CHAPTER I

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1.1 BACKGROUND

In recent decades, groundwater resources have become increasingly threatened by the leaching of contaminants from uncontrolled landfill, containing industrial and/or household wastes. Infiltration of pesticides and fertilizers from agricultural areas and leakage of a wide range of organic pollutants from petrol stations, refineries, pipelines etc. are some of the most severe problems for groundwater.

In many circumstances, complex geochemical reactions, such as sorption, biodegradation, oxidation/reduction and precipitation/dissolution occur when contaminants enter the groundwater system and mix with the ambient water. While other factor, density differences between contaminant plumes and the ambient water might influence contaminant transport, particularly when instabilities develop and lead to increased spreading of contaminants or other groundwater constituents. Jodie Duggan (2005) studied about potential of contamination by landfill leachate in U.K. and reported landfill leachates as one of the major sources of groundwater contamination. While, Cheryl E. Halim et.al. (2005) has simulated the heavy metals collected from landfill leachate by using PHREEQC which indicates landfill leachates as the major cause of contamination of groundwater.

The environmental problems are increasing everyday due to industrial growth and unplanned dumping of municipal sewage wastes and garbages. Solid wastes may potentially contain any of solid material found in nature and in addition many man made materials. They constitute the most heterogeneous collection of substances possible. Calvo et.al. (2005) has explained the environmental diagnosis methodology for municipal solid waste landfill. Themistoklis D. Kontos et al. (2005) has studied the municipal solid waste and reported high contamination whereas Pradeep (2004) studied
about heavy metal content in soil reclaimed from municipal solid waste landfill and reported high contamination in soil from unplanned municipal landfill.

Central Pollution Control Board (CPCB) (2000) in its report mentioned a substantial increase in generation of wastes in both absolute and per capita terms due to increase in high population of Delhi (census 2001). Delhi still has no planned landfill sites, which cause leaching of pollutants from landfills to ground water. These contaminants have caused concern about their possible effects on plants, animals, and human beings. The anthropogenic input of certain heavy metals into the environment equals or exceeds the amount released by natural sources.

1.2 CURRENT SITUATION OF DRINKING WATER IN DELHI

1.2.1- Urban developments and the formal and informal Role of groundwater in the city’s water supply

Delhi, the capital city of India, has a specific status in the Indian political federalism. The city of Delhi is located in the National Capital Territory of Delhi (NCT Delhi). This territory has a pseudo-state status and is under the mixed control of the central government, and of a local government similar to other state’s government. The National Capital Territory spreads over a total area of 1483 km², of which more than 60% is now urban (Census of Government of India 2001). This political situation has a direct impact on the city’s access to water resources since in the Indian constitution; the management of water resources is primarily under the responsibility of the states. The National Capital Territory of Delhi, with a population around 15 million people (census 2001) has, therefore, very few resources under its direct control. Thus, it is very essential to protect our groundwater resource (main source of drinking water in Delhi), from being contaminated by leaching of pollutants.

The public authority in charge of housing development, the Delhi Development Authority (DDA) has not been able to cater the demand. According to various estimates, a proportion of 50% of Delhi’s population lives in some kind of informal, unplanned and/or precarious settlement. Among them, more than two million people,
representing more than 15% of the total population, live in illegal settlements and faces a permanent risk of eviction. The accountability of the municipal utility in charge of water supply and sanitation towards populations living in informal settlements is loosely defined, and most of them do not have a proper connection to the network. According to the Water and Sanitation Program (WSP), more than 40% of the urban population in India rely only on groundwater resources through hand pumps and shallow wells for their water supply.

Around 75% of the households in Delhi are reported to have access to piped municipal supply either through a private connection or a common standpoint, and around 20% of the population relies on hand pumps tapping the shallow aquifer for their water supply.

1.2.2 Depiction of Ground Water Quality in Delhi

The researchers and scientists of different organizations have raised the issue of drinking water contamination time to time but very few are bothered about real cause of drinking water contamination in Delhi region. While Central Ground Water Board (CGWB) and Central Pollution Control Board (CPCB), India, have reported groundwater as major source of drinking water in Delhi and deteriorating groundwater quality every day by leaching of pollutants from unplanned landfills and hence, this study is mainly concerning the groundwater quality in vicinity of selected landfills in Delhi, which represent a homogenous picture of all landfills and are believed to be contaminated by leaching of pollutants.

It is essential to study the mechanisms of groundwater pollution, release and movement of pollutants, and to take remedial measures in order to minimize the adverse effect of landfill sites on groundwater pollution. The mechanisms and pathways of groundwater pollution is different from that of surface water. The effect of surface water pollution is evident in sort time due to perceptible changes in colour, order and taste. While the groundwater contaminations may be initiated after several days, months or years after the pollutants are discharged on lands. The factors which affect the rate of groundwater contamination are reaction in top soil, zone of aeration, unsaturated or saturated zones,
laminar flow of pollutant, effect of specific gravity and viscosity, subsoil characteristics and movement rate of pollutants. Groundwater flow through strata is very slow in sharp contrast to rapid and some times turbulent flow of surface water. So in this study, it is emphasized the study of the impact of landfills on groundwater quality, study of solute transport (mainly pollution) by using software Visual MODFLOW / MT3D developed by Waterloo Hydrological Inc., Canada.

