in heavy ss too. My son has devel- some scalp problem due water," she added.

colony is located right the Bhalaswa landfill site th Delhi.

thousands of people liv- ar the landfill site, oper- since 1995, it is a problem an't get rid of.

ple from scores of similar ies across Delhi were relo- to the Bhalaswa resettle- colony in November 2002.

More than 4,000 households — its population approximately 25,000 — are directly affected due to water contaminated by leachate, a highly toxic solution that seeps through soil and pollutes groundwater.

Mohammad Maqsood (22), a driver, said, "I have already started loosing so much of hair at this age."

THE SURVEY:

Bhalaswa Lokshakti Manch, a community based organisation, and Hazard Centre, an advocacy group, carried out a study to understand the relationship between the quality of groundwater and the general health of people. Along with Bhalaswa, the respondents comprised people from neighbouring Shraddhanand colony, Mukundpurgaon and Nathupura.

Water samples from 15 locations near the landfill site showed high concentration of total dissolved solids (TDS). All groundwater samples exceeded the desirable limit of TDS (500 ppm) and seven of them crossed the permissible limit (2,000 ppm).

The respondents, around 900, said the health problems include gastro-intestinal problems, diarrhoea, stomach ache, vomiting, skin infection, eye irritation and hair loss.

Dr Sanjay Jain, senior consultant, department of gastroenterology and hepatology, Apollo Hospitals, said: "Several gastro-intestinal and lever infections occur due to poor quality water."

WHAT NOW?

Dunu Roy from Hazard Centre said: "The government has dumped people from various areas at the resettlement colony just like the entire garbage of the city is dumped at the landfill site."

Delhi Jal Board (DJB) CEO Ramesh Negi admitted that groundwater contamination is bound to happen as the site has no anti-leachating provisions.

Also, tankers draw water from sourced from a Ranny well, which tap shallow aquifers and sub-surface water from floodplains, that has salty water.

"However, apart from salty water, if there are any other problems due to our tankers, we will look into it," Negi assured.

I have rashes all over my hands. I also suffer from severe hair loss due to the salty water.

ZUBINA BEGUM, Housewife

Water is mostly yellow, at times brackish. My children refuse to drink this water.

AYUB AHMED, Technician

ALARMING SITUATION

For residents of colonies near the landfill site, it is a daily battle with health problems

POLLUTANTS

Total dissolved solids (TDS): High TDS is an indicator of presence of iron, manganese, sulphates, bromides and arsenic. The desirable limit is 500 ppm and the maximum permissible limit is 2,000 ppm.

- Of the 15 samples, all exceeded the desirable limit while seven samples exceeded the permissible limit. Samples from Shraddhanand Colony and Bhalaswa resettlement colony had TDS ranging from 2,373 ppm to 5,846 ppm.

Lead: As per WHO guidelines, 0.01 mg/l (ppm) is permissible while BIS permits maximum of 0.05 mg/l. Nine of the samples tested lead concentration more than WHO guidelines while only one sample had lead concentration (0.053 mg/l) higher than BIS.

Water from community taps has a yellowish colour. Some poor families even cook with this water.

Faecal coliform: Of the 15 water samples, seven gave positive result for faecal contamination, rendering them unfit for drinking.

Health problems

70% people have gastro-intestinal irritation

20.4% people complain about skin infection, rashes and allergy

19.8% people reported diarrhoea and vomiting

17.9% people have burning sensation in eyes

9.7% people suffer breathlessness

GRAPHIC: SANJAY KAPOOR

GHAZIPUR LANDFILL SITE TO HOUSE POWER PLANT

HT Correspondent
htreporters@hindustantimes.com

NEW DELHI: With the Ghazipur landfill site unable to take in more waste, the Municipal Corporation of Delhi (MCD) has decided to empty part of it in the next three years.

The site contains 46 lakh metric tonnes of garbage that will be segregated and used for generating energy.

After three years, a plant for generating energy from solid waste will be built on the part of land that has been cleared.

Leader of the House in MCD, Subhash Arya said that the Planning Commission had approved the proposal to process the garbage at Ghazipur landfill site.

