Status of drinking water quality of Sub-standard settlements in Delhi

A study on potability of available water sources of five J.J Clusters and six Resettlement Colonies in Delhi

Hazards Centre
Sanchal Foundation
2005-06

Acknowledgements

We thank Dr. Imrana Qadeer who has provided
her valuable inputs into the study.

We would also like to acknowledge
the generous support of
Mobile Crèches (Madanpur Khadar), SAT (Molarbund),
NMPS (Bawana), Swati (Kanakdurga), Bhalaswa Lok Sakti Manch (Bhalaswa),
Mamta (Tigri) and DSS (Vikaspuri) in conducting the study.

Content

Drinking water: a basic resource

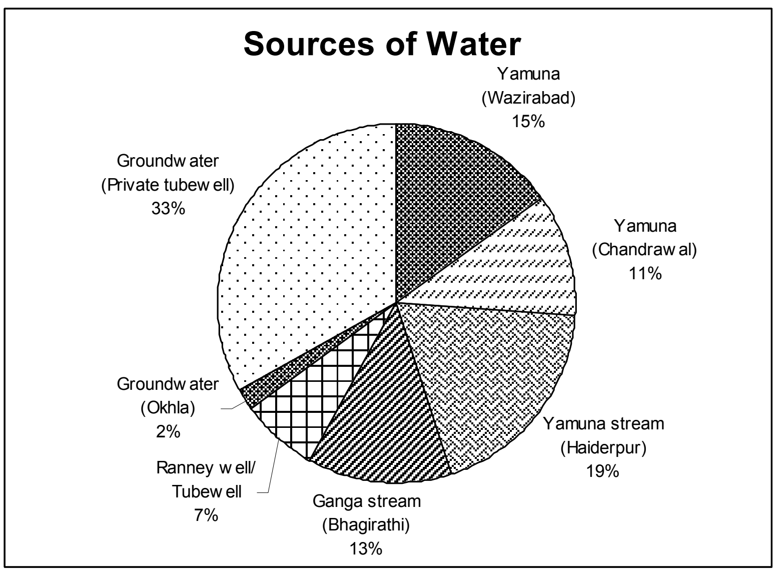
Introduction:

There was a time when the availability of water was taken for granted. But today, even the middle class knows that it is not so, although they can get away by either breaking the rules or purchasing water. The brunt of the drinking water crisis is borne by the urban poor. The city of Delhi is striving to become “world-class”, but has huge problems as far as provisioning this basic amenity to its people is concerned.

The Supply and Distribution of Water:

Delhi receives 800 million gallons per day (mgd) of water from the Yamuna, the Western Yamuna Canal, the Ganga Canal, and rainwater. The chief source of water in Delhi is the river Yamuna on which a barrage was constructed at Wazirabad in 1955 to separate the source from the polluted Najafgarh nala, and to supply water to the central part of Delhi. An equivalent amount of water is lifted indirectly from the Yamuna, as also the Ganga, through canals that have been built further upstream. A smaller amount of water is arranged from Ranney wells in the bed of the river; while a significant amount is extracted from ground water all over Delhi through bore wells.

1. Fig: Pie chart showing percentage of water supplied by various sources in Delhi



Source: Delhi 1999 fact sheet, Bharat Sarkar 1999.

As per the norms of Delhi Development Authority (DDA), the agency that makes the Master Plan for Delhi, there should be a supply of 360 litres of water per capita per day (lcpd). The Delhi Jal Board (DJB) serves a total population of nearly 140 lakhs, i.e. approximately 28 lakh families, through only 14.7 lakh water connections. One fourth of the total families, i.e. 7 lakh, live in authorized colonies, which are apparently served with individual water connections, leaving 7.7 lakh of water connections available for approximately 21 lakh families dwelling in unauthorized colonies, jhuggi jhonpries (JJ) and other sub-standard settlements. The total the city receives is 800 mgd (or 3,500 mld – million litres per day). If this quantity of available water were to be distributed equally, every person in Delhi should get more than 250 lcpd. This is significantly (8 times) more than what the jhuggi jhonpri and resettlement colony population (about 40% of the total) gets, and even more than 2½ times what the DDA flat residents (20% of the city) receive. Some areas like West End, Jor Bagh, and Chanakyapuri are reported to be provided with a daily round-the-clock supply of more than 400 lcpd. On the other hand, there is no specific time and duration of water supply in slums and resettlement colonies. Public taps provide about 15-18 lcpd in JJ clusters. Two thirds of the population in the city receives less than 37 lcpd. The residents of JJ clusters, resettlement colonies, and unauthorized colonies fulfil most of their requirements with water from hand pumps and Municipal Corporation of Delhi (MCD) bore wells.

