Journal of Earth Science & Climatic Change
Research Article Open Access

Analysis of Physio-Chemical Characteristics of Soil and Groundwater Contamination due to leachate Migration around Ghazipur Landfill Site

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Abstract

The present study highlights the physio-chemical characteristics of soil and groundwater contamination due to migration of leachate. The selected site is the Ghazipur landfill site near eastern part of Delhi, India. The presence of landfill sites in densely populated regions affects the health of humans, animals and plants residing in the surrounding areas. In this paper the extent of contamination on the basis of physio-chemical characteristics of water and soil affecting neighboring regions has been studied. Ghazipur landfill site was installed to regulate the percolation of rainwater into the soil subsequently reaching the groundwater and changing its quality parameters. In this study 8 different locations in a radius of 8km around the Ghazipur landfill site were selected measure the concentration of chloride (Cl-), sulphate (SO4--), Nitrate(NO3-) along with total dissolved solids, hardness etc. The Atomic Absorption Spectroscopy (AAS) technique was used to determine the abundance of heavy metals like Zinc (Zn), Cadmium (Cd), Copper (Cu), Chromium (Cr) and Iron (Fe). Soil and water samples were collected from the same sites. The water analysis report was obtained from Water Testing Laboratory, Uttar Pradesh Jal Nigam, Quarsi Ramghat Road, Aligarh, India for parameters such as pH value, total dissolved solids (TDS), total hardness (as CaCO3), total alkalinity (as CaCO3), chloride (as Cl),Iron (as Fe), Nitrate (as NO3), Fluoride (as F), sulphate (as SO4) and electrical conductivity(EC), while soil testing was done at Soil Testing Laboratory, Aligarh, India for parameters pH, EC, Organic Carbon (OC), available phosphorous (P), nitrogen (N) and potassium (K). All the parameters were compared with specific standards given by Bureau of Indian Standards (BIS10500-2012) to ensure the availability of safe drinking water for Indian citizens.

Keywords: Heavy metals toxicity; Landfills; Groundwater contamination; Electrical conductivity; Total dissolved solids; Percolation and leachates

Introduction

The unplanned disposal of domestic and industrial waste at dumpsites leads to enhanced health and ecological risk to residents near these sites. An unhealthy and noxious condition around the dumpsites generates many health related problems such as skin irritation, allergies, gastrointestinal problems and respiratory inflammation [1, 2]. A number of waste streams are responsible for the continued accumulation of heavy metals in the environment, which are nonbidegradable in nature [3]. Ground water pollution has been reported in different parts of world such as India [4], China and USA. In many developing nations solid wastes are disposed without precaution to deal with the leachate generation and emission of gases. Although research is going on to study the presence of heavy metals around the unorganized landfill sites globally but still there is a wide scope improvement. Unorganized waste management is one of the major causes for contamination especially in developing nations. Many studies have shown health risk due to exposure towards heavy metals using target hazard quotient (THQ). In Delhi (India) there are three major landfill sites having lack of base liner or cover increasing the possibility of heavy metal contamination of plants, soil and water. The water crisis is an additional problem in Delhi and its nearby cities due to improper solid waste disposal. The open dumping of such huge volumes of municipal solid and industrial waste creates environmental impacts that are not good for human health. Solid waste dumped in low-lyingregions comes in contact with groundwater and rainwater. These results in the formation of leachate and the water have a high level of dissolved inorganic substances, heavy metals, organic compounds, and xenobiotic organic compounds, nonengineered dumping degrades groundwater by forming leachate and percolates into the ground. Leachate formation is also affected by moisture conditions, surface topography, soil permeability, groundwater intrusion and field capacity of refuse. It is also affected by factors like pH value, temperature, age, water content, oxygen presence, natural mixing, and composition. The appearance of leachate is typically blackish and yellowish with an offensive smell. Concentrate leachate with high chemical oxygen demand (COD) and a low ratio of BOD to COD (Biochemical oxygen demand to chemical oxygen demand). Leachate composition understanding is vital for understanding landfill in the long term [5]. The refuse continues to decompose even after the landfill is covered, LPI (leachate Pollution Index) defines the quantity of leachate contamination potential and provides an overall pollution potential. Geological and hydrological features. Of a specific region controls the migration and composition of leachates away from a landfill, once the contaminant seeps below ground, it can remain there for several years and can make groundwater unsuitable for drinking and many other uses, a number of studies have been done across the world, to a study the leachate effect on groundwater [6]. A number of techniques have been used to study its groundwater qualities. Citizens using groundwater near dumping sites are at great health risk as they

