

INFLUENCE OF LEACHATE ON GROUNDWATER NEAR PIRANA LANDFILL SITE

Focused on heavy metal and Arsenic contamination

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Abstract: Landfill leachate is the liquid generated due to water percolation through the solid waste, oxidation, and decomposition of the waste dumped into the site. Poorly designed landfill sites allow the leachate to infiltrate in ground water through soil strata easily. In the present report, an experimental investigation is undertaken to scrutinize the effects of leachate on geo-environmental properties of the bore water surrounding Pirana Landfill Site, Ahmedabad. From results, it can be concluded that groundwater contamination is nearly negligible as the percolation of leachate through soil is low during the summer season.

Index Terms – Groundwater, Leachate, Contamination, COD, BOD.

I. INTRODUCTION

Gujarat is known as one of the most industrialized Indian states, having a population of more than 60 million. According to a Times of India report, 42.6% of the state's total population is living in urban areas. Due to a high rate of urbanization and increasing population, the amount of generated municipal solid waste is increased and thus it needs to be managed [1]. Study shows that landfills play an important role in managing solid waste as it reduces exposure to the environment [2]. It is necessary that proper land is provided for sustainable and suitable landfilling formulating future requirements. Every district must be allotted with land for waste disposal and MSW management should be planned scientifically.

Groundwater is the water that seeps through rocks and soil and is stored below the ground. It is considered as an important resource which provides water for various purposes like irrigation, industries, drinking. Unmanaged dumping and not proper segregation of waste leads to the generation of leachate in landfill sites. This leachate then penetrates into the soil and contaminates groundwater. Furthermore, leachate has hazardous effects on human health and the environment [3].

II. STUDY AREA

Ahmedabad is the 7th largest city located in western India covering area of 464km². It at 23°02' N latitude and 72°57' E longitude on the bank of Sabarmati River. Ahmedabad has characteristics of a semi-arid region and so the climate is generally hot and humid

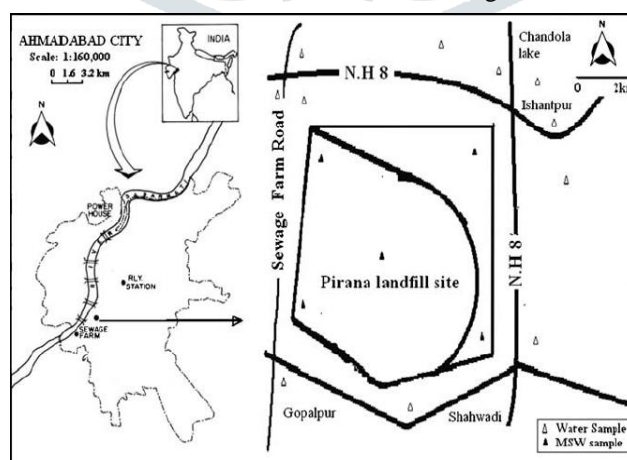


Figure 1 Layout of Pirana Landfill Site [10]

with an annual rainfall of 800mm occurs during, mid-June to mid-September. Ahmedabad is known as an industrial hub and inhabits more than 5.5 billion population. Due to this, waste generation is also increased. The entire city's waste is dumped at Pirana Landfill Site located in Daskroi.

Pirana falls on the latitude of 22.980368 and longitude of 72.56212 and has been Ahmedabad's garbage dumping spot since 1980. Pirana Landfill site is surrounded by industries/factories and Sabarmati River is located 3km from the dumpsite. The waste is spread over 84 hectares and height of over 200metres. The layout of Pirana Landfill site is shown in figure 1.

Pirana receives approximately 4000 tons of waste every day and most of it is dumped in the landfill untreated. The mountain of garbage not only affects the aesthetics but also has many hazardous effects on surrounding soil as well as groundwater [10]

III. METHODOLOGY

3.1. Data Collection

Ahmedabad lies on alluvial layers which comprise alternate layers of sand, clay, gravel, and silt. Several layers of sand are found at the depth of 50m. The layers are dispersed but interrelated and may be treated as a single unconfined aquifer. Thus, a thick layer of silt/clay separates deeper aquifer. Large aquifers have large extent and generally supplies the city's most of the water at present [10] (NEERI Report 1994). And there lies the importance of determining Ground water properties.

Pirana is the largest dump site of Ahmedabad city since 1982. Pirana landfill is spread over 84 hectares and many industries are established surrounding the Landfill site. Pirana falls on the latitude of 22.980368 and longitude of 72.56212. Site map of Pirana Landfill site was collected with the help of google earth and divided into 4 coordinates. Groundwater/Bore water samples at the distance of 400m from the center point of Pirana were collected as shown in figure 2.

