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Assessment of ground water quality near solid waste dumping site Bhanpur, Bhopal

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Abstract
Groundwater is the most economic source of potable water for rural, semi-urban and urban areas in India. Non scientific disposal of solid waste from various sources pollutes the environment as well as ground water sources. The present work aims to find out the groundwater pollution at the very vicinity of landfill site at Bhanpur, Bhopal, India. The landfill site is closed for the dumping of waste since 2018 by Bhopal Municipal Corporation hence an attempt has been made to see the post closure impacts of closed dumping site on ground water resources. During the study six sampling locations were identified for the collection of samples within the periphery of dumping site. The collected water samples were analyzed for the physicochemical parameters *viz.*, pH, Electrical conductivity, TDS, chloride, total hardness, calcium hardness, magnesium hardness, nitrate, phosphate. The results showed higher concentration of contamination in most parameters like conductivity, TDS, chloride, total hardness, calcium hardness, magnesium hardness, which exceeds the limits of standards prescribed by BIS:10500. It was found that ground water near the closed dumping site is contaminated and is not fit for direct drinking purposes.

Keywords: solid waste, dumping site, ground water, water quality, Bhanpur

Introduction

Solid waste generation and its management has become a growing environmental and public health problem around the world, especially in developing countries where poverty, increased population growth, unplanned urbanization, industrialization and changing consumer habits produced huge amount of solid waste [1]. In most of the developing countries, solid waste is disposed unscientifically in open areas that result in risk to the surrounding environment and human population [2]. Open dumping is the oldest and the most common way of disposing solid waste. More than 90% of the Municipal Solid Waste (MSW) generated in India is directly dumped on land in an unsatisfactory manner [3]. During rainfall, precipitation infiltrates the solid wastes which is disposed of on land mixes with the liquids (comes from refuse piles of the waste and leach compounds from the solid waste). This leads to the formation of leachate [4].

Leachate contains innumerable organic and inorganic compounds. Dispersal of leachates poses potential threats to local ecosystems especially to soils and ground waters. The composition of leachate depends upon the nature of solid waste buried, chemical and biochemical processes responsible for the decomposition of waste materials, and water content in total waste. Leachates generated by the MSW in uncontrolled landfills have become a major environmental problem across the globe [5].

Areas near dumping site have a larger possibility of groundwater contamination because of the potential pollution source of leachate generating from the nearby dumping site. Such contamination of groundwater results in an extensive risk to local groundwater users. Once groundwater becomes contaminated, full restoration of its quality is not probably possible in some cases [6].

The continuous degradation of groundwater quality by anthropogenic activities particularly from waste dumpsites, especially non scientific dumpsites will greatly affect its portability. Similarly, physicochemical, bacteriological and heavy metal pollution of groundwater has a direct impact on human health which leads water-borne diseases such as typhoid, cholera and dysentery [7]. Therefore, the present study was designed to assess the impact of dumpsites on groundwater quality in the nearby areas of the dumpsite.

Materials and methods

Study area

The present research work was conducted on Bhanpur dumpsite, Bhopal. The total area of Bhanpur dumpsite is 57.80 acres and it is located at latitude 230 17’47.59’’N, longitude 770 25’11.54 E and an altitude of 625msl. The surrounding residential area of dumpsite has observed heavily air, soil and water pollution through the gas and leachate coming out of hazards from the solid waste. The leachate generated from this dumpsite flows into the soil and ground water tables around the site without any engineering operations. The lack of a barrier system or a leachate collection system in the Bhanpur landfill results in the release and flow of leachate into the surrounding groundwater resources and cropland.

In December 2018, this landfill site was closed for waste disposal due to huge amount of waste accumulated, which released pungent smell and contaminating water resources. Hence, an attempt has been made to assess the impact of leachates coming from this dumping site and affecting groundwater resources nearby it.