"After reclaiming the site, a plant for generating energy from solid waste will be set up. Garbage will be processed here and waste will be dumped at Jaitpur mines," Arya said.

Spread across 31 acres and in operation since 1984, the Ghazipur landfill site has been full for the last few years.

The entire lot of waste will take about 10 years to empty and the operation will take ₹25crore.

As per the plan, the MCD will take 2,000 tonnes of garbage from the site daily and spread it on a concrete platform to dry.

"After this, it will be put on conveyor belts for recycling. It will go through magnetic separator and air density classifiers and ferrous metals, stones and plastic will be extracted," Arya added.

REDEVELOPED SITES

- Millennium Indraprastha Park on the outer Ring Road was developed in 2004 on top of a landfill site
- Part of Bhalaawa landfill site has been used to build a compost plant
- Narela-Bawana landfill site has been cleared and houses a processing unit that segregates waste to obtain refuse derived fuel (RDF) for industrial use.

THE HINDU

Okhla waste plant to power BSES

Staff Reporter

The Hindu File picture of waste material being dumped at Ghazipur landfill along Delhi-Uttar Pradesh border. Photo: Rajeev Bhatt

Power distribution company BSES on Wednesday signed a 25-year-power-purchase agreement with Timarpur-Okhla Waste Management Company Private Limited (TOWMCL) to buy electricity from the Capital's largest "city waste to power" initiative being set up at Okhla.

As per the agreement, BRPL will purchase 50 per cent of 16 MW electricity to be produced by TOWMCL at the Okhla plant.

"Under the terms of agreement, BRPL will procure 50 per cent of the exportable electricity that will be generated by the under-construction 16 MW 'waste to energy' integrated power plant in Okhla. BRPL will procure power at a DERC approved competitive tariff rate, determined by a competitive bidding process," said BRPL Chief Executive Officer Gopal Saxena.

The agreement allows the promoters to sell the remaining 50 per cent electricity through a suitable open access mechanism.

"The project, awarded to TOWMCL will process over 643,500 lakh metric tonnes or one-third of municipal solid waste (MSW) per year generated in Delhi. Of this, around 1,300 tonnes per day (TPD) of MSW will be sourced from the Okhla landfill site and 650 TPD from Timarpur. The plant, to be commissioned in late 2010-2011, is expected to annually lead to emission reductions of 266,066 metric tonnes of carbon dioxide equivalent per annum," said Mr. Saxena.

The power plant at Okhla is the second such project in the Capital that will utilise the city's solid waste to generate clean and renewable electricity. The other project is coming up at Ghazipur.

In November, BYPL had signed a 25-year-agreement to procure 49 per cent of the electricity generated from the 'city waste to power initiative' at Ghazipur. Together the two projects will generate 26 MW of electricity by cumulatively processing around over 3,000 tonnes of solid waste daily. These 'city waste to power' initiatives will also earn carbon credits for the MCD and the promoters.

"These novel projects offer an integrated opportunity to not only manage the city's colossal municipal solid waste in an environment-friendly manner, but also provides clean, green and pollution-free electricity", said a BRPL official.

Keywords: TOWMCL, Okhla, Waste Management, DERC, BSES

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Delhi to Empty Overflowing Landfill for Energy Recovery

02 February 2012

The Municipal Corporation of Delhi (MCD) has decided to empty part of the Ghazipur landfill over the next three years, with the intention of building material and energy recovery facilities, according to a report in the Hindustan Times

The 31 acre site that has been in operation since 1984 is reported to contain 4.6 million metric tonnes of waste, and has been full for the last few years and unable to take any new deposits.

The report said that the waste emptied from the landfill will be segregated, and after three years - when sufficient space has been cleared - a plant for generating energy from solid waste will be built on the part of land that has been cleared.

Leader of the House in MCD, Subhash Arya is reported to have said that the Planning Commission has approved the proposal to process the waste at Ghazipur landfill site.

"After reclaiming the site, a plant for generating energy from solid waste will be set up. Garbage will be processed here and waste will b dumped at Jaitpur mines," Arya said.

To empty the entire site is expected to take around 10 years and cost The entire lot of waste will take about 10 years and cost Rs 250 million ($5 million).

