Ground Water Quality and Health Impacts in Bhalaswa, New Delhi

A report

By

Bhalaswa Lok Shakti Manch,
and
Hazards Centre, New Delhi

2012

Bhalaswa Groundwater and Health Report

Introduction

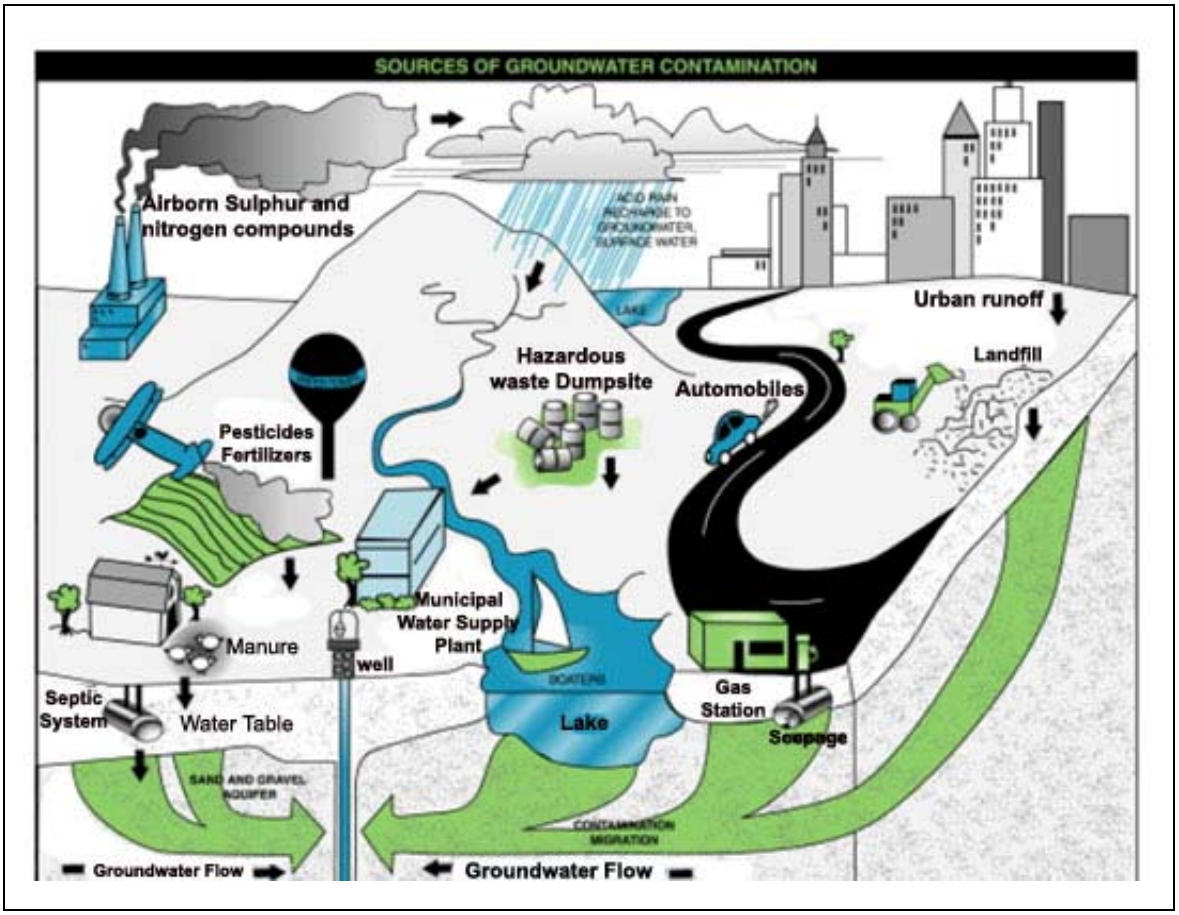
Bhalaswa Landfill site that is located in North Eastern part of Delhi came into operation in 1993. The landfill site occupies 21.06 acres of land that was once used for sugar cane plantation. About 6 hectares is devoted to a composting facility. The landfill is not scientifically lined as the pit is only used as a dump site. It has only got a layer of *malba* topped with soil, instead of having a layer of plastic or a special type of clay layer required for a secure landfill. At present it receives about 2,200 tonnes per day of waste out of which about 700 tonnes per day goes to the compost plant. The landfill has already reached about 22m of height, and it was supposed to be closed in November 2009. The landfill is publicly owned and is managed by the Municipal Corporation of Delhi.

A very important danger to human health from landfills such as Bhalaswa is the use of groundwater that has been contaminated by leachate. Contaminants are leached from the solid waste as water percolates through the landfill and mixes with ground water.

People were relocated to the Bhalaswa resettlement colony in November 2002 from eleven *jhuggi-jhompri* clusters on the pretext of beautification of the city. The resettlement colony is located right next to the landfill. The site is surrounded by sewage ponds and a foul smell is perpetual. The people here had to fight for basic necessities such as water and electricity, schools and public toilets, subsidised basic provisions under the Public Distribution Scheme (PDS) and bus services. They are still struggling for facilities such as water and sewage disposal, transport and health.

The water supply in Bhalaswa resettlement colony is mainly through tankers that are irregular. In some cases, the water provided by the tankers is also not clean. However, the main source of water is hand pumps. The groundwater obtained is usually used for domestic purposes, and in some cases is also used for drinking.

Sources of groundwater contamination



Source: http://www.groundwater.org/gi/sourcesofgwcontam.html

Environmental Setting

Delhi is the national capital, located between latitudes 28º42' 30''N and 28 º45' N, and longitudes 77 º 07'30''E and 77 º11'54''E. The topography of Delhi can be divided into three different parts, the plains, the Yamuna flood plain, and the ridge. Bhalaswa landfill site is located near the Bhalaswa Lake, which is a fresh water oxbow lake on Yamuna floodplain.

Climatic conditions: The climate is semi-arid. The climatic conditions throughout the year have high variations, especially between summer and winter. The average annual rainfall is approximately 670 mm (27 inches), most of which falls during the monsoons, in July and August.

Hydrogeology: The geology of the study area is mainly alluvium. There are several small patches of aquifers, but scientifically all of them comprise a single aquifer.

Oxbow lake- A crescent-shaped lake formed when a river changes its course and cuts through the strip of land in the middle of an oxbow, abandoning its previous course and isolating the water in the oxbow.

Objectives:

The objectives of this study were:-

- To assess the potability of the groundwater from the pumps located in areas that surround the Bhalaswa landfill site, like the Bhalaswa resettlement colony, Shraddhanand colony, and Mukundpur, Nathupura and Nanglipuna.
- To assess the health of the people of Shraddhanand Colony, Bhalaswa resettlement colony and Mukundpurgaon, and Nathupura.
- Understand the relationship between the quality of groundwater and the general health of the population.

Methodology:

This study has been done to analyse the effect of the Bhalaswa landfill on the health of the population living around the landfill, especially the people living in the Bhalaswa resettlement colony that has a population of more than 4000 households, consisting of people who were displaced from various regions of Delhi and then resettled there by the government.

Groundwater samples were taken from handpumps and borewells located in Shraddhanand colony, Bhalaswa resettlement colony, Mukundpurgaon, Nathupura and Nanglipuna. Surveys were done to find out about the general health of the sample population. A total of 877 people were interviewed. Of these, 154 people were residents of Shraddhanand Colony that is situated right adjacent to the Bhalaswa landfill, situated about 50-100 m away from the landfill. 608 people were residents of Bhalaswa resettlement colony, which is located about 400-600 m away from the landfill. The last group consisted of 115 people living in Nathupura and Mukundpur. Nathupura is located about 3.7 kms from the landfill in the north-east direction. Mukundpurgaon is located about 2.5 kms from the landfill in the east. Survey was not carried out in Nanglipuna as the population of this locality is of a different socioeconomic profile.

Profile of the respondents

The population consisted of people mostly in the age group 18-60 (see Table 1). The population sample consisted of 567 females and 310 males.