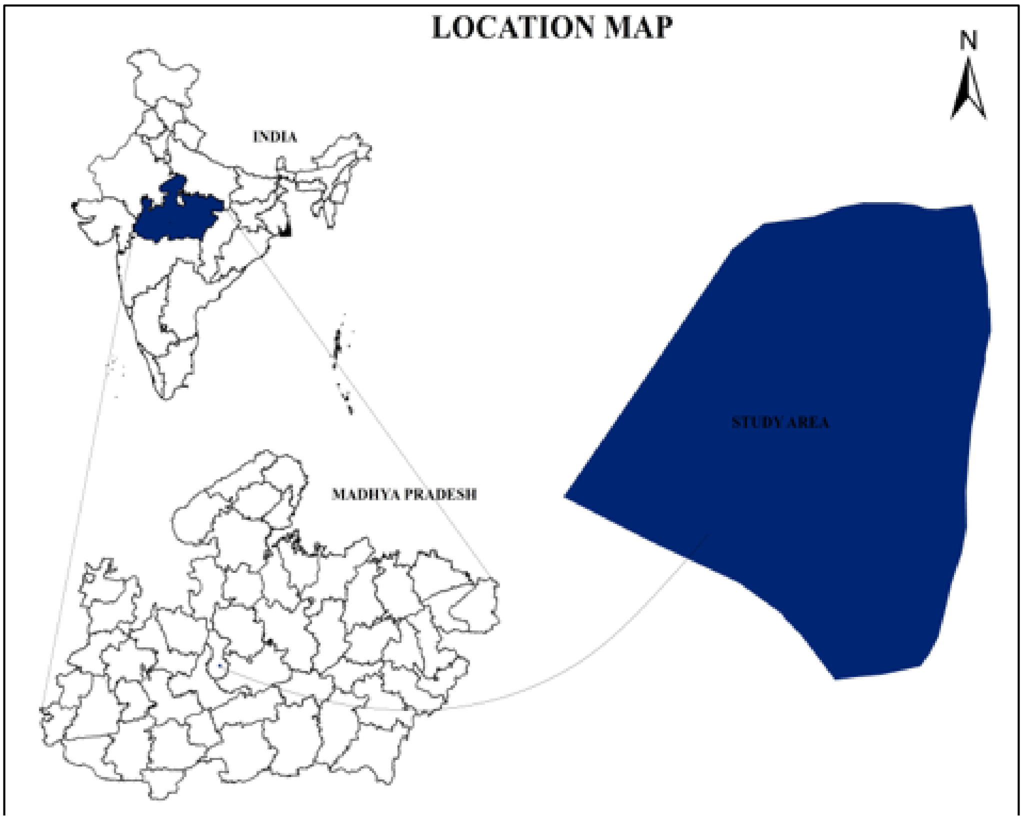

Fig 1: Map showing study area

Methodology

The ground water samples of Bhanpur, Bhopal were collected in wet season *viz.*, monsoon and postmonsoon to assess the ground water quality. The aim of the study was to look for ground water pollution caused by solid waste dumping after the closing of the site. Six samples were collected from the vicinity of the dumping site. The samples were collected in polyethylene bottle from selected sampling sites and were analyzed for physicochemical parameters *viz.*, temperature, pH, conductivity, TDS, chloride, total hardness, calcium hardness, magnesium hardness, nitrate, orthophosphate by using standard methods and procedures [8, 9].

