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Impact of Landfill Leachates on the Physico-Chemical Properties of Groundwater at Okhla Landfill Site

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Graphical Abstract

ABSTRACT

Physico-chemical analysis of water samples collected from the groundwater at Okhla landfill situated in Delhi to measure the impact of the landfill leach ate. Temperature, pH, turbidity, total dissolved solids (TDS), Dissolved oxygen (DO), Total Iron, Total Hardness, Nitrite, Nitrate, Calcium, and heavy metals such as Zinc, copper, and lead are the parameters that are determined in the groundwater at Okhla through the standard laboratory procedures and conventional equipment. These parameters are considered as the indicator of traceable pollution. The pH of the toxic pollution ranges from 5.7 to 6.8.Turbidity values of this pollution range between 26.5 to 27.50C. The Values of temperature for these parameters are considered as 266.5 to 27.50C. The concentration of the heavy metals found in the groundwater such as iron, nitrite, nitrate, and calcium ranged from 0.8 to 1.3 mg, 1.29 to 60 mg, 1 to 9.6 mg, and 16 to 121 mg respectively. The presence of chromium in the

groundwater is not directly affected by landfills. From the statistical analysis, it is clear that significant differences among all the parameters for the samples were test at a 95% level.
Keywords: Okhla Site, Landfill, Groundwater, Heavy metals, Leachates

1. Introduction

Landfill leach ate has been treated as one of the major challenges of groundwater. Throughout the world, landfills have become the primary concern of the environmentalist. In India, 90 percent of the Municipal Solid Waste (MSW) isinappropriately dumped on the land. The solid waste gets underflow or gets infiltrated from the precipitation. The dumped solid wastes get mixed with water during rainfall and through the waste decomposition, the by-products of the wastes get decomposed. Various innumerable organic and inorganic compounds are contained in the liquid known as leach ate. At the bottom of the landfills,leach ate is accumulated with the help of soil and reaches the groundwater. The potential pollution source of leeches is prominent near the dumping site that affects the areas present near the landfills.

Chances of groundwater contamination are maximum near the landfills areas that result in a substantial risk to the natural environment and local groundwater resources. In the various studies, the impact of landfill leach ate on the groundwater has risen due to rapid growth in the population. Groundwater can be accessed through various approaches. Mathematical modeling can be used to assess the water contamination by the determination of the impurities present on the groundwater and surface water contamination. In this study, the impact of landfill leach ate percolation on the physicochemical properties has been estimated at Okhla landfill sites of Delhi. The depth and distance of the landfill from the groundwater sources have been studied.

2. Literature Review

2.1 Groundwater contamination due to landfill leach ate

Landfills are considered one of the major challenges of groundwater resources. To each groundwater undercurrent, open dumps and squander situated in landfills are exposed. The underlying interstitial water of the dump solid squanders slowly is discharged and its by-products get moved through the waste store. Countless home gowns and inorganic mixes are contained in such fluid that is referred to as leach ate [14]. Dirt present inside the landfill sites give birth to the leach ate. Groundwater tainting is more common in the areas near landfills as the growth of leach ate is maximum near the landfill area. A great hazard of the network is represented by the contamination of the groundwater due to the presence of leach ate. Okhla is the landsite present in Delhi where the effect of leach ate permeation on groundwater will be examined. Various psychos chemical parameters of the landfills are affected by the leach ate that contains various heavy metals that discharge in the groundwater. Okhla landfills are present in Delhi which has more than 14 million populations and creates 7000 metric tons of garbage per day. Industrialization and urbanization are considered the most important reason for groundwater pollution.

The rapid growth of the population has increased the landfill's leach ate that has affected the psycho-chemical properties of groundwater at Okhla without any regard for environmental consequences. Based on the physical and chemical soluble parameters, the quality of the groundwater decreased due to the various anthropogenic activities. A lot of attention has been gained by the leach ate impact on the groundwater and other water resources. A high risk to the groundwater has been identified due to the migration of leeches from the landfills [12]. It releases pollutants from the sediments. Groundwater protection is one of the major environmental challenges as it affects human health and disturbs the ecological balance. Solid wastes get disposed of in the open dumps and it is considered as the most common way for throwing solid wastes. Rapid growth of the population, industrial and technological revolutions has made waste management more complex.