Ahmedabad city receives water from Sabarmati river and it is only 3km away from Pirana Landfill site. So, to know the influence of landfill in such proximity, one sample from Sabarmati river was also taken. Thus total of 5 water samples were collected.

Coordinate 1 (Leachate): This sample's latitude is 22.983811 and longitude is 72.567376. The Lat Long of this point falls in Pirana Landfill site and Sample (Leachate) collected from this point had dark black color and foul smell.

Coordinate 3 (Factory): This sample's latitude is 22.979305 and longitude is 72.569933. The point was located around 400m from the dumping site. Sample was collected from a factory where bore water was supplied. The water seemed clean and odorless.

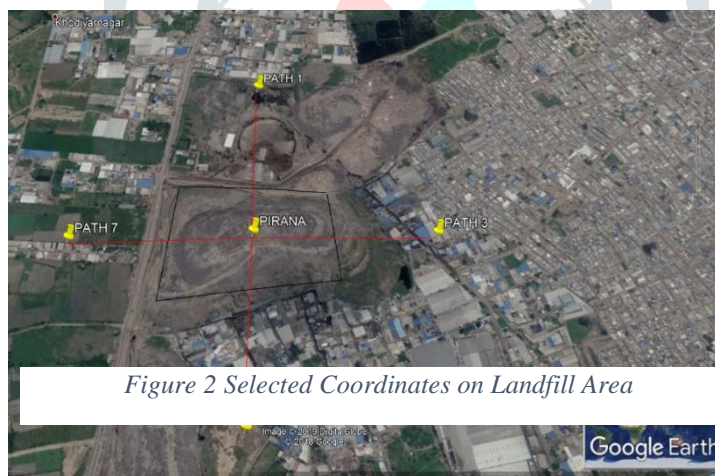


Figure 2 Selected Coordinates on Landfill Area

Coordinate 5 (Roadside shop): This sample's latitude is 22.976968 and longitude is 72.565029. The collected sample was found colorless when poured into a bottle but slightly yellow color was noticed where it was stored. It was a Bore water sample and the shop's owner said bore well was situated at a shallow depth.

Coordinate 7 (Farm): This sample's latitude is 22.981408 and longitude is 72.562495. Sample point was falling into a farm where bore water was supplied. Water sample was colorless and odorless but had some amount of suspended solids.

Sabarmati water sample: Sabarmati water sample was collected from the 22.99616 and 72.56584 latitude and longitude respectively. The water sample collected from Sabarmati riverfront was odorless but contained heavy amount of suspended solids. The water sample had a green color and algae floating into it.

3.2. Sample collection

Coordinate 1: (Leachate): leachate was collected from the point shown in the figure with the help of an empty container found at the site and was stored in a pet bottle.

Coordinate 3 (Factory): this sample was taken from a tap located inside the factory.

Coordinate 5 (Roadside shop): this sample was collected from a roadside tea stall. They used Bore water for washing purpose.

Coordinate 7 (Farm): It was from a borewell, a tap was used to collect sample water.

Sabarmati water sample: The water sample of Sabarmati River was drawn out with the help of a rope and bucket from the Sabarmati Riverfront located approximately 3kms away from the landfill site. The sample was stored in a pet bottle.

3.3. Sample Analysis:

Once the sample collection was completed, various tests were performed on the samples in order to determine their characteristics.



Figure 3 leachate at coordinate 1



Figure 5 groundwater sample at coordinate 5

The tests for determining characteristics of water samples were carried out according to IS 3025. Concentration of Lead (Pb) Zinc (Zn), Copper (Cu) and Arsenic (As) in bore water samples were calculated as the method described in APHA 3500. Following is the list of tests performed on the samples:

1. pH: pH is a scale used to specify how acidic or basic a water-based solution is.

S.No.	Sample Description	Temperature of Sample (°C)	pH
1.	Sabarmati sample	25 °	8.08
2.	Leachate (Point 1)	25 °	7.70
3.	Factory (Point 3)	25 °	7.78
4.	Roadside shop (Point 5)	25 °	7.70
5.	Farm (Point 7)	25 °	7.99

2. Conductivity: The ability of wastewater to conduct/ transmit Heat, Electricity or Sound.

Sr.No	Sample Details	Conductance (mS)
1.	Tap Water	1.94
2.	Distilled water	0.08
3.	Sabarmati sample	0.97
4.	Leachate	>20
5.	Factory (Point 3)	2.91
6.	Roadside shop (point 5)	2.62
7.	Farm (Point 7)	2.23

3. Total Dissolved Solids: It is a measure of the dissolved combined content of all inorganic and organic substances present in a liquid in molecular, ionized or micro-granular suspended form.