1.3 WORLD SCENARIO

In current scenario of world, on one hand we are moving towards sophistication of material development, on the other hand dumping these toxic solid wastes in low lying land areas like bank of river etc, which cause concern to environmentalist about possibility of contamination of surface water and groundwater by leaching of pollutants. Decomposition and leaching of these pollutants in groundwater raised the water quality issue around world about contamination of groundwater. Saro Lee (2003) has studied the evaluation of waste disposal site by using DRASTIC system in Korea. Perrin et al. (2004) has tried to study the vulnerability assessment in krastic areas in Switzerland. The large-scale study about the analysis of the distribution of inorganic constituents in a landfill leachate-contaminated aquifer Astrolabe Park Sydney, Australia were carried out by Jorstted et.al. (2004). Alison R. Keimowitz et.al. (2005) studied about naturally occurring arsenic and mobilization through landfill. This study sought to determine the source of arsenic to the aquifer, the processes responsible for arsenic mobilization, and to evaluate the effectiveness of remediation efforts that have occurred at this site.

All around the world a number of researchers reported the leaching of pollutants from the municipal solid waste landfills. Other scientists have studied in Al –Sulaibiyah landfill in Kuwait and reported higher concentration of Ni and V, which indicates leaching of metal from disposal of petroleum related waste product. Muttamara and Leong (1997) have studied impact assessment of solid waste disposal site of the On-Nooch site in Bangkok, Thailand. They have reported higher concentration of heavy metals than the allowable level in wastewater discharged by leachate treatment plant.
(Cr 1.03, Mn 1.07, Hg 0.025 mg/l). The USGS has developed software for the solute transport process like, Saturated-Unsaturated Flow and Transport (SUTRA) model.

Internationally, almost 70% of municipal solid wastes (MSW) are disposed to landfill (OECD, 2001 and Zacarias-Farah and Geyer –Allely, 2003). MSW contain hazardous substances in the form of paints, vehicle maintenance products, and mercury containing wastes, pharmaceuticals wastes, batteries and many other diffuse products, which are discussed in details by Slack et al. (2004). Vast stores of underground water played a leading role in transforming California into the nation's top agricultural producer and most populous state. Today, ground water supplies about 40 percent of the water for Californians use or about 16 to 17 million acre-feet per year (acre-foot = the amount of water needed to cover an acre to the depth of one foot or approximately 326,000 gallons). The state's largest subterranean reserves lie beneath the fertile farmlands in the Central Valley of California. An estimated 100 million acre-feet of usable water is available. Worldwide, geologists say about 90 percent of the world's usable water supply occurs as ground water. It was not until the beginning of this century that ground water came into the widespread use for irrigation because advances in drilling and pumping technology made the water easier to access.

Ground water use became so widespread that by the 1930s dropping water tables and escalating pumping costs focused efforts on development of surface waters and construction of extensive storage and conveyance systems such as the State Water Project and the Federal Central Valley Project. Ground water continues to meet many of California’s water needs.

1.4 INDIAN SCENARIO

India is one of the developing countries suffering from high level of contamination in groundwater. In India, still there is no planned dumping site due to many reasons. One of them is the negligence of this important issue in our country. Though, we read about groundwater pollution almost every day in newspaper in the form of article but nobody is bothered about real cause of groundwater contamination. Lots of works have been
done to understand the problem of groundwater pollution and for simulation of solute transport, like Anandh and Sinha (2004) who did simulation of groundwater in Orrisa etc. Mahadevan and Krisnaswamy (1984) studied about the impact of various sources of pollution on the quality of groundwater in Madurai, India. Jinkun Song and Brajesh Dubey (2005) studied about implication of chromium speciation and disposal discarded CCA-treated wood. Fluoride problem in Delhi has been reported by Singh et.al. (2004). But very few have concentrated on one of the major point sources (landfills), which is supposed to be point source of groundwater pollution.

In this research work, a large-scale study on groundwater has been carried out along the River Yamuna, covering three landfills out of which, two are still in working condition while third one is closed. A comparative study has also been carried out to understand more explicitly the impact of landfills on the groundwater quality.

1.5 IMPORTANCE OF WORK

As mentioned earlier, groundwater is the most precious gift of nature. The huge population of Delhi is dependent on groundwater resources. All around the world, various studies indicate groundwater pollution due to leaching of pollutants from unplanned landfills. This scenario induced us to study groundwater pollution near the vicinity of landfills which are the source of pollution. There is an urgent need to minimize the groundwater pollution around landfill sites. A successful approach to understand the solute transport mechanisms have been done by using Visual MODFLOW/MT3D software. The simulation of solute transport helped us in determination of rate of movement of pollutants from these point sources (landfills) as well as path lines of contaminant transport and movement. Simulation also helps to plot the rate of discharge with time. This study thus helped to solve a few problems of groundwater contamination and to identify the major point source of pollution in Delhi.