Nutrients release rate leaching of nutrients sludge organic matter on the sorption degradation, metals through macrospores as suspended slides are the various issues that are responsible for the groundwater pollution. To understand the impact of landfill leach ate it is important to study the leaching of hydrophobic organisms and long-term bioavailability [15] . Waste present in the soil contains various toxic chemicals that have a high concentration of nitrate and phosphate that are harmful to both ground and surface water. Snakes, rodents, insects, dust, bad odor, and noises are some of the major important problems related to groundwater pollution. The volume of solid waste increased in the Okhla landfills over time from 60,000 metric tons to 75,000 tons in 2018. It has been found that 80% of the wastes present in the Okhla landfill are organic. 15.72% of wastes are plastic and nylon and 1 percent wastes belong to metal. Groundwater pollution in the Okhla landfill increased through the increment in the waste generation and disposal of wastes in the open dump.

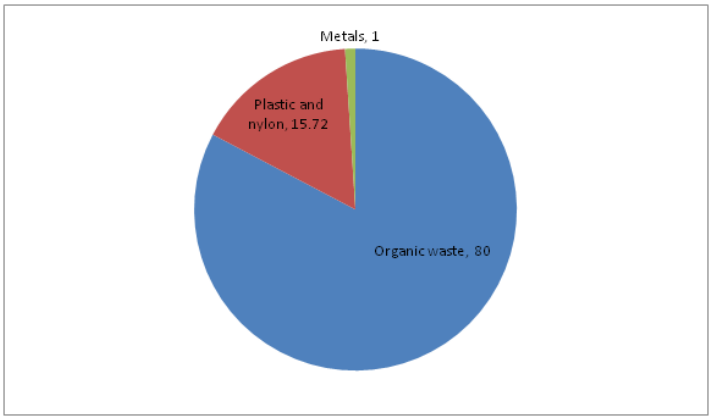

Figure1: Type of Waste present at groundwater at Okhla landfills

2.2 Status of Municipal Solid Waste in Delhi

Delhi is considered the most populated and urbanized area that generates 9000 metric tons of solid waste every day. In the year 2021, it has been estimated that that data will rise to 17000to 25000 tons every day. Municipal solid waste that is generated by Delhi is considered five times higher than the national average [11]. In Delhi, the average domestic hazardous is generated about 0.03 t 1 kg every day from each home. Batteries, paint, discarded syringes, CFL bulbs, discarded medicine, and discarded syringes are the sources of domestic hazardous waste. Interaction of these wastes with the

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other solid wastes and getting discharged in the groundwater raise the risk of groundwater pollution as well as environmental pollution. In domestic hazardous waste, the presence of heavy metals such as nickel, lead, and mercury is the maximum that enhances the metal concentration in the groundwater. Accumulation of waste has been increased due to the improper collection of the wastes as well as inappropriate transportation of the wastes. The efficiency of the collection of waste in both big cities and small cities differ from 70 to 50 percent respectively [10].

Table 1: Three uncontrolled/active landfill sites in Delhi.

S.No.	Name	Location	Area (hectares)	Starting year	MSW received T/day	End of landfills
1	Okhla	South Delhi	22.89	1994	1200	2005
2	Bhalswa	North Delhi	26.22	1993	3200	2005
3	Gazipur	East Delhi	29.62	1984	2100	2008

From the above table, it has been cleared that Okhla, Ghazipur, and Bhaiswa are the landfill sites that collect the waste from the north, south, and east residential areas of Delhi. Industrial waste, poultry, and vegetable market wastes are collected by these landfills. In this study, we are studying the Okhla landfill that collects the wastes from the residential area of South Delhi. These landfills do not have any leach ate collection system as well as a greenhouse gas trapping system [9]. Depending on the year, these landfills are classified as young, intermediate, and stabilized. Okhla landfill along with these two landfills is considered an old landfill site category. In table 2, the present infrastructure and facilities of Okhla landfill along with Bhaiswa and Ghazipur have been shown.