Results and discussion

During the study statistical analysis *viz.*, standard deviation among the readings were calculated (Table: 1 and Table: 2). The ground water samples were collected, analyzed and compared with the drinking water quality standards (Table: 3). The pH in the present study around dumping sites was ranged between 6.7 - 7.3 and 7 to 7.25 during monsoon and post monsoon, respectively. The pH results indicate that all the groundwater samples fall within permissible limits and are in alkaline state according to BIS and WHO standards (Table :3). The electrical conductivity ranged between of 680-1620 μScm^{-1} and 930-1830 μScm^{-1} during monsoon and post monsoon, respectively. The value of EC was high in post monsoon against monsoon in collected groundwater samples due to the dilution factor. Maiti *et al.* [11] also obtained high EC value in groundwater samples of Dhapa, Kolkata near the closed dumpsite. The high values of EC of groundwater sample indicate higher concentration of anions and cations. The TDS of Bhanpur ranged from 550-1050 mgl^{-1} and 650-1282 mgl^{-1} during monsoon and post monsoon, respectively. The TDS concentration was found above the acceptable limits due to the leaching of various pollutants into the ground water which can decrease the potability and may cause gastrointestinal irritation in human body and may also have laxative effects [15]. Raman and Narayanan [12] also reported high TDS vale in groundwater samples. High TDS value leads to objectionable taste, odor and color in water which makes it unfit for drinking purpose. The total hardness was found in range of 360-720 mgl^{-1} and 320-960 mgl^{-1} during monsoon and post monsoon, respectively. Sonel and Mourya [13] also reported the higher concentration of total hardness 992 mgl^{-1} at the vicinity of

Bhanpur dumping site. Water hardness is usually due to the multivalent metal ions, which comes from minerals dissolved in water. Calcium hardness was recorded as 240-590 mgl^{-1} and 283-651 mgl^{-1} during monsoon and post monsoon, respectively. All the groundwater water samples exceeded the standard limit of BIS and WHO. The magnesium hardness ranged between 10.9-31.5 mgl^{-1} and 8.9-75 mgl^{-1} during monsoon and post monsoon, respectively. Most of the locations, magnesium hardness fall within the permissible limits of BIS and WHO. Chloride level in ground water samples was ranged between 120 mgl^{-1}-285 mgl^{-1} and 140 mgl^{-1}-379 mgl^{-1} during monsoon and post monsoon, respectively. High concentration of chloride ions results in unpleasant taste in water. Sonel and Mourya [13] also observed higher concentration chloride which was 558 mgl^{-1}. The chloride values in the water samples was due to the dissolution of rocks surrounding the aquifer and probably due to the leakage of sewage and anthropogenic pollution (agricultural activities). High concentration of chloride gives salty taste to water and may result in hypertension, osteoporosis, renal stones, and asthma. The high chloride content in groundwater is from pollution sources such as domestic effluents, fertilizers, septic tanks, and leachates [1]. The value for nitrate was recorded between the range of 0.10 mgl^{-1} – 0.39 mgl^{-1} and 0.315 mgl^{-1} - 0.745 mgl^{-1} during monsoon and post monsoon, respectively. The nitrate concentration was found within the desirable limit of BIS and WHO at all the sampling sites. In general, the major sources for nitrate in ground water includes domestic sewage, runoff from agricultural fields, and leachate from landfill sites [1]. During the study period, phosphate concentrations in water samples were in the range of 0.22 mgl^{-1}-0.88 mgl^{-1} and 0.180 mgl^{-1}-0.360 mgl^{-1} during monsoon and post monsoon, respectively. Bureau of Indian Standards (BIS, 2012 revised) has not prescribed any norms for phosphate in drinking water as phosphate is not considered as harmful constituent in drinking water. However, its presence fastens the growth of algae.

Table 1: The physicochemical characteristics of ground water at study area during monsoon

S. No.	Parameters	GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	Std. dev.	Avg.
1	pH	6.8	7.3	7.1	6.8	6.7	6.8	0.23	6.9
2	Conductivity (μScm^{-1})	1620	715	680	695	880	1060	362.9	941.6
3	TDS (mgl^{-1})	1050	606	550	605	730	885	194.6	737.6
4	Chloride (mgl^{-1})	285	190	130	125	170	120	62.8	170
5	Total hardness (mgl^{-1})	720	405	380	360	460	480	131.9	467.5
6	Ca hardness (mgl^{-1})	590	297	240	280	415	360	126.9	363.6
7	Mg hardness (mgl^{-1})	31.5	26.2	34	19.4	10.9	29.16	8.6	25.19
8	Nitrate (mgl^{-1})	0.18	0.28	0.18	0.105	0.39	0.11	0.04	0.125
9	Phosphate (mgl^{-1})	0.32	0.22	0.43	0.55	0.88	0.32	0.23	0.453