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Received: 01-Aug-2023, Manuscript No: jescc-23-110213; **Editor assigned:** 03-Aug-2023, PreQC No: jescc-23-110213 (PQ); **Reviewed:** 18-Aug-2023, QC No: jescc-23-110213; **Revised:** 25-Aug-2023, Manuscript No: jescc-23-110213 (R); **Published:** 30-Aug-2023, DOI: 10.4172/2157-7617.1000722

Citation: Sharma S, Singh G, Mehmood G (2023) Analysis of Physio-Chemical Characteristics of Soil and Groundwater Contamination due to leachate Migration around Ghazipur Landfill Site. J Earth Sci Clim Change, 14: 722.

groundwater for drinking purposes. THQ (Targeted Hazard quotient) term has been used by many researchers for the measurement of essential human health risks due to heavy metal exposure risk. Tells about the contamination in the underground water in Erode city situated on the bank of the Cauvery river in Tamil Nadu has been studied. Forty-three groundwater samples and seven surface water samples were collected in February 2009. Various chemical analyses were done to ascertain the suitability of water for drinking and compared with the Bureau of Indian Standards (BIS) and the World Health Organization (WHO). The ground was found to be alkaline. The concentration of cations like Na+ and Mg+2 ions was found to be higher than the maximum allowable limit for drinking water. The surface water was found at the top to be within the permissible limit at all places except one where industrial discharges and sewage water was found to be mixed. Studied the effect of the physio-chemical parameters on the groundwater. Water samples were collected from around the dump yard boundaries [7]. The study area was the Pirana landfill site near Sabarmati. The study showed that values of various parameters near Nagma Nagar, Faisalnagar, Chippakuva, and Bhrampur are too large compared to the safe limit given by the Indian Standards of Drinking Water and World Health Organization. It is suggested that the water is not suitable for drinking and monitoring wells and clay liners are required to reduce groundwater contamination. The total population of Ghazipur is 75,544 according to the census of India densely populated area of Delhi [8]. Total Organic carbon (TOC), Chemical Oxygen demand (COD), Total nitrogen (TN), and pH value of leachate varies from season to season. These values are higher in winter as compared to summer. Other parameters that determine contamination in groundwater are Total Suspended Solids (TSS), Volatile Suspended Solids (VSS), Metal & inorganic nitrogen (MIN). These parameters do not change in the winter and summer seasons. Leachate is more dangerous in summer and winter as compared to the rainy season. According to the annual report on the implementation of SWM rules up to 10% of people are throwing garbage on streets in Delhi [9]. EDMC has one plant to convert waste into energy and it produces 12MW of electrical energy. (Delhi: Engineered Landfill Site to Reduce Waste, Make City Free of Garbage Mountains - India Today) SDMC disposes of the solid waste at Okhla landfill site where only one site and plant are operational. In this study a systematic analysis has been carried out to identify the chemical and physical characteristics of soil and ground water around the 8 locations near Ghazipur landfill site and an attempt has been made to connect the dots among the soil and water impurities which collaborates and contaminates the ground water in a huge extent [10].

Material and Methods

Experimental design

The sampling location in Ghazipur landfill site was selected within a radial distance 0 m (N 28° 37' 30.8784", E 77° 19' 40.764") to 8000 m. The population resides at a radius greater than 500 m. In this region the groundwater is typically used for drinking and agricultural purposes. So it is essential to conduct its investigation which will, undoubtedly, be helpful for the residents as well as policy makers of that region. The eight locations for sample collections of soil and water are shown in the (Table 1) Soil and water samples were collected from each location [11].

Table 1: Sample locations around Ghazipur landfill site.

Locations	Area (Ghazipur, Delhi)
A1	Mayur Vihar Phase III
A2	Mayur Vihar Phase III
A3	Mayur Vihar Pase III
A4	Gharoli extension
A5	Gharoli
A6	Kondli
A7	Kalyan Samiti Phase III
1	Dairy Farms, Ghazipur Site

Soil samples

The soil samples collected from different sites is air dried and grinded into fine powder. This powdered soil is sieved using 2 mm mesh. For measuring pH a solution of 2 mm fraction is dissolved in water in the ratio 1:5 (solid/ water) and then measured with the help of pH meter [12]. The electrical conductivity was measured using conductivity meter. For calculating concentrations of heavy metals 1 g of each sample was air dried and digested with 8ml of aqua regia (1 part HNO3 and 3 parts HCl) for 3 hours on sand bath. The Atomic Absorption Spectroscopy (AAS) technique was used to analyze these mineralized samples (Table 2).