Table 2: Present infastructure and facilities available at three landfills of Delhi

Landfill Site	Area (acres)	DOC (Date of commissioned)	Zone covered in waste collection	Border fence	workers	Equipment is used	Gas Venting	LCS Leachate Collection System

Okhla	32	finished	South, Central, Najafgarh, and Delhi Cantonment Board (DCB)	Not completely	80	Two Hydraulic Excavators One Backhoe Loader, Two Bulldozers	No	No
Ghazipur	70	finished	North and South Shahdara City, Sadar Paharganj	Not completely	80	One Backhoe Loader, TWo Hydraulic Excavators, Six Bulldozer	No	No
Bhaiswa	40	finished	Civil Line, rohini, Narela, Karol Bagh and Najafgarh	Not completely	130	Two Hydraulic Excavators, Six Bulldozers, One Backhoe Loader five Bulldozer	No	No

These landfills are without pre-cover and unlined-based. During the daytime, avian diversity gets hovered over the landfill. During monsoon, pre-monsoon, and post-monsoon leachate are generated and drain into the canal that is present outside the landfill. Chamber facilities are also lacking in the Okhla landfill and unable to capture the various toxic gases that result in a fire that adversely affects the health of humans and animals. Waste to the energy treatment plant is a facility that has been established in Delhi however, the toxic gases released from the chimney cause serious health effects on human beings. Okhla landfill is located at Okhla Phase-I that is close to the National Highway from the maingate site of the landfill and adjacent to the landfill on the South-East of the city. Okhla landfill covers an area of 56 acres. Solid wastes that are generated in South Delhi and Central Delhi are collected by Okhla landfills [1] . Treatment for this site as well as arrangement for leach ate collection is not available at these sites. Through the open drains, the Leachate gets deposited into

the existing sewer. All the solid waste found at this site is restructured and compacted with the help of hydraulic bulldozers.

3. Materials and methods

A. Study Area

Groundwater at Okhla landfill is considered as the study area that collects the wastes present at the resending of the South Delhi. Delhi is considered the most populated and urbanized area. Many people migrate to Delhi for various purposes including jobs, education, and many more. 7000 metric tonsof waste is generated per day in Delhi, New Delhi Municipal Corporation, and Delhi Cantonment. Disposed practices of MSW are not considered safe for the human and environment;Okhla sites review all kinds of wastes including oil products, food waste, agricultural wastes, and debris, hospital waste and liquid waste. There is no specific landfill for storing each type of waste. Municipal or hazardous waste doesn't practice pre-treatment for the waste before dumping. In any of Delhi's waste disposal sites; there is no proper management of the landfill. Steep slopes don't allow covering the waste pile at the site. The presence of high temperature leads to bad odors and self-waste combustion. Okhla, Bhaiswa, and Ghazipur are the three landfills that are used for collecting waste material from Delhi [4].

Okhla landfill sites, Delhi have been used in this study to collect the leach ate that has been used in this study. A large volume of buried waste has been present on this site. This landfill site is located near the residential area of Delhi. 1200 tons of wastes are deposited at these sites every day. Construction and demolition waste has increased the waste density by about 1.2 tons per cubic meter. In the year 2004, it has been estimated that 2.83 minion tons of waste were deposited at Okhla landfill sites. Lower than 35% of the organic wastes were found in the Okhla landfill and 75% of wastes were considered as biodegradable waste. All these landfills including Okhla are found in the alluvial plains of Yamuna river and this is one of the prominent reasons for increasing groundwater pollution.