Table 1: Distribution of respondents in the study areas by age groups

Age group (yrs)		Shraddhanand		Bhalaswa		Mukundpur-Nathupura		**Total**
		No.	%	No.	%	No.	%	No.
<18	M	3	3.9	21	11.4	3	6.1	27
	F	4	5.1	15	3.5	1	1.5	20
19-60	M	63	82.9	153	82.7	42	85.7	258
	F	71	91.0	379	89.6	62	93.9	512
>60	M	10	13.2	8	4.3	4	8.2	22
	F	1	1.3	16	3.8	3	4.5	20
No response	M	0	0	3	1.6	0	0	3
	F	2	2.6	13	3.1	0	0	15
Total		**154**	100	**608**	100	**115**	100	**877**

The maximum number of *katcha* houses was observed in Shraddhand colony (29%), and the least in Mukundpurgaon and Nathupura (see Table 2).

Table 2: Type of housing of respondents

Housing	Shraddhanand		Bhalaswa		Mukundpur-Nathupura		**Total**
	No.	%	No.	%	No.	%	No.
No. of *Katcha* houses	45	29.2	102	16.8	11	9.6	156
No. of *Pukka* houses	109	70.8	500	82.2	103	89.6	692
No response	0	0	6	1.0	1	0.9	7
Total	**154**	100	**608**	100	**115**	100	**877**

Larger families were observed in Shraddhanand colony and Bhalaswa resettlement colony and smaller families in Mukundpurgaon and Nathupura. In Shraddhanand colony, 64% of the respondents have 5-8 individuals per family (see Table 3), in Bhalaswa 66% of the respondents have 3-6 individuals per family and in Mukundpur-Nathupura, 72 % of the families have 3-6

individuals. On average, it was observed that the number of individuals per family was between 3-8 people.

Table 3: Number of family members in a household

No. of family members	Shraddhanand		Bhalaswa		Mukundpur-Nathupura		**Total**
	No.	%	No.	%	No.	%	No.
≤2	4	2.6	42	6.9	6	5.2	52
3-4	29	18.8	157	25.8	41	35.7	227
5-6	62	40.3	244	40.1	41	35.7	347
7-8	37	24.0	92	15.1	19	16.5	148
≥8	21	13.6	64	10.5	6	5.2	91
No response	1	0.6	9	1.5	2	1.7	12
Total	**154**	**100**	**608**	**100**	**115**	**100**	**877**

Sources and quality of water

This study has been done to try and relate the quality of drinking water, and the health of the people. The different sources of water in these areas include piped water supply from Delhi Jal Board, hand pump water, bore well water (both DJB and private bore wells), as well as tankers (see Table 4). Some people in Bhalaswa also fetch their drinking water in cans from neighbouring areas such as Jahangirpuri and Rohini, or their place of work. However, the major source of drinking water in Bhalaswa is the water supplied by DJB (88%), which is supplemented by hand pumps when this water is not available. **Each house has a hand pump that they use mainly for domestic chores**, however occasionally, they use it for drinking purposes also, when they do not have access to the other types of drinking water.

Table 4: Sources of drinking water for the household

Sources of drinking water	Shraddhanand		Bhalaswa		Mukundpur-Nathupura		**Total**
	No.	%	No.	%	No.	%	No.
Handpump	55	35.7	505	83.1	60	52.2	620
Borewell (DJB)	118	76.6	540	88.8	27	23.5	685
Tanker	39	25.3	106	17.4	25	21.7	170
Piped water supply (DJB)	72	46.8	61	10.0	76	66.1	209

During the survey, people were asked about the visible characteristics of the water that they receive. A large number of people reported problems such as not obtaining clear water, but getting coloured water having sediments. For example, 82% people in Shraddhanand colony, 89% in Bhalaswa and 68% in Mukundpur and Nathupura said they received yellow coloured water. The people reported that on letting the water stand for some time, a layer of sediments is observed at the bottom. In some of the hand pumps near the landfill, the water that comes out sometimes is brownish-blackish in colour. Additionally, according to data from the Central Groundwater Board and the Central Pollution Control Board, groundwater in Bhalaswa is fresh water up to 30m-60m depth. However, 94% of the respondents said that the drinking water is salty in taste. Even in Shraddhanand colony, 77% of the respondents and in Munkundpur-Nathupura 87% of the respondents said that the drinking water is saline.

Table 5: Quality of drinking water (as perceived by respondent)

Water quality		Shraddhanand (%)	Bhalaswa (%)	Mukundpur-Nathupura (%)
Colour	Yellow	56.6	16.4	47.0
	Red	2.0	2.2	9.6
	Black	0	0	0
	Mixed	25.7	73.6	20.9
	Clear	13.2	7.6	22.6
Taste	Salty	75.0	94.2	87
Odour	Bad	0	2.8	0
Sediments	Sand/mud present	35.6	1.7	13.9

The photographs show the colour of water from a hand pump in Shraddhanand colony

Groundwater testing

In addition, groundwater samples were taken in November 2010 by random sampling from hand pumps and bore wells located near the landfill site, and the quality of groundwater was analysed by various tests. The sites were chosen in a radial direction in the north and east sides and at increasing distances from the landfill. On the western and southern sides, the landfill is bordered by a drain.

Various parameters of the samples such as pH, total dissolved solids (TDS), chemical oxygen demand (COD), heavy metals such as lead, zinc, chromium and presence of faecal coliforms were tested.

- **pH** is a measure of the acidity or alkalinity of a water sample, and it was measured using a pH meter.

- **TDS** comprises inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulphates) and small amounts of organic matter that are dissolved in water. TDS in drinking-water originate from natural sources, sewage, urban runoff and industrial wastewater. To measure TDS, electrical conductivity (EC) was measured using an EC meter, and that value was converted into a TDS value.

- **Faecal coliforms** are tested to see if the water has been faecally contaminated. If the water has been faecally contaminated, there is a possibility that there are also pathogens in the water sample. Faecal contamination was tested by the Presence-Absence test.

- **Chemical Oxygen Demand (COD)** is used to indirectly measure the amount of organic compounds in water. It was tested by the closed reflux, titrimetric method (APHA).

- **Heavy metals** were measured by atomic absorption spectrophotometry (AAS).

Sampling sites:

WS 1: The sample was collected from a hand pump of depth 27.4 m in a house in Shradhanand colony. It was located 230 m from the landfill. The water is used for cooking and other domestic chores but not for drinking.

WS 2: The sample was collected from a hand pump of depth of 9.1 m from a house in Shradhanand colony. The water is not used other than for flushing the latrine occasionally. It was black coloured water with a bad odour.

WS 3: The sample was collected from a hand pump located in the Bhalaswa resettlement colony. The depth of the hand pump is 6.1m. The water obtained from it is hard and is used for cooking and other domestic chores but not for drinking.

WS 4: The sample was collected from hand pump of depth 25.9 m located in the Bhalaswa resettlement colony. The water is sometimes used for drinking.

WS 5: The sample was collected from a hand pump of depth 7.6 m located in a house in Shradhanand colony.

WS 6: The sample was collected from a hand pump located in the Bhalaswa resettlement colony. The depth of the hand pump is 6.1 m. The water is used for cooking and other domestic chores but not for drinking.

WS 7: The sample was collected from a hand pump located in the Bhalaswa resettlement colony. The depth of the hand pump is 6.1 m. The water is very hard and is not used for drinking. When the water is kept standing for a while, it becomes yellow in colour and sediments are observed at the bottom.

WS 8: The sample was collected from a hand pump in a house in Mukundpurgaon. The depth of the pump is 9.1 m. The water is very hard and is used for domestic chores but is not used for drinking and bathing.

WS 9: The sample was collected from a hand pump in Mukundpur gaon, market area. The depth of the pump is 6.1 m. The water obtained from it is very hard and is not used for drinking.

WS 10: The sample was collected from a hand pump located in a house in Nanglipuna. The depth of the hand pump is 15.2 m. It is treated and used for all purposes.

WS 11: The sample was collected from a hand pump located in a house in Nanglipuna. The depth of the hand pump is 9.1 m, and it provides very clean water according to the user.

WS 12: The sample was collected from a hand pump from a crop field in Nathupura located besides the police station. The depth of the hand pump is 7.6 m, and the water is used for all purposes.

WS 13: The sample was collected from a bore well from a house in Shastri Park, Nathupura. The depth of the bore well is 6.1 m and the water is used for domestic purposes.

WS 14: The sample was from piped drinking water supply that comes from a borewell in Nanglipuna and was collected from a house in Shradhanand colony. It is used for drinking and other household chores.

WS 15: The sample was collected from the Bhalaswa Lake.

Site location

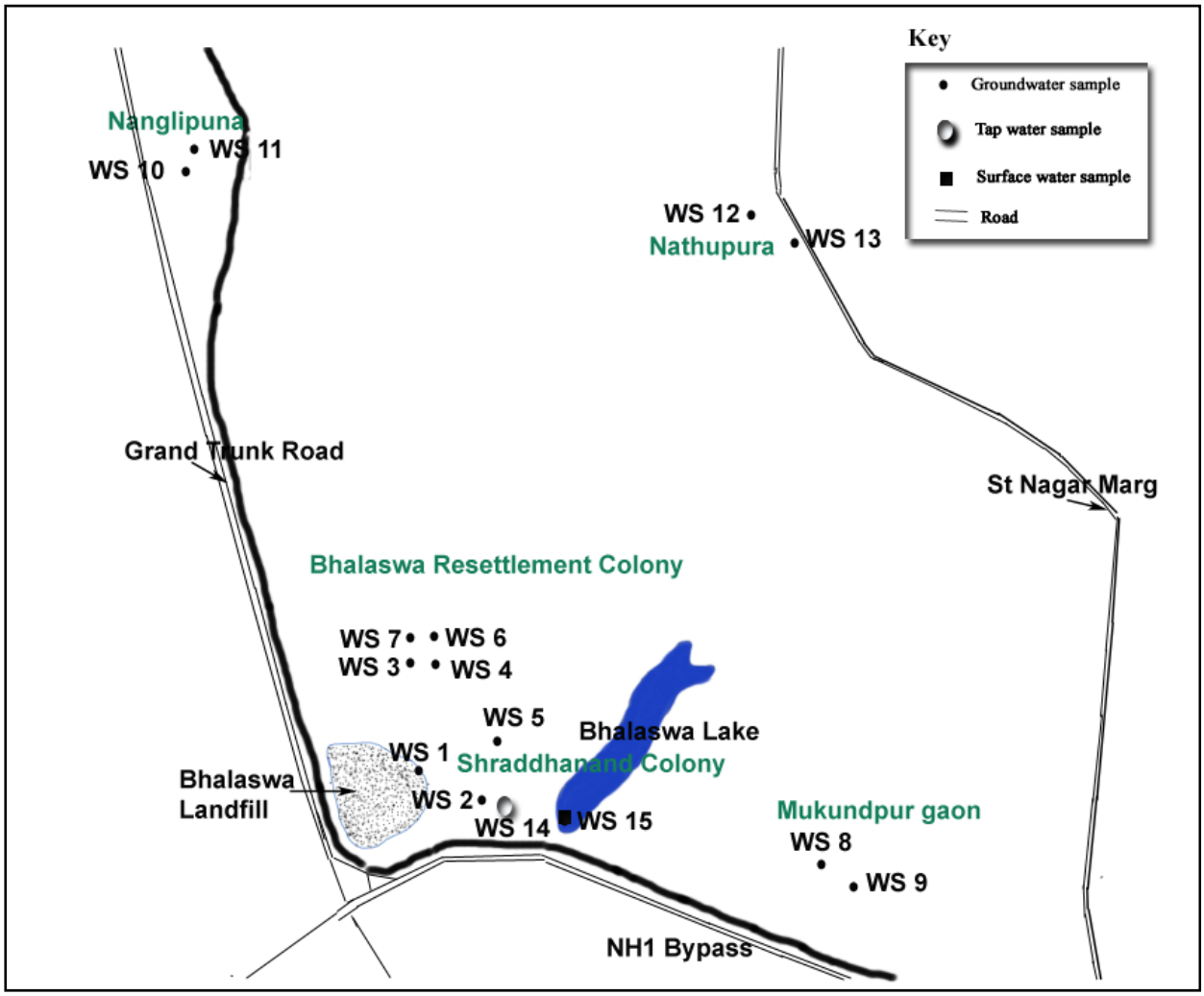


Figure 1: Location of sampling sites

Results

Sample	Distance[+] (m)	Depth (m)	Zn	Pb	Cd	pH	COD	EC (µs)	TDS**	Faecal coliform
1	230	27.4	ND	0.027	ND[++]	6.5	**37.6**	8352	**5846**	**Positive**
2	640	9.1	0.12	ND	ND	8	**92.4**	5616	**3931**	**Positive**
3	640	6.1	0.473	0.018	ND	6.5	**22.56**	6128	**4290**	**Positive**
4	650	25.9	0.001	0.044	ND	7	**45.12**	4192	**2934**	**Positive**
5	750	7.6	0.02	0.04	ND	7	**22.56**	3390	**2373**	Negative
6	810	6.1	0.516	0.031	ND	8	**75.2**	3706	**2594**	**Positive**
7	840	6.1	ND	0.013	ND	7.5	**82.72**	8864	**6205**	Negative
8	2440	9.1	ND	**0.053**	ND	8	**82.72**	2154	1508	Negative
9	2520	6.1	0.012	ND	ND	8	**90.24**	2894	**2026**	Negative
10	3580	15.2	ND	ND	ND	7.5	3	2132	1492	Negative
11	3650	9.1	ND	0.027	ND	7.5	**52.64**	2740	1918	**Positive**
12	3730	7.6	ND	0.009	ND	8	**90.24**	2150	1505	Negative
13	3740	6.1	0.036	0.018	ND	7.5	**75.2**	1198	839	Negative
14	-	Tap water	0.012	0.009	ND	6	**45.12**	1338	937	Negative
15	960	0.0	ND	0.018	ND	7	7.52	2532	1772	**Positive**

[+] Distance from the landfill

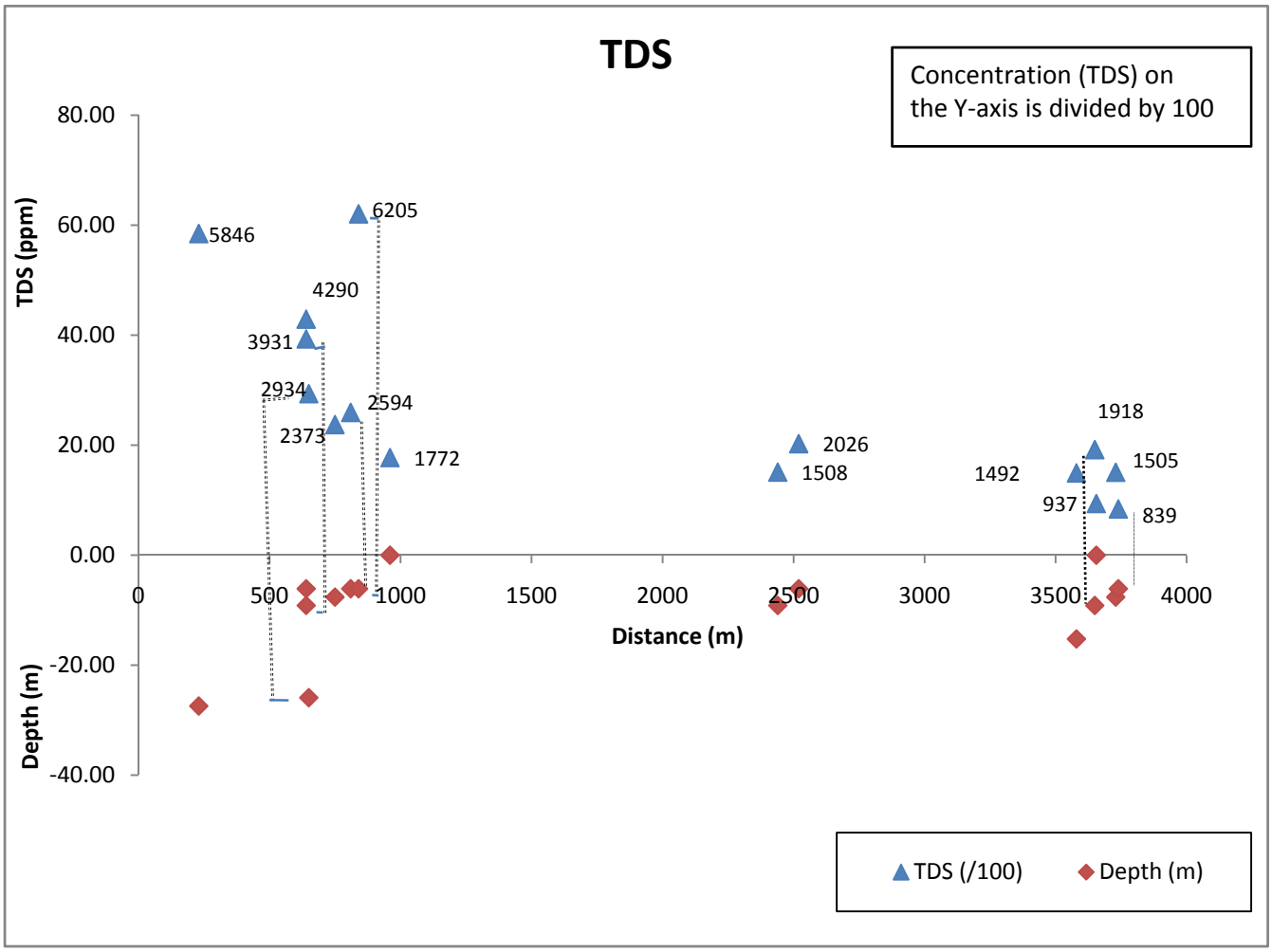
[*] Zn, Pb, Cd, COD and TDS in ppm

[**] estimated TDS= EC*0.7 (11)

++ Not detected

Total Dissolved Solids (TDS)

TDS is only an aesthetic and technical factor; however a high concentration of TDS is an indicator that harmful contaminants, such as iron, manganese, sulphate, bromide and arsenic, can also be present in the water. This is especially true when the excessive dissolved solids are added to the water as human pollution, through runoff and wastewater discharges. According to the BIS standards (1991), the desirable limit for drinking water is 500 ppm, and the maximum permissible limit is 2000 ppm. Water containing TDS more than 500 mg/L causes gastrointestinal irritation. Young landfills are characterized by leachate of high TDS.



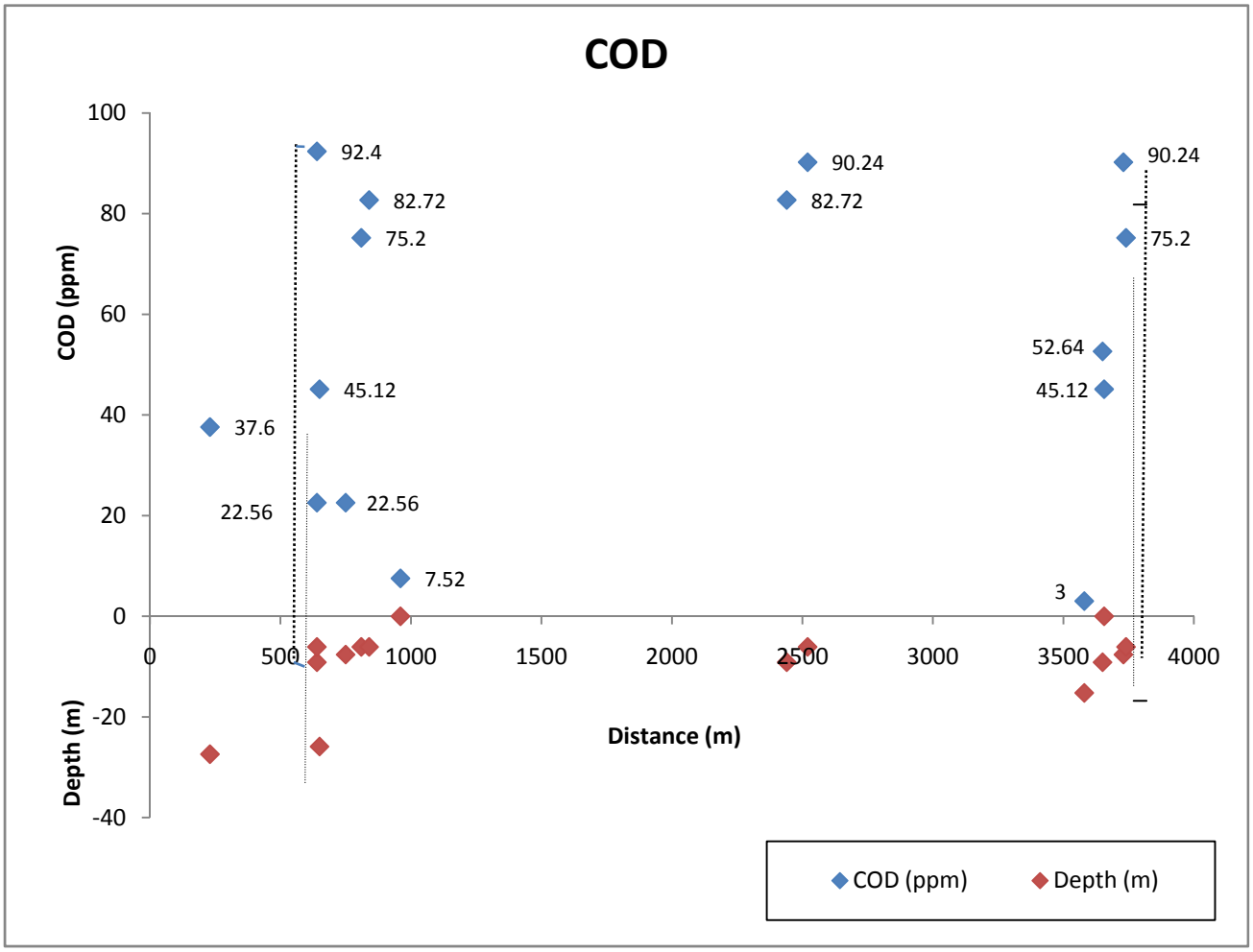
TDS Concentration in Groundwater around Bhalaswa Landfill

It can be seen from the graph that the concentration of TDS in the groundwater samples decreases with increasing distance from the landfill. Of the groundwater samples taken, all of them exceeded the desirable TDS limit of 500 ppm, and seven of the samples exceeded the permissible limit of 2000 ppm. It was observed that the samples located in Shraddhanand colony and Bhalaswa resettlement colony had high TDS, ranging from 2373 ppm to 5846 ppm. Sampling site 1 was closest to the landfill and had a very high TDS (5846 ppm). On average, the samples that were located less than 1km from the landfill had dangerous levels of TDS, whereas those located beyond 1km were comparatively safer.

The highest TDS was found at the sampling site 6 (6205 ppm). This could be because this site was located next to a drain that was an additional source of contamination. Additionally the depth of the water sample was not very deep (6.1 m); hence little purification could have occurred due to filtration by soil.

Samples located in Mukundpur - Nathupura had lower TDS, ranging from 836 ppm to 2026 ppm. However, sample 9 (2026 ppm) and sample 10 (1918 ppm) were located near drains and there could have been contamination from it.