Groundwater samples

Groundwater samples were analyzed for heavy metal contamination because hand pump water, tap water and bore well water are commonly used around the selected regions of Ghazipur landfill site. 1000 ml water was collected from each location in clean plastic bottles. The acid digested samples were filtered and then analyzed for Iron (Fe), Copper (Cu), Cadmium (Cd), Zinc (Zn) and Chromium (Cr) using AAS [13]. The metal contents in groundwater were compared with safe limits of heavy metals as described by Bureau of Indian Standard (BIS).

Statistical analysis

Bar-graph analysis has been used to compare the physio-cemical parameters such as total hardness (mg/l), TDS, chlorides, fluorides, nitrates, conductivity, sulphate and total alkalinity at different locations (as described in Table 1). Concentrations of various heavy metals and their corresponding absorbance have been plotted using quadratic relations according to Beers law [14]. The relations for various concentrations versus absorbance for heavy metals are as follows:

I. Cadmium (Cd)

$y = 0.3484x^2 + 0.1027x + 2 \times 10^{-6}$, where x is concentration and y is the absorbance.

II. Iron (Fe)

$y = 0.6068x^2 - 60.3176x + 0.0474$

III. Copper (Cu)

$y = 0.0131x^2 + 0.0602x + 6 \times 10^{-6}$

IV. Zinc (Zn)

$y = 0.0189x^2 + 0.2073x + 0.0002$

V. Chromium (Cr)

$y = 0.0005x^2 + 0.0216x + 1 \times 10^{-5}$

Results and Discussion

Heavy metal content

Groundwater Samples

The observed physical characteristics such as taste, colour, odour and turbidity for different locations at landfill site are presented in

Table 2: Physical characteristics of water samples.

Sample Location A1					
S. No.	**Parameter**	**Unit**	**Test Result**	**BIS-10500-2012 Specified values**	
				Acceptable Value	**Causes for Rejection**
1	Taste		Agreeable	Unobjectionable	Unobjectionable
2	Hazen		1	5	15
3	Odour		Agreeable	Unobjectionable	Unobjectionable
4	Turbidity	N.T.U.	3.62	1	
Sample Location A2					
1	Taste		Agreeable	Unobjectionable	Unobjectionable
2	Colour	Hazen	1	5	15
3	Odour		Agreeable	Unobjectionable	Unobjectionable
4	Turbidity	N.T.U.	2.11	1	5
Sample Location A3					
1	Taste		Agreeable	Unobjectionable	Unobjectionable
2	Colour	Hazen	1	5	15
3	Odour		Agreeable	Unobjectionable	Unobjectionable
4	Turbidity	N.T.U.	3.01	1	5
Sample Location A4					
1	Taste		Agreeable	Unobjectionable	Unobjectionable
2	Colour	Hazen	1	5	15
3	Odour		Agreeable	Unobjectionable	Unobjectionable
4	Turbidity	N.T.U.	1.65	1	5
Sample Location A5					
1	Taste		Agreeable	Unobjectionable	Unobjectionable
2	Colour	Hazen	1	5	15
3	Odour		Agreeable	Unobjectionable	Unobjectionable
4	Turbidity	N.T.U.	1.92	1	5
Sample Location A6					
1	Taste		Agreeable	Unobjectionable	Unobjectionable
2	Colour	Hazen	1	5	15
3	Odour		Agreeable	Unobjectionable	Unobjectionable
4	Turbidity	N.T.U.	0.96	1	5
Sample Location A7					
1	Taste		Agreeable	Unobjectionable	Unobjectionable
2	Colour	Hazen	1	5	15
3	Odour		Agreeable	Unobjectionable	Unobjectionable
4	Turbidity	N.T.U.	1.03	1	5
Sample Location 1					
1	Taste		Agreeable	Unobjectionable	Unobjectionable
2	Colour	Hazen	1	5	15
3	Odour		Agreeable	Unobjectionable	Unobjectionable
4	Turbidity	N.T.U.	2.24	1	5