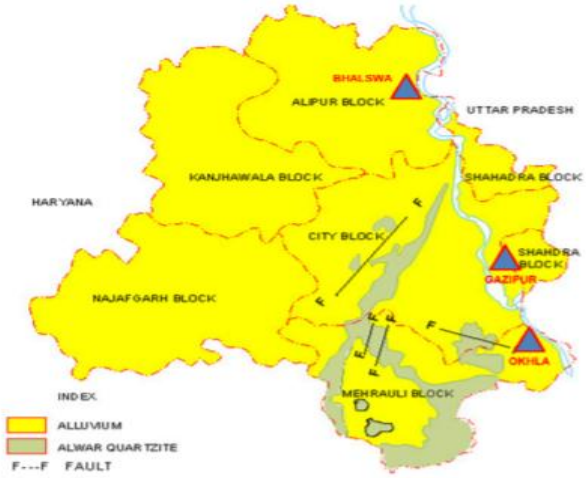

Figure 2: Okhla and various landfill sites and geology of the study area

Leachate characteristics

Okhla landfill site, Delhi has been chosen for collecting the leach ate in this study. At 4 degreesCelsius, the collected leach ate was stored in the laboratory for further analysis. To evaluate the impact of landfill leach ate on the groundwater at Okhla landfill has been analyzed with the various parameters including Chemical Oxygen Demand (COD), chloride, hardness, alkalinity, pH, Total dissolved solids (TDS), Total Suspended Solids (TSS), and metals. According to the Standard Methods for the Examination of Water and Wastewater has been sued for performing further analysis [5].

Analysis of leachate toxicity

Static 96h fish bioassays have been used for determining the toxicity of the leachate. Guppy fish has been used as test organisms. Variations in the leach ate percentage were used to expose the fish with the leach ate dilution with the tap water. Determination of toxicity values was done by observing the fish mortality at frequent time intervals. From the test vessels, dead fish were removed immediately. Leachate concentration (%v/v) has been used for expressing Toxicity that causes the death of the 50% of fishes used in the test [6]. The Spearman-Karber method has been used for calculating the LC50 tests.

4.Result and Discussion

Leachate characteristics

In June and December, Leachate samples were collected. Two different places of the landfill sites have been used for collecting the Leachate. Table 1 shows the values for the various parameters that affect the characteristics of the leached variation with time and space.

Table 3: Characteristics of Okhla landfill leachates used in groundwater

Parameters	Range of values
Alkalinity	12,000- 31,000
pH	7.5-8.1
Chloride	15,000-22,000
Hardness	8,000-24,000
NH3-N	1,000-3,000
COD	5,000-19,000
TDS	2,000-18,000
TS	23,000-53,000
TSS	19,000-34,000

Leachate toxicity

The study has been done to assess the acute toxicity of leach ate by estimating the mortality rate of the fish. From the study, it has been found the appropriate dilution range for leach ate. It has been found that leachate was more toxic with 96-h LC50 that has been shown in figure 3 and figure 4. Physicochemical and toxicological analyses were done simultaneously and there has not been any correlation found about the physicochemical characteristics of the groundwater and leachate toxicity [7]. Synergistic interactions among the various pollutants are responsible for the toxicity of the complex leach ate matrix.Organic matter, the presence of nitrogen, and a high concentration of heavy metals have contributed a lot to enhance the toxicity levels in the environment. Ecosystems and public health are adversely affected by these classes of compounds.