Chemical Oxygen Demand (COD)



COD Concentration in Groundwater around Bhalaswa Landfill

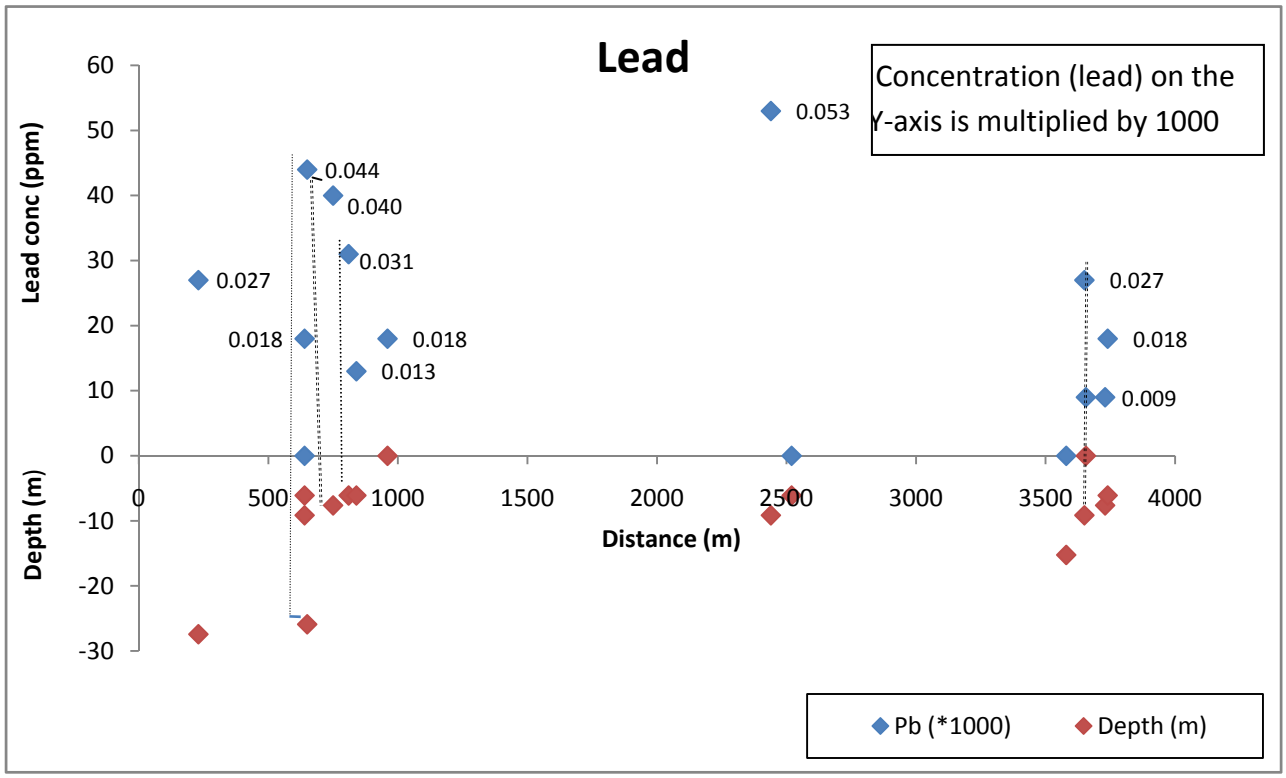
COD is a parameter that is usually associated with sewage, and not drinking water, or water that is used for domestic purposes. Thus, no guidelines have been issued by the Bureau of Indian Standard (BIS). The WHO guideline for COD in drinking water is 10 mg/L. Only two samples, Sample 10 and Bhalaswa lake water have values less than the standard.

Heavy Metals

Lead

The WHO guideline for lead in drinking water is 0.01 mg/L (ppm). Of the groundwater samples tested, nine of the samples tested had lead concentration greater than the WHO guidelines. According to the BIS, the maximum permissible limit for lead is 0.05 mg/L. Only sample 8 had lead concentration greater than the permissible level according to BIS standard. Of the samples tested, the highest concentration of lead was found in sample 8 (0.053 ppm).

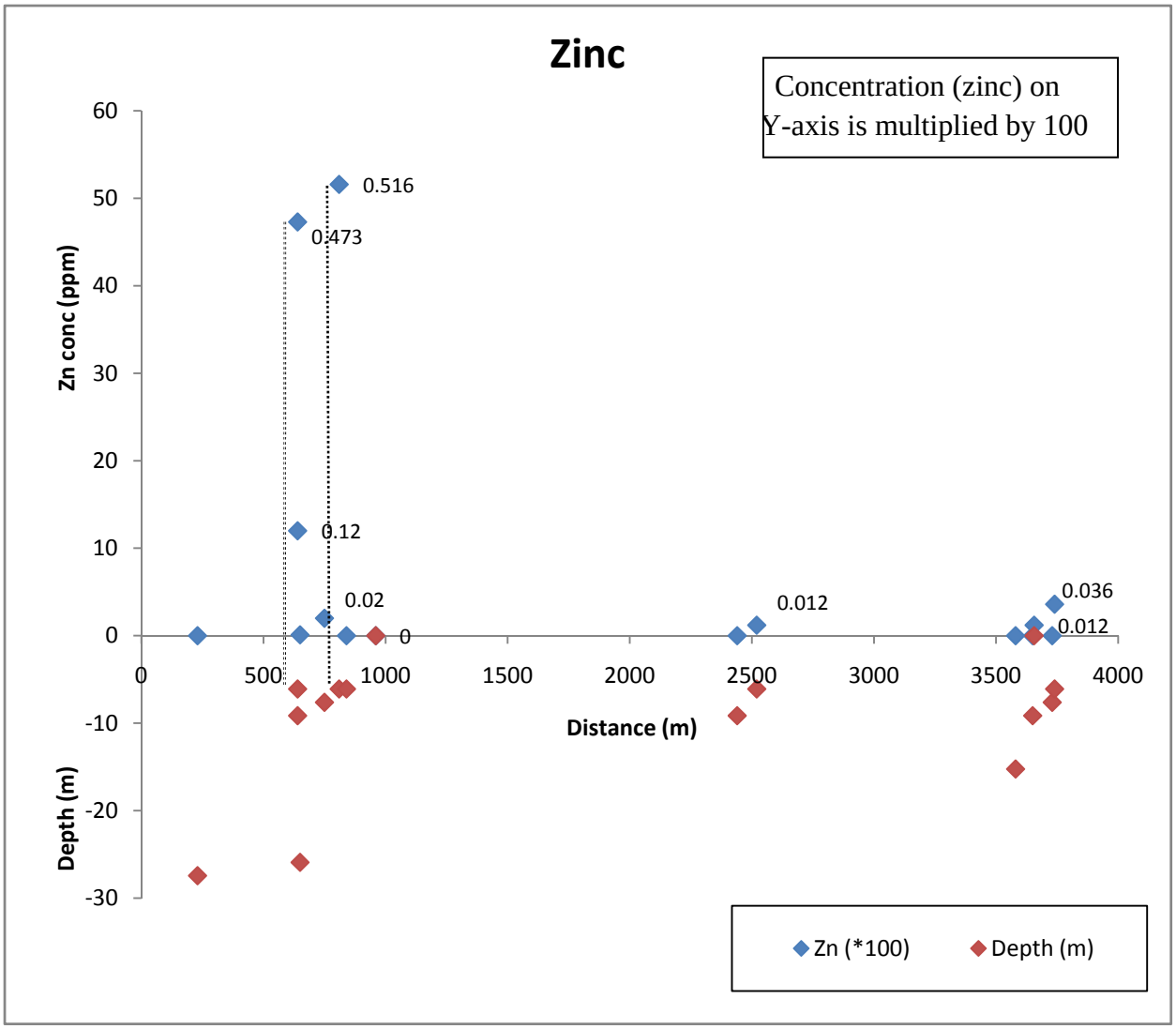
Of the samples tested, the samples from Shraddhanand and Bhalaswa had greater lead concentrations, ranging from 0 to 0.044 ppm. The samples located farther from the landfill had lower concentration of lead. Thus, the landfill could be the source of contamination of groundwater by lead.



Lead Concentration in Groundwater around Bhalaswa Landfill

Possible sources of lead in the landfill could be lead batteries, e-waste, construction waste (having lead-based paint) and chemicals for photograph processing. Leaching of lead from landfills has been studied in other cases as well.