Table 2. The Physical characteristics show different ranges of turbidity level for all the locations. The highest turbidity was found at location A1 (3.62 N.T.U.) while the lowest turbidity was at the location A6 (0.96 N.T.U.). pH values for groundwater (Table 3) near the landfill sites at locations A1, A2, A3, A4, A5, A6, A7 and location 1 are found to be respectively 7.46, 7.75, 7.31, 6.68, 7.02, 7.69, 7.61, 7.74 , these values lie within the acceptable values specified by BIS-10500-2012. Table 4 shows the TDS values at different locations [15]. The maximum value of TDS was at location A1 (4465 mg/l) while the lowest value was at location A3 (534 mg/l). The permissible limit as per BIS lies in the range 2500 mg/l to 2000 mg/l. Total hardness as been shown in with locations A1, A5 and location 1 having values exceeding the permissible upper limit. Total alkalinity (as CaCO3) at all the locations was found to be within the acceptable value. The maximum values of chloride, nitrates, fluorides and sulphates are found to be 1928 mg/l, 9.2 mg/l, 2.01 mg/l and 328 mg/l at the locations A1, A5, A4 and A1 respectively shows electrical conductivity at various locations. Shows various physio-chemical parameters in the form of bar-graph. In this study, mainly five heavy metals have been analysed i.e. Cadmium (Cd), Iron (Fe), Copper (Cu), Zinc (Zn), Chromium (Cr) [16]. The above Concentration Vs Absorbance graphs represent that these 5 heavy metals are present at all the locations but in different range and greater than the limit (IS 3025). The presence of Cadmium at location 1 was found to be highest while at A2 and A3, Cadmium was not present. Although, except these

Table 3: pH Value of 8 sample locations.

Location	**pH Value**	**BIS-10500-2012 Specified values**	
		Acceptable Value	**Causes for Rejection**
A1	7.46	6.5-8.5	6.5-8.5
A2	7.75		
A3	7.31		
A4	6.68		
A5	7.02		
A6	7.69		
A7	7.61		
1	7.74		

Table 4: TDS of 8 sample locations.

Location	TDS (mg/l)	BIS-10500-2012 Specified values	
		Acceptable Value	Causes for Rejection
A1	4465	500	2000
A2	1332		
A3	534		
A4	807		
A5	1261		
A6	578		
A7	716		
1	1820		

locations Cadmium was present, it means that both anthropogenic and geogenic content were there which rises the cadmium amount. The high level of Iron shows that steel scrap is also dumped and presence of Iron around the landfill site has been found at each location and Highest is at location A2.The primary causes of the leachate's dark brown hue are the oxidation of ferrous iron to ferric iron, the creation of ferric hydroxide colloids, and complexes of ferric hydroxide with fulvic/humic material as suggested. Fluorescent batteries and lamps increase the amount of Zinc and according to locations has found the maximum amount of Iron content. The amount of Chromium and Copper content in the waste are potentially toxic substances (if present more than the limit) due to anthropogenic sources at landfill site. Cu and Cr are both present more than the specifications limit at each location which creates more contamination around the landfill site [17].

Soil samples

Soil samples were collected from same locations nearby as the collected water samples collected from the roadside to a depth of 0.0-5.0cm using a soil auger. To prevent soil samples from being mixed up, the soil samples were tagged and kept in plastic bags [18]. Next, it was transported to the lab and kept in an area that was air-dried before being tested for Phosphorous and Nitrogen. Potassium was found to be very high at most of the locations while Phosphorous comes out to be low. Other than that, pH, Organic carbon and electrical conductivity have also been checked and shown in (Table 4).

Conclusion

All the sites were proven to be unsatisfactory results for water use while in case of Location 1, Cd, Fe, and Zn were found to be in maximum range and also potassium and phosphorous in soil are present in higher side. On the other hand, Cadmium, chromium and Copper for locations A2 and A3 were below detection limit but Iron and Zinc were present. Floro-cations A1, A4 and A7 Iron was not detectable but Cu, Zn, Cd, Cr were present. In this study, Potassium and Phosphorous were found to be out of the range lies between 189-450 kg/hec, according to the Indian Standards (IS 2720). The high levels of EC, TDS, Cl-, Total hardness, total alkalinity, heavy metals and Sulphates of Groundwater near Ghazipur landfill has deteriorated in quality, making it unfit for drinking and other domestic uses. Moreover, in connection to leachate percolation, the presence of Cl-, NO3 -, Fe, Cu, Cd, Zn, Cr can be employed as a tracer. Also discovered to be bacteriologically hazardous were the samples. It may be established that leachate has a considerable impact on groundwater quality close to the vicinity of the Gazipur dump site because there is no natural or other explanation for the high concentration of these contaminants. Even while the quantities of a few contaminants do not surpass the requirement for drinking water, the quality of the ground water nevertheless poses a serious hazard to public health.

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