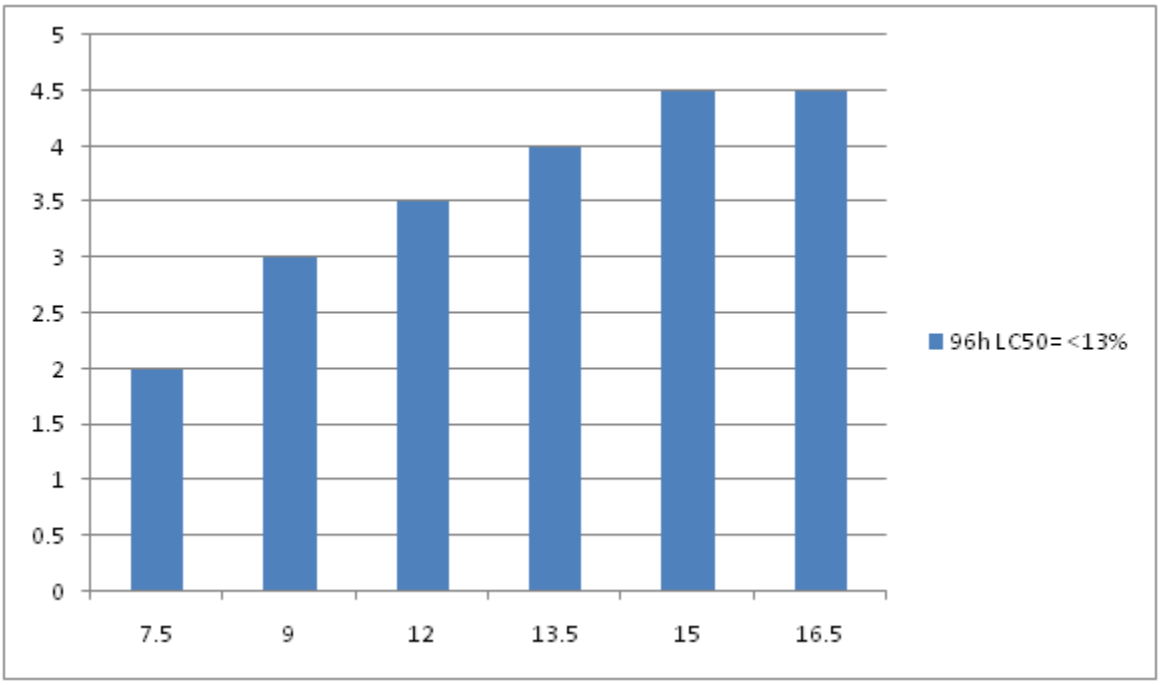

Figure 3: Toxicity assay

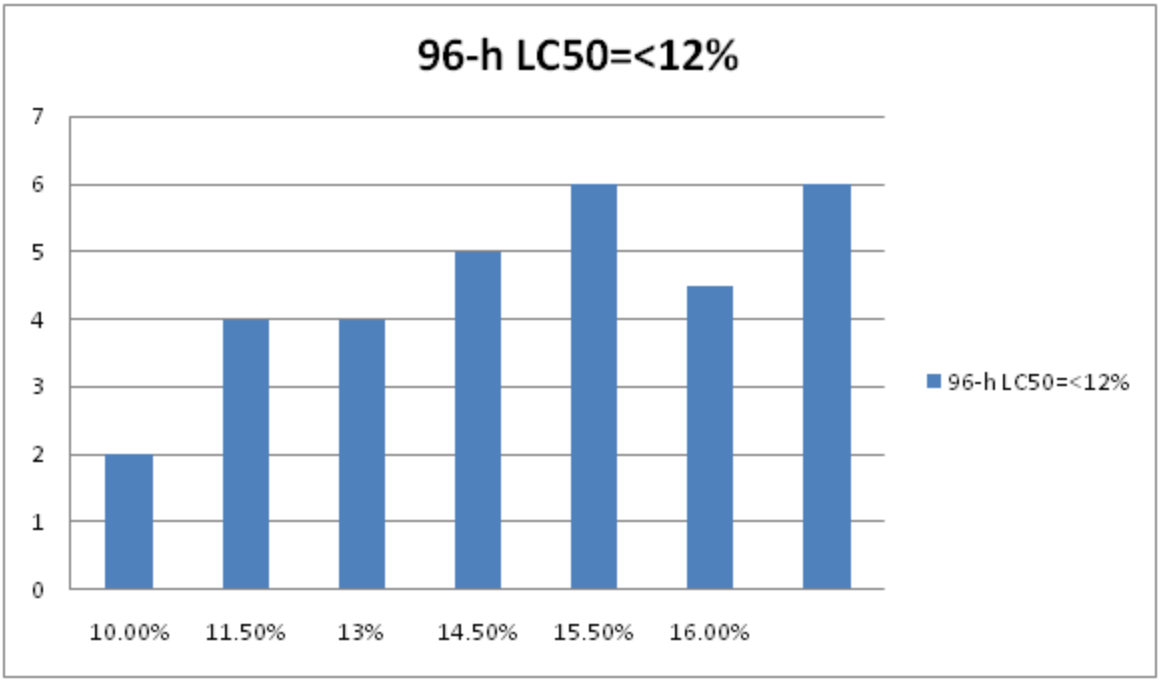

Figure 4: Toxicity assay

Metals in the leachate

Complexation with organic substances with low molecular weight and hydrated ions are caused by the mobilization of the heavy metals from the landfill into leach ate. Both organic and inorganic particulate matter gets bound with a significant amount of heavy metals. Leachate transportation is done by these various constituents. Various metals have been found in the study that is hazardous to the environment. Cadmium (Cd), Lead (pb), Chromium (Cr), Cobalt (Co), and Nickel (Ni) have been identified in this study and found as hazardous to public health and the environment [10]. Pb has been found as the most carcinogenic element that has toxic effects on humans and causes various diseases including paralysis, muscle, tremor, and coma. In this study, lead has been ranged between 0.9 t0 1.5 mg/L. Cadmium has been found as the major reason for agonistic and antagonistic effects on the hormones that lead to various malformations like renal damage. Nickel and Cadmium have been classified as carcinogens. Cr, Zn, Cu, and Co were considered as the elements that are responsible for the various health problems. Mn and Fe were detected with water and leachate at very high concentrations. In all the four leach ate samples, Fe and Ni have shown higher concentrations. Fe was ranged between 4 to 9 g/L and Ni was found in the range between 1 to 5 mg/L [12].

Table 4: Heavy metals detect in Okhla landfill leachate

Metals	Range of values
Cadmium (Cd)	0.2-0,3
Lead (Pb)	0.8-1.4

Manganese (Mn)	0.1-0.4
Copper (Cu)	0.1-1.4
Chromium (Cr)	0.7-2.1
Zinc (Zn)	0.7-1.4
Iron (fe)	3.0-9.,4
Cobalt (Co)	0.2-1.0
Nickel (Ni)	1.0-4.0