Zinc



Zinc Concentration in Groundwater around Bhalaswa Landfill

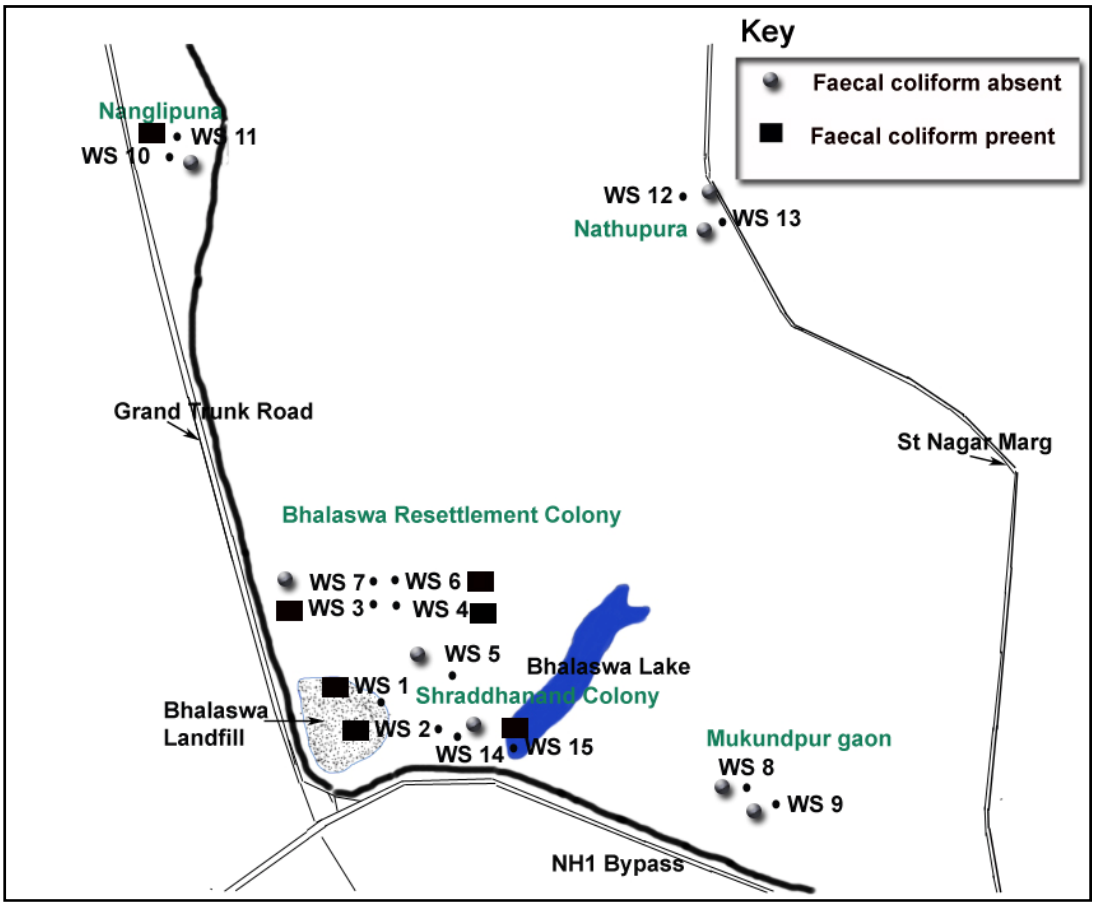
The permissible level of zinc in drinking water is 15 mg/L. The concentration of zinc found in the samples tested ranged from below detection limit to 0.516 ppm. Thus all the samples had zinc levels below the permissible limit. In seven samples, they exceeded the levels normally found in groundwater (about 0.01 ppm).

Cadmium

The concentration of cadmium in all the samples was below detection level.

Faecal coliform

Faecal coliforms are tested to see if the water has been faecally contaminated. Faecal contamination was tested by the Presence-Absence test. Of the 15 water samples tested, seven gave positive result, indicating that they are unfit for drinking.



Occurrence of faecal coliforms in groundwater around Bhalaswa landfill

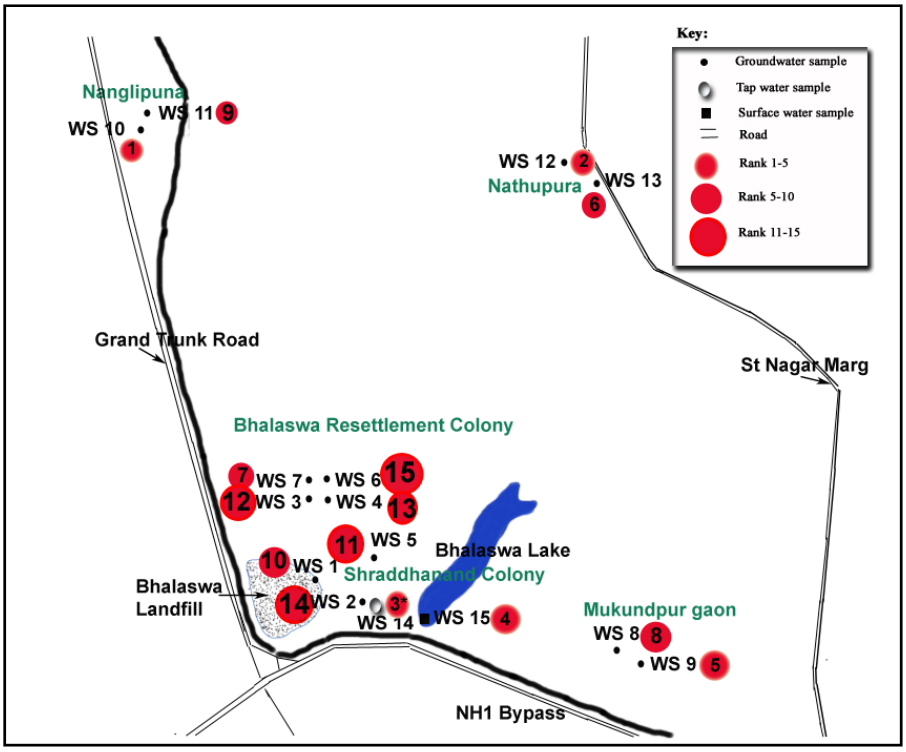
Of the samples located in Shraddhanand colony, two of the three samples showed presence of faecal coliforms. Of the samples located in Bhalaswa resettlement colony, three of the four samples showed presence of faecal coliforms. In summation, of the handpumps and borewels located less than 1km from the landfill, 5 of the 7 groundwater samples tested positive for faecal coliforms, whereas of those located greater than 1km from the landfill, only 1 of the 6 tested positive. This could indicate that the groundwater is being faecally contaminated by the landfill. In other studies also, landfills have been observed to be the source of faecal contamination. However, faecal contamination could also occur due to the poor sanitary conditions in the region. Sampling site 11 located in Nanglipuna was located next to a drain. It is possible that the water had been contaminated by the drain.

Occurrence of faecal coliforms in groundwater around Bhalaswa landfill

Sample	Faecal coliform	Distance (m)	Depth	Source
1	**Positive**	230	27.4	Handpump
2	**Positive**	640	9.1	Handpump
3	**Positive**	640	6.1	Handpump
4	**Positive**	650	25.9	Handpump
5	Negative	750	7.6	Handpump
6	**Positive**	810	6.1	Handpump
7	Negative	840	6.1	Handpump
8	Negative	2440	9.1	Handpump
9	Negative	2520	6.1	Handpump
10	Negative	3580	15.2	Handpump
11	**Positive**	3650	9.1	Handpump
12	Negative	3730	7.6	Handpump
13	Negative	3740	6.1	Borewell
14	Negative	3656	-	Borewell
15	**Positive**	960	0	Surface water

Cumulative Grades of the quality of water samples

Cumulative grades were assigned to the different water samples according to the overall water quality as demonstrated by the values obtained on testing of some water quality parameters. For this, the samples were ranked from 1-15 (total 15 samples were tested), and then these ranks for the different parameters were totalled, to arrive at the cumulative grade of the sample. The sample with the least cumulative grade is the best quality water, and as is visible for the figure, water samples taken from sources near the landfill were the worst with respect to their cumulative grades. Thus the worst 6 water samples were from Shraddhanand colony and Bhalaswa resettlement colony. As the distance from the landfill increased, the quality of the water is observed to be better.



Cumulative grades of water samples

Sample	Distance (m)	Depth (m)	TDS	COD	Pb	Zn	Faecal coliform**	Cumulative grade	Rank
1	230	27.4	14	5	10	1	7	37	**10**
2	640	9.1	12	15	1	13	7	48	**14**
3*	640	6.1	13	3	7	14	7	44	**12**
4	650	25.9	11	6	14	8	7	46	**13**
5	750	7.6	9	4	13	11	0	37	**11**
6	810	6.1	10	9	12	15	7	53	**15**
7	840	6.1	15	11	6	1	0	33	**7**
8	2440	9.1	5	12	15	1	0	33	**8**
9	2520	6.1	8	13	1	9	0	31	**5**
10	3580	15.2	3	1	1	1	0	6	**1**
11	3650	9.1	7	8	11	1	7	34	**9**
12	3730	7.6	4	14	4	1	0	23	**2**
13	3740	6.1	1	10	8	12	0	31	**6**
14	3656	-	2	7	4	10	0	23	**3**
15	960	0.0	6	2	9	1	7	25	**4**

* Tap water sample from a house in Shraddhanand Colony. Source of piped water is from Nanglipuna

** Samples with positive faecal coliform have been given 7 points, and negative faecal coliform 0 points

A relationship between the depth of the handpump and borewell with the quality of the water can also be observed. The depth of the handpumps sampled falls in 3 ranges- 5-10m, 10-20m, and greater than 20 m. The sample that was of the best quality (according to the cumulative grades value) fell in 10-15m range depth. Additionally, the handpump sample taken closest to the landfill (230 m) was the deepest handpump; fell in the most dangerous zone of less than 1km distance from the landfill. However, of the 7 samples taken in this region, it was observed to be second in quality only to the 7^{th} sample, indicating that some amount of filtration occurred with increasing depth of the handpump.

Health problems

The respondents also suffered from some health problems that recurred, or they had to continuously take medications to keep the illness at bay. Of these illnesses, gastro-intestinal problems, musculo-skeletal pain, skin and eye irritation, and respiratory problems were faced by a large number of respondents.

Table 6: Health problems of respondents (self)

Health problems	Shraddhanand (%)	Bhalaswa (%)	Mukundpur-Nathupura (%)
GIT	78	79	71
Musculoskeletal	38	68	41
Respiratory	26	9	13
Skin	24	26	30
Eye	57	41	44
Nerve	10	6	6
Cardiovascular	12	3	10
Infections	1	5	2
Others	34	10	15

Gastro-intestinal diseases

A very large number of people have recurring gastro-intestine diseases. In Shraddhanand colony 78% (see Table 6), Bhalaswa resettlement colony 79% and in Mukundpur and Nathupura, 71% have recurrent gastro-intestinal problems. Of these people, many complained of recurring diseases like diarrhoea, and also constantly suffer from stomach ache, vomiting, etc. 21.1% of the women and 31.9% of the men of the sample population in Bhalaswa resettlement colony suffer from diarrhoea and vomiting. This could indicate occurrence of faecal contamination of the drinking water. During analysis of water from hand pumps, of the four hand pumps tested, three were found to give faecally contaminated water.

None of the people surveyed in Nathupura and Mukundpura complained of recurrent diarrhoea or vomiting. In these areas, none of the water samples were found to be faecally contaminated. However, a large number of people (62.6%) suffered from problems like gas and stomach ache.

Table 7: Gastro-intestinal problems of the respondents (self)

GIT	Shraddhanand				Bhalaswa				Mukundpur-Nathupura				Total
	M		F		M		F		M		F		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Diarrhoea & Vomiting	0	0	0	0	39	21.1	135	31.9	0	0	0	0	174
Gas/ Acidity	43	56.6	38	48.7	131	70.8	335	79.2	28	57.1	44	66.7	614
Generic gastric trouble	16	21.1	27	34.6	0	0	2	0.5	3	6.1	7	10.6	55
Total number of people	57	75.0	63	80.7	133	71.9	347	82.0	31	63.3	51	77.3	682

Gastric problems in Bhalaswa resettlement colony

It is observed that most of the people surveyed in blocks C6 (71.4%), B4 (64.4%) and C2 (63.9%) complained of recurring diarrhoea and vomiting (table 8). On the other hand, lower levels of occurrence of diarrhoea and vomiting were observed in A3, B6, B7 and C5 blocks.

Table 8: Bhalaswa resettlement colony (GIT problems)

Bhalaswa resettlement colony Block	No. of people surveyed	Vomiting/ Diarrhoea	%	Stomach ache	%
A2	99	41	41.4	96	97.0
A3	51	3	5.9	36	70.6
B4	59	38	64.4	56	94.9
B7	106	9	8.5	88	83.0
C2	61	39	63.9	60	98.4
C5	47	4	8.5	33	70.2
C6	14	10	71.4	13	92.9
D1	112	15	13.4	59	52.7
B6	53	2	3.8	27	50.9
A5	6	1	16.7	6	100.0

Skin problems

The percentage of people having skin problems was also found to be significant. 13.2% men and 16.7% men in Shraddhanand colony (see Table 9), 20% men and 18.2% women in Bhalaswa resettlement colony and 18.4% men and 27.3% women in Mukundpur-Nathupura complained of itching. Itching and skin rash can be caused due to contact with polluted water. Landfill leachate can have volatile organic chemicals such as benzene, chloroform, ethylbenzene, toluene etc that can cause eye and skin irritation. Itching can also be caused due to exposure to many gases like chloroform, carbonyl sulphide etc that are produced in landfills, and also presence of pollutants in the water. Other problems that were observed were pigmentation, dry skin, ringworm infection, skin allergy and rash.

Table 9: Skin problems of respondents (self)

Skin	Shraddhanand				Bhalaswa resettlement colony				Mukundpur-Nathupura				Total
	M		F		M		F		M		F		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Allergy/Itching	14	13.2	15	16.7	37	20.0	80	18.9	9	18.4	24	27.3	179
Pigmentation	1	1.3	0	0	6	3.2	16	3.8	0	0	1	1.5	24
Dry and cracking skin	0	0	0	0	0	0	7	1.7	0	0	0	0	7
Burning sensation	1	1.3	0	0	0	0	2	0.5	0	0	0	0	3
Ringworm	0	0	0	0	2	1.1	6	1.4	0	0	0	0	8
Acne/boils	0	0	1	1.3	1	0.5	9	2.1	0	0	0	0	11
Total	14	18.4	16	20.5	47	25.4	110	26.0	9	18.4	25	37.9	221

Eye problems

Eye problems were also observed in high percentages. Bathing and other contact of eyes with contaminated water can lead to eye problems such as pink eyes etc. Presence of volatile organic chemicals such as benzene, ethylbenzene, toluene, tetrachloroethylene, etc. can cause eye irritation. Additionally, gases that are released from landfills such as ammonia, acrylonitrile, carbonyl sulphide, methyl ethyl ketone etc all have negative impacts on eyes, causing problems such as burning sensation, watering and eye irritation.

In Shraddhanand colony, that is located nearest to the landfill, 32.9% men and 32.1% women had persistent watering in their eyes (see Table 10). 22.2% men and 19.4% women in Bhalaswa resettlement colony and 28.6% men and 13.6% women in Mukundpur-Nathupura had persistent burning sensation in their eyes. One respondent said that vapours rise from the stagnant water lying around the landfills, which causes persistent watering from the eyes. This water is so toxic that even mosquitoes do not come here. Other problems that were observed are itching, redness of the eyes, allergies, eye infections, and also problems such as weak eyesight and pain in the eyes.