Table 2: Physicochemical characteristics of ground water at study area during post monsoon

S. No.	Parameters	GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	Std. dev.	Avg.
1	pH	7	7.5	7.5	7.2	7	7.1	0.23	7.21
2	Conductivity (μScm^{-1})	1830	930	990	1290	1180	1240	320.2	1243.3
3	TDS (mgl^{-1})	1282	640	650	880	790	905	235.7	773
4	Chloride (mgl^{-1})	379	190	140	259	209	120	93.9	216.16
5	Total hardness (mgl^{-1})	960	400	320	640	580	520	224.05	570
6	Ca hardness (mgl^{-1})	651	320	283	390	420	399	128.7	410.5
7	Mg hardness (mgl^{-1})	75	19.4	8.9	60.7	38.8	29	25.1	38.6
8	Nitrate (mgl^{-1})	0.315	0.480	0.750	0.679	0.745	0.41	0.18	0.61
9	Phosphate (mgl^{-1})	0.180	0.210	0.300	0.284	0.360	0.23	0.26	0.27

Table 3: Drinking water quality standard recommended by WHO and BIS

S. No.	Parameters	WHO Standards	BIS Standards	
			Desirable	Permissible
1	pH	6.5-9.2	6.5-8.5	No relaxation
2	Electrical Conductivity (μScm^{-1})			
3	TDS (mgl^{-1})	500	500	2000
4	Chloride (mgl^{-1})	250	250	1000
5	Total hardness (mgl^{-1})	200	200	600
6	Calcium hardness (mgl^{-1})	75	75	200
7	Magnesium hardness (mgl^{-1})	30	30	100
8	Nitrate (mgl^{-1})	0.5	45	No relaxation
9	Phosphate (mgl^{-1})	-	-	-