1.6 GROUNDWATER QUALITY

Ground Water is generally a renewable resource. However, the natural supply of groundwater in hard rock is limited in time and space. Further, the quality of available
fresh water resources is under severe threat. One of the most important issues in the groundwater management is extending minimum negative effect to the environment while exploiting it for the maximum economic benefits. Through out the world, regions that have sustainable groundwater balance are shrinking day by day. There are three problems which dominate groundwater use, depletion due to overdraft, water logging due to mostly inadequate drainage and insufficient conjunctive use and pollution due to agricultural, industrial and other human activities. Practically natural quality of water depends upon the physical environment and the origin of movement of water. As the water moves through the hydrological cycle, various chemical, physical and biological processes change its original quality though the reaction with soil, rocks and organic matter. Natural processes and human activities cause changes in groundwater quality directly or indirectly.

The geochemical properties of groundwater generally depend upon those of recharge of water viz., atmospheric precipitation, inland water surface waters and seawater and subsurface geochemical processes. The knowledge of geochemical processes often lead to an understanding of groundwater quality and occasionally aid in making useful predictions.

1.7 ASSESSMENT OF GROUNDWATER POTENTIAL

Applying modeling approach it has been carried out the optimal utilization of groundwater for proper assessment. Groundwater resource assessments help us to determine the sources, their extent and their dependability. The estimation of groundwater potential includes determination of various parameters like rainfall, infiltration, evaporation, transpiration, groundwater recharge, discharge and movement. In Delhi, precipitation is the major source of groundwater recharge as well as Yamuna River is also very important. A variation of water level is easily detected as moving away from the bank of river. Regional groundwater recharge and balance approach can be used which takes care of inflow and outflow component also.
Lee and Chen (1999) estimated groundwater recharge by adopting the water budget model combining the rainfall data and soil parameters with the infiltration model. Meyer et al. (1999) provided a simplified model for the transient water budget of a shallow unsaturated zone to estimate groundwater recharge and flux of that may transport a dissolved contaminant into the groundwater. Lee et al. (2000) also applied the water-balance method in conjunction with an independent estimation of recharge from a finite difference simulation of groundwater levels.

1.8 OBJECTIVE OF THE STUDY

The objective of this study is to understand the groundwater quality variation around all three landfill (Okhala Phase II, Indraprastha and Bhalswa) sites to predict the potential contamination of groundwater resource by their leachates. Out of these, Bhalswa and Okhala landfills are still used for dumping, while Indraprastha Landfill is closed, but all of them are located in the bank of the Yamuna River. For the present groundwater quality study, sampling has been carried out over an area of 28 km² around each landfill covering around 3 km radius for each landfill site following standard procedure. The main aim of study is to:

1. To understand the details of the hydrogeochemical variations of the groundwater quality in vicinity of all three landfills in Delhi.
2. To carry out a comparative study of hydrogeochemistry in vicinity of working landfills (Okhala and Bhalswa landfill) and closed landfill (Indraprastha) in space and time.
3. To simulate the flow pattern of groundwater to get an insight into its hydrogeological variations using Visual MODFLOW provided by Waterloo Hydro geological Inc., Canada.
4. To delineate the Nitrate, Fluoride, Heavy Metals contaminated zones in Delhi and suggest suitable remedial measures to reduce its impacts.
5. To identify the pathway and movement of contaminants in groundwater aquifer system in vicinity of landfills (Okhala Phase II and Indraprastha) by using Visual MODFLOW/MT3D.
1.9 JUSTIFICATION

India is one of the developing countries, which is having groundwater pollution problem due to leaching of pollutant since long times. Literature review indicate that many researchers reported the groundwater contamination is mainly due to the leaching of pollutants from unplanned landfill sites like Bhalswa, Okhala and Inraprastha. Central Pollution Control Board reported possible leaching of contaminant from these landfills. Further, Dinesh Kumar et.al (2005) reported high concentration of heavy metals and other contaminant in landfill leachate of Okhala and Bhalswa. All these aspects attracted me to undertake this study on the groundwater pollution and to locate exactly the point sources of these pollutants and to provide possible scientific solution /suggestion to minimize the groundwater pollution problem. A successful approach to study the solute transport was carried out using Visual MODFLOW/MT3D. Simulation of the solute transport made to determine the pathway/line of contaminant movement from point source (landfill). The outcome of this study will help to solve the problem of groundwater contamination and help to delineate the major point source of groundwater pollution in the Delhi. The geology of study area is mainly made of alluvium, which is more susceptible for contamination of groundwater by leachates from landfills causing pollution (Saro lee, 2003). Hence, vast sampling in space and time, analysis and interpretation carried out to point out the major sources of the pollutants in these areas. Further possible alternative measures will be taken to minimize the contamination of the groundwater.