Sr.No	Sample Details	TDDS (ppt)
1.	Sabarmati sample	0.51
2.	Leachate	10

3.	Factory (Point 3)	1.49
4.	Roadside shop (point 5)	1.61
5.	Farm (Point 7)	1.18

4. Biological Oxygen Demand: Readings were recorded in the table according to the procedure described in 4.4.2. and BOD5 was calculated from the given formula:

$$\text{BOD5 (mg/l)} = \{[D1-D2]-[B1-B2]\} / P$$

Where: D1 = DO of the sample immediately after preparation, mg/L

D2 = DO of the sample after 5 days incubation at 20°C

B1 = DO of blank immediately after preparation, mg/L

B2 = DO of blank after 5 days incubation at 20°C, mg/L

P= dilution factor

S no.	Sample Details	Burette Reading			BOD5 (mg/l)
		0 th Day Reading (IR) (ml)	5 th Day Reading (FR) (ml)	FR-IR (ml)	
1.	Sabarmati	33	15.5	16.7	1670
2.	Leachate (Point 1)	29	24	29.2	2920
3.	Factory (Point 3)	38.2	27.6	23.6	2360
4.	Roadside shop (Point 5)	35	23.5	22.7	2270
5.	Farm (Point 7)	30	18	22.2	2220

5. Chemical Oxygen Demand: FAS used for each Sample as well as for blank solution was noted. The COD of each solution was then calculated from the below formula:

$$\text{COD (mg/L)} = [(A-B) \times M \times 8000] / \text{Volume of Sample}$$

Where: A = FAS used for sample, mL (table)

B = FAS used for blank, mL (1ml)

M = Molarity of FAS (0.25)

Sample no.	Sample details	Burette Reading		Volume of FAS (Ferrous Ammonium Sulphate) 'A'	COD (mg/l)
		Initial reading	Final reading		
1.	Blank solution	0	1	1	-
2.	Sabarmati	0	1.4	1.4	320
3.	Leachate (Point 1)	0	2.4	2.4	1120
4.	Factory (Point 3)	0	1.3	1.3	240
5.	Roadside shop (Point 5)	0	1.8	1.8	640
6.	Farm (Point 7)	0	1.7	1.7	560

6. Heavy Metal Concentration: Heavy metal concentration of Lead (Pb) Zinc (Zn), Copper (Cu) and Arsenic (As) was found on the basis of laboratory experiment results.

S.No	Type of substance	Conc. of Lead	Conc. of	Conc. Of Copper	Conc. of Arsenic

		(mg/l)	Zinc (mg/l)	(mg/l)	(mg/l)
1.	Sabarmati sample	-	0.010	-	-
2.	Leachate (Point 1)	0.026	0.564	0.105	0.02
3.	Factory (Point 3)	-	0.021	-	0.001
4.	Roadside Shop (Point 5)	-	0.004	-	0.002
5.	Farm (Point 7)	-	-	-	0.002

IV. RESULT AND DISCUSSION

On the basis of conducted tests, it can be concluded that pH value and total dissolved solids of all the co-ordinates/points are within permissible limits. While COD and BOD values of each sample are considerably higher than the permissible limits.

Co-ordinate 1 shows presence of all the heavy metals i.e. Copper, Zinc, Lead, Arsenic but within a permissible value. Co-ordinate 3 and 5 indicates the presence of Zinc and Arsenic but shows negative results for Copper and Lead. Co-ordinate 7 shows a positive result for Arsenic metal only.

Tests conducted on a water sample collected from Sabarmati River indicates the presence of zinc only.

Hence it can be concluded that concentration of Copper, Zinc, Lead, and Arsenic are within Permissible limits for each co-ordinate. One of the reasons for low concentrations can be less percolation of Leachate due to Summer Season.

Sr. no	Test Performed	Permissible limit*	Obtained result of Sabarmati Sample	Obtained result of Leachate (Point 1)	Obtained result of Factory (Point 3) Sample	Obtained result of Roadside Shop (Point 5)	Obtained result of Farm (Point 7)
1	pH	5.5-9	8.08	7.70	7.78	7.70	7.99
2	Conductivity	-	0.97	>20	2.91	2.62	2.23
3	TDS	600 mg/l	0.51 mg/l	10 mg/l	1.49 mg/l	1.61 mg/l	1.18 mg/l
4	COD	250 mg/l	320 mg/l	1120 mg/l	240 mg/l	640 mg/l	560 mg/l
5	BOD	30 mg/l	1670 mg/l	2920 mg/l	2360 mg/l	2270 mg/l	2220 mg/l
6	Copper	3 mg/l	-	0.105 mg/l	-	-	-
7	Zinc	5 mg/l	0.010 mg/l	0.564 mg/l	0.021 mg/l	0.004 mg/l	-
8	Lead	1.0 mg/l	-	0.026 mg/l	-	-	-
9	Arsenic	0.2 mg/l	-	0.02 mg/l	0.001 mg/l	0.002 mg/l	0.002 mg/l

*Environment protection rules: 1986

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