Table 10: Eye problems of respondents

Eye	Shraddhanand				Bhalaswa Resettlement Colony				Mukundpur-Nathupura				Total
	M		F		M		F		M		F		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Burning sensation/ itching	5	6.6	6	7.7	41	22.2	82	19.4	14	28.6	9	13.6	157
Watering	25	32.9	25	32.1	5	2.7	10	2.4	4	8.2	4	6.1	73
Redness	0	0	0	0	4	2.2	7	1.7	0	0	1	1.5	12
Pain in eye	2	2.6	4	5.1	29	15.7	66	15.6	1	2.0	5	7.6	107
Weak eyesight/ cataract	12	15.8	8	10.3	9	4.9	18	4.3	5	10.2	12	18.2	64
Total number of people	44	57.9	43	55.1	82	44.3	168	39.7	24	49.0	31	47.0	392

Respiratory problems

The occurrence of respiratory problems among the populations in Shraddhanand colony, Bhalaswa resettlement colony and Mukundpur-Nathupura was surveyed. A large number of people in Shraddhanand colony (27.6% men and 19.2% women) (see Table 11) were observed to suffer from breathlessness. Comparatively fewer people in Bhalaswa resettlement colony and Mukundpur-Nathupura suffer from problems like breathlessness. Landfills are a source of many gases such as benzene, ethylbenzene, tetrachloroethylene, particulate matter, mercury, sulphur dioxide, etc., which have an impact on the respiratory system. Additionally, people also said that earlier there used to be frequent fires in the landfill, leading to greater impact on the respiratory system.

Table 11: Respiratory problems of respondents

Respiratory problems	Shraddhanand				Bhalaswa Resettlement Colony				Mukundpur-Nathupura				Total
	M		F		M		F		M		F		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Breathlessness	21	27.6	15	19.2	11	5.9	27	6.4	4	8.2	7	10.6	85
Pain/difficulty in breathing	0	0	0	0	4	2.2	9	2.1	0	0	0	0	13
Cough	2	2.6	2	2.6	1	0.5	3	0.7	1	2.0	3	4.5	12
Bad throat	0	0	0	0	1	0.5	12	2.8	0	0	0	0	13
Total number of people	23	30.3	17	21.8	15	8.1	34	8.04	5	10.2	10	15.2	104

Musculo-skeletal problems

Many people reported musculoskeletal problems, especially pain in knees and joints, as well as general body ache. This could be because the occupations of the people are mostly labour-intensive. It could also possibly be due to contamination of the groundwater by fluorides.

Table 11: Musculo-skeletal problems of respondents

Musculo-skeletal pain	Shraddhanand				Bhalaswa Resettlement Colony				Mukundpur-Nathupura				Total
	M		F		M		F		M		F		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Joint pain	5	6.6	8	10.3	55	29.7	152	35.9	7	14.3	14	21.2	241
Backache	3	3.9	8	9.0	13	7.0	36	8.5	0	0	5	7.6	65
Body pain	22	28.9	23	29.5	68	36.8	168	39.7	11	22.4	19	28.8	311
Total number of people	28	36.8	39	50.0	116	62.7	300	70.9	18	36.7	50	75.8	551

Other illnesses

28.9% men and 30.8% women Shraddhanand colony also suffered from headaches. Gases that are released from landfills such as carbon monoxide, chloroform, tetrachloroethylene, etc. also cause neurological effects, including headaches, dizziness, fatigue. Shraddhanand colony that is located nearest to the landfill had the highest percentage of people having headaches. In Bhalaswa, 20.8% of the people complained of headaches.

Conclusion

The groundwater from the hand pumps located in the vicinity of the landfill show increased concentrations of contaminants. The water samples had high levels of TDS, COD as well as specific contaminants such as lead, zinc. Some of the water samples were faecally contaminated. This indicates that there is a possibility of contamination occurring due to the landfill.

In the hand pump samples in the resettlement colony, each of the four samples had higher TDS than the maximum permissible limit (BIS) and three of the four samples were faecally contaminated. One of the samples had TDS value 6205 ppm, three times higher than the maximum permissible limit of 2000 ppm (BIS). Each of the samples had COD, two of them having a COD of 82.72 and 75.2 ppm. Thus the groundwater available to the residents of the resettlement colony was unfit for human consumption. However, due to the lack of piped water supply or regular tanker water supply, the residents are forced to use this impure water.

The residents suffer from a number of illnesses, especially gastro-intestinal diseases, musculo-skeletal pain, skin and eye irritation, and respiratory problems. For example, 79% of the sample population of Bhalaswa resettlement colony suffer from different types of stomach problems, including 31.9% females and 21.1% males who complained of diarrhoea and vomiting. Some blocks such as C6, B4 and C32, had especially greater problems, and the groundwater in the region also was not good. This could indicate that the groundwater in the area around the landfill is being contaminated due to leachate from the landfill, and additionally as there is no regular provision of clean drinking water in the colony, the people have to suffer. Regular contact with the polluted groundwater for use in domestic chores such as bathing, washing utensils and clothes has also lead to a large number of people suffering from skin irritation and itching and eye irritation. Landfill leachate has presence of contaminants such as benzene, toluene, ethylbezene that cause problems such as eye and skin irritation. In addition, the location of the colony being so near the landfill also exposes the population to harmful landfill gases such as benzene, ethylbenzene, acrylonitrile, carbon disulphide, etc., which have impacts on the respiratory system and eyes.

This study is indicative, and there is a need to carry out a more detailed study, with a larger number of samples being taken. Steps have to be taken to ensure a clean water supply to the residents, and also to ensure that the landfill does not lead to further contamination of the groundwater. The landfill is nearing its closure date, and it should be capped properly.

References

1. A Case Study of Bhalaswa Lok Shakti Manch. (2009). Hazards Centre.
2. Bansil, P. C. (2004). Water management in India. Concept Publishing Company.
3. Department of Urban Development Government of Delhi. City Development Plan.
4. Guidelines For Drinking-Water Quality, Third Edition, Incorporating The First And Second Addenda Volume 1 Recommendations (WHO). (2006).
5. http://www.angelfire.com/cantina/fourtwenty/articles/caloramameters.htm
6. http://censusindia.gov.in/Tables_Published/HH-Series/HH-Series_link/HH1City_Delhi.pdf
7. http://cpcb.nic.in/upload/NewItems/NewItem_50_notification.pdf
8. http://www.groundwater.org/gi/sourcesofgwcontam.html
9. http://www.indiawaterportal.org/ask/5395
10. http://delhi-masterplan.com/about-delhi.php Delhi Master Plan 2021
11. http://www.safewater.org/PDFS/resourcesknowthefacts/TDS_AND%20_pH.pdf
12. Indian standard drinking water - specification (First Revision) IS-10500:1991. BIS, New Delhi, India.
13. Jhamnani, B., and Singh, S. K. (2009). Groundwater Contamination due to Bhalaswa Landfill Site in New Delhi, *International Journal of Civil and Environmental Engineering*, **1(3):121-125**.
14. Karanth, K. R. (1987). Ground water assessment: development and management. Tata Mc Graw Hill.
15. Kaur, G. J., and Karmakar, A. Impact Of Population On Water Resources Of Zone – J 'South Delhi'.
16. Kolhatkar, D. G., Bhagat, S. M., Shinde, L. P., and Deshpande, M. N. (2011). Study of physicochemical characteristic of ground water from different sites in Nanded city. *Journal of Chemical and Pharmaceutical Research.* **3(5): 496-500.**
17. Mehta, L. (ed.) (2009). Displaced by development: confronting marginalisation and gender injustice. Sage Publication India Pvt Ltd.
18. Mor, S., Ravindra, K., Dahiya, R. P., and Chandra, A. (2006). Leachate Characterization and assessment of groundwater pollution near municipal solid waste landfill site, *Environmental Monitoring and Assessment*, **118 (1-3): 435-456.**
19. Sharma, B. K. (2001).Environmental Chemistry. Goel Publishing House.

For further details, please contact:

Bhalswa Lok Shakti Manch
B7/115, Bhalswa Punerwas Colony,
Delhi –110042
PUSHPA – 8800631852
Email : pushpa.rti@gmail.com
ManmohanSingh@socialworker.net

Hazards Centre
92H, 3rd floor, Pratap Market
Munirka, New Delhi – 110067
Ph- 011-26187806/26714244
hazardscentre@gmail.com
www.hazardscentre.com