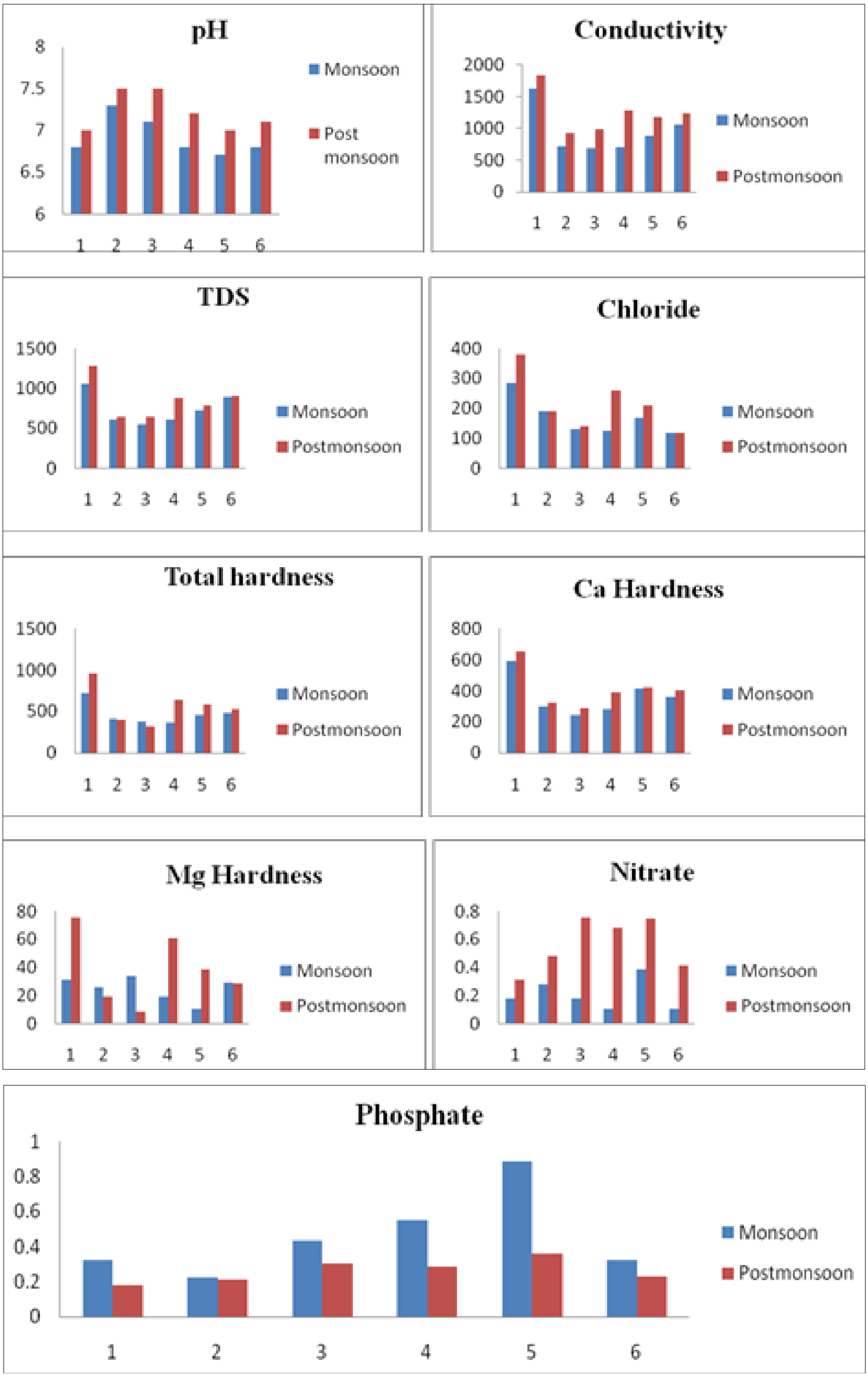

Fig 2: Graphical representation of ground water at study area during monsoon and postmonsoon

Correlation analyses for different groundwater quality parameters

Correlation analysis is a bivariate method used to evaluate the degree of interrelation and association between two variables. A correlation of +1 indicates a perfect positive relationship between two variables where as a correlation of –1 indicates that one variable changes inversely with relation to the other. A correlation of zero indicates that there is no relationship between the two variables at a significant level of ≤ 0.5. More precisely it can be said that parameters showing $r \geq 0.7$ are considered to be strongly correlated where as "r" between 0.5 and 0.7 shows moderate correlations [1, 14].

Table 4: Correlation matrix among different groundwater quality parameters of study area during monsoon

	pH	EC	TDS	Cl^-	TH	Ca^{2+}	Mg^{2+}	NO_3^-	PO_4^-
pH	1								
EC	-0.44165	1							
TDS	-0.53825	0.966561	1						
Cl^-	-0.02747	0.781437	0.643996	1					
TH	-0.37124	0.98874	0.931647	0.855986	1				
Ca^{2+}	-0.51379	0.946254	0.913058	0.841827	0.963146	1			
Mg^{2+}	0.457915	0.289125	0.196205	0.168061	0.270323	0.001396	1		
NO_3^-	0.076785	-0.12768	-0.14189	0.257628	-0.00881	0.15295	-0.58046	1	
PO_4^-	-0.60474	-0.22599	-0.18295	-0.22447	-0.20613	0.017025	-0.827	0.525138	1

* Good correlation values are given in bold

Table: 4 shows that Electrical Conductivity exhibits a significant positive linear correlation with Total hardness (r=0.9887, ≥ 0.01), major water quality parameters during monsoon. Equally, Electrical Conductivity shows fairly high correlation with TDS (r=0.9665, ≥ 0.01),Ca^{2+} (r=0.9462, ≥ 0.01), and Cl^- (r=0.7814, ≥ 0.01), Some of the other highly significant and positive correlation were found between TH-Ca^{2+} (r=0.9631, ≥ 0.01), TDS-TH (r=0.9316, ≥ 0.01), TDS-Ca^{2+} (r=0.9130, ≥ 0.01), Cl^--TH (r=0.8559, ≥ 0.01), Cl^--Ca^{2+} (r=0.8418, ≥ 0.01) which also indicates linear correlation. Few moderately correlations were also found between TDS- Cl^- (r=0.6439, ≥ 0.01) and NO_3^-- PO_4^- (r=0.5251, ≥ 0.01). The pH was negatively correlated with all the parameters except Mg^{2+} and NO_3^-. Few parameters were found to have highly negative correlation between Mg^{2+}- PO_4^- (r= -0.827), Mg^{2+}- NO_3^- (r= -0.580).

Table 5: Correlation matrix among different groundwater quality parameters of study area during postmonsoon

	pH	EC	TDS	Cl^-	TH	Ca^{2+}	Mg^{2+}	NO_3^-	PO_4^-
pH	1								
EC	-0.7396	1							
TDS	-0.74591	0.99327	1						
Cl^-	-0.47982	0.836243	0.790094	1					
TH	-0.7745	0.970613	0.95771	0.900036	1				
Ca^{2+}	-0.76589	0.971022	0.965609	0.849615	0.972378	1			
Mg^{2+}	-0.72274	0.893528	0.871783	0.89472	0.956209	0.861492	1		
NO_3^-	0.276728	-0.57848	-0.6514	-0.38958	-0.53583	-0.62439	-0.38129	1	
PO_4^-	-0.05296	-0.43821	-0.49937	-0.37149	-0.38403	-0.44537	-0.27639	0.92426	1

* Good correlation values are given in bold

In Table: 5 EC and TDS show good positive correlation with major water quality parameter during post monsoon**.** The correlation (r=0.9932, ≥ 0.01) between these two parameters for the analyzed samples in this study show a linear correlation. Equally, Electrical Conductivity shows fairly high correlation with Ca^{2+} (r=0.9710, ≥ 0.01), TH (r=0.9706, ≥ 0.01), Mg^{2+} (r=0.8935, ≥ 0.01), Cl^- (r=0.8362, ≥ 0.01).Similarly TDS shows good correlation with Ca^{2+} (r=0.9656, ≥ 0.01), TH (r=0.9577, ≥ 0.01), Mg^{2+} (r=0.8717, ≥ 0.01), Cl^- (r=0.7900, ≥ 0.01). TH also showed significant correlation with Ca^{2+} (r=0.9723, ≥ 0.01), Mg^{2+} (r=0.9562, ≥ 0.01). Some of the other highly significant and positive correlation were found between NO_3^-- PO_4^- (r=0.9242, ≥ 0. 01), Cl^-- TH (r=0.9000, ≥ 0.01). Cl^-- Mg^{2+} (r=0.8947, ≥ 0.01), Ca^{2+} - Mg^{2+} (r=0.8614, ≥ 0.01), Cl^-- Ca^{2+} (r=0.8496, ≥ 0.01), which also indicates linear correlation. The pH was negatively correlated with all the parameters except NO_3^-. Some highly negative correlations were also observed between the groundwater quality parameters like TDS- NO_3^- (r= -0.6514), Ca^{2+} - NO_3^- (r= -0.6243), EC- NO_3^- (r= -0.5784), TH- NO_3^- (r= -0.5358).

Conclusion

The groundwater quality of Bhanpur was investigated and the results were compared with BIS: 10500 and WHO drinking water quality standards**.** The concentration of various physicochemical parameters *viz.*, conductivity, total dissolved solids, total hardness and chloride were reported higher at all the sampling sites around the dumping site, while few parameters were within the desirable limit.

It has been concluded that the Bhanpur municipal solid waste dumping site, Bhopal is found prone to the ground water contamination through leaching action. This dumping site is being closed for waste disposal since 2018 but still the concentration of contaminants is not being controlled and properly looked after. Thus, there is a need of protective cover of dumpsite and regular monitoring of the ground water quality in the vicinity areas of dumping site to aware the people about the contamination.

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