According to the Hindustan Times, the MCD plans to remove around 2000 tonnes of waste each day, with the waste removed being spread on a concrete platform to dry.

"After this, it will be put on conveyor belts for recycling. It will go through magnetic separator and air density classifiers and ferrous metals, stones and plastic will be extracted," Arya is reported to have added.

Read More

Landfill and Waste to Energy Sites Open in Delhi
he Municipal Corporation of Delhi has begun operations at its new landfill site at Narela-Bawana in northwest Delhi, according to a report by the Tribune News Service.

Waste to Energy for Integrated Waste Management in India

If the Indian Waste to Energy industry can exhibit self-responsibility in emissions control, it could established itself as a solution to a crisis and lead the way for reforms in implementation of regulations across all other industries, according to a recent study.

Okhla Waste to Energy Emissions to Face Scrutiny in India

India's environment secretary, Keshav Chandra, has visited the area where the controversial Okhla waste to energy facility is located in Delhi, India as the government vows to keep a close eye on the facility as it ramps up to full capacity

MUNICIPAL CORPORATION OF DELHI

Ambedkar Stadium, Near Delhi Gate, New Delhi-110001
Reclamation of Land at Ghazipur Dumpsite on
Public Private Partnership (PPP) basis

REQUEST FOR QUALIFICATION (RFQ)

Municipal Corporation of Delhi (MCD) is among the largest municipal bodies in the world providing civic services to an estimated population of 18.00 million citizens in the capital city of India. MCD proposes to seek private sector participation for reclamation of land at Ghazipur Dumpsite due processing of the waste (the Project). Ghazipur Landfill Site was made operational in 1984. Its maximum height is 30.5 m and average height is 25.5 m. The average side slope is 60°-70°. The volume of wastes deposited on the site is 4.5-5.0 million m³ and occupies 25.177 Ha area.

Scope of work

The scope of work of the private operator shall include:

- Design, finance, construct, operate and maintain the project facility
- Excavation of the existing waste at the site, segregation and processing of the existing waste
- Disposal of products/byproducts (including but not limited to biodegradables, rubber, leather, textile, metals, leachate etc.)
- Dumping of inert material by transporting inert material to location specified by MCD

Who Can Apply

A single entity or a group of entities with the below mentioned Technical and Financial Capability as detailed out in RFQ document

i. Technical Capability of experience in
   1. Dumpsite/Landfill reclamation projects

      or

   2. Collection transportation, processing and disposal of Waste
ii. Financial Capability of minimum Net Worth of Rs. 15 Cr at the close of the preceding financial year

How to Apply

Eligibility criteria, bid process, and other details of the Project has been provided in the RFQ which can be obtained from the office of Room No. 31, First Floor, Gate No. 9, MCD, Ambedkar Stadium, Near Delhi Gate, New Delhi - 110001 on a written request accompanied by cost of the RFQ. Alternatively the RFQ can be downloaded from the website of the department **(www.mcdonline.gov.in)**. In such case, the cost of the document has to be paid in accordance with the terms of RFQ.

Cost of RFQ document: Rs. 10,000/- (Rupees Ten Thousand Only) payable through a non-refundable demand draft in favor of **"Commissioner, MCD", payable at New Delhi**

Key dates:

Sale of RFQ document Up to 16.02.12........up to 3:00 PM
Last date of Submission of Application 05.03.12........up to 3:00 PM
Last date of Submission of pre bid query 17.02.12......up to 3:00 PM
Last date of reply to query 27.02.12

For procuring RFQ or enquiry/clarification please revert to:

Shri. Manoj Kumar, Executive Engineer (DEMS)-V, Room No. 31, First Floor, Gate No. 9, Ambedkar Stadium, Near Delhi Gate, New Delhi-110001, Ph: 011-23701299, Mobile No. 9717787037, E-mail: ee_dems_v@mcd.org.in.

MCD reserves the right to cancel this RFQ and/or invite afresh with or without amendments to this RFQ, without liability or any obligation for such RFQ and without assigning any reason. Information provided at this stage is indicative and MCD reserves the right to amend/add further details during any stage of the bidding process.

Sd/-

RO No. 426/DPI/2011-12 **Executive Engineer (DEMS)-V**