Bioavailability of organic compounds and toxicity

In the toxic analysis, the structure or organic compound is considered as the determining factor. Various metabolites have been present in the organo nitrogenated substances that enhance their potential for polluting the groundwater. In table 1, a higher concentration of ammoniacal nitrogen has been shown. It has been found in the study that higher concentration of organo-halogenated compounds contained in the landfill leachates [9]. The rate of reproduction and other activities gets decreased with the effects of toxicity of the organic compounds on humans. A high potential of bioavailability is present in the organo nitrogenated compounds and heavy metals. To identify the relationship between adsorption and de-adsorption, pH values and ion exchange capacity plays the most important factor. In the study, it has been seen that the pH value of leach ate was slightly alkaline. A methanogenic phase of solid waste degradation at the landfill is the reason that makes the leach ate more soluble [6].

Conclusion

The high pollution potential of the Okhla landfill leach ate has been highlighted through the toxicity assays of the leach ate. Various scant information has been present on the adverse effects of the leach ate. It is important to monitor the leach ate toxicity that flows through the municipal landfill. The toxicity of the data is supported through the presence of heavy metals released from the different sources of waste. It has been seen in the study that the Leachate Pollution Index is found as a potential technique to find the hazardous potential of the landfill sites. Infrastructure being practices have been started to deal with the exponentially growing municipal solid waste.

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