But how much water is actually needed and how much is DJB providing? A survey done in 15 slums (*jhuggi jhonpri*) and resettlement colonies by *Sajha Manch* in 1999 revealed that the people living in these colonies are receiving less than 30 lcpd, while another survey conducted by Hazards Centre in 2002, in 2500 DDA flats indicated that the residents were satisfied if they got 90 lcpd.

The water authorities have attempted to conceal the inequalities by raising the bogey of water scarcity, increasing population, and wastages.

The norm for per capita water supply has remained the same for new plans and policies. The three Master Plans for Delhi show the following data on water requirement for Delhi's population and the requirement met by the water supply system at the end of the implementation period of the Plan. This proves that the paucity of water in Delhi is not due to shortage of water or overpopulation, but because of its unequal distribution.

1. Table: Water Supply in Delhi Plans

Delhi Master Plans for years	Required water supply as per norms of 70lpcd (mgd)	Percentage of fulfillment of the requirement
1962	230	39%
1981	496	51%
2001	1096	59%
2021 (projected)	1840	NA

Determinants of quality of water:

Water that may be considered absolutely pure is not to be found in nature. Even rainwater collects impurities such as dust, gases, and bacteria etc. during its passage through the atmosphere. That portion of rainwater, which flows over the surface as run off, and river water, picks up organic and inorganic impurities, whereas the portion percolating through the ground gathers mineralogical, organic, and inorganic matter while traversing through the underground strata before reaching the water table. With increasing demand, and unsustainable development and urbanization, water pollution by agricultural, municipal, and industrial sources has become a major concern for the welfare of mankind. The menace of water-borne diseases and epidemics threatens the well being of the population. Thus, the quality as well as the quantity of clean water supply is of vital significance for the welfare of human health.

Delhi has over 32.5 lakh people residing in slums and slum-like conditions. Though the slums are not legal and regularized, government agencies are bound to provide water and sanitation services to these areas. In Delhi, during recent years, eviction and resettlement in the name of rehabilitation of the urban poor have been ruthlessly increasing. The people are evicted and removed to areas 30-40 km away from their original homes and workplace. Although these resettlement areas are legal, they are located on barren lands with no provision of civic amenities. Even MCD data shows that, during 1990-2005, a total number of 53,210 families residing in slum areas were relocated. This “planned” relocation is supposed to improve the life of the “unplanned” slum dwellers. The real question is, “Does it?”

In slums and resettlement colonies of Delhi, DJB bore well, tanker supply, and hand pump supply have been reported to contain bacteriological as well as chemical contaminants. The condition of drinking water in some colonies is observed to be awful. Even by observing the physical characteristics (colour, odour, suspended matter etc) of water, one can say, without any laboratory analysis, that the water is aesthetically non-potable.

Water quality monitoring:

Monitoring and assessment of the quality of drinking water, by the supplier as well as the user, is very important for protecting health. Water quality is determined by assessing three classes of attributes: biological, chemical, and physical. There are standards of water quality set for each of these three classes. The physical impurities give taste, odour, colour and turbidity. The chemical parameters involve tests for determination of total solids, hardness, pH, chlorides, fluorides, dissolved solids, iron, manganese, other inorganics including heavy metals, and organic substances. Biological attributes comprise mainly of bacteriological tests for drinking water quality. Drinking water monitoring is done to check the potability of water. The source of these chemical and biological parameters and their effects in humans, are incorporated in the study that is described in this report.

- **Nitrate** in water is derived from mineralization of soil organic matter or excessive use of nitrogen fertilizer and seepage of sewage. Babies below six months are susceptible to nitrate as it causes a disease named Blue Baby Syndrome (Methemoglobinemia). In this syndrome 10% of haemoglobin in blood is converted into methanoglobin form. Death occurs when 40% of the haemoglobin is converted. It also causes goitre, gastrointestinal diseases, cardiovascular problems, vasodilatory problems in men, and also an increased rate of bearing malformed children in pregnant women. At high levels it causes cyanosism where haemoglobin becomes incapable of transporting oxygen. So it is very necessary that drinking water should be free of nitrates.

- **Fluorides** largely occur in chemical wastes from industries. Water drawn from the subsurface through some geological layers may also contain high amounts of fluorides. If it is present in small concentrations up to 1 mg/l in water it causes reduction of teeth cavities in children. Children under nine years of age, if exposed to 2 mg/l of fluoride, may develop a condition known as endemic dental fluorosis. In this condition there is dark brown spotting of the permanent teeth. In certain cases, the teeth become chalky white in appearance. Above 4 mg/l it causes crippling skeletal fluorosis in humans, which is a serious bone disorder. Some other symptoms of fluorosis are - joint pains, gastro-intestinal discomfort, excessive thirst, excessive tendency to urinate, fatigue, muscle weakness and frequent headache.

- **Chloride** is a major constituent of most waters. It is normally present in low concentrations in surface water, while groundwater will contain varying amounts of chloride depending on the surrounding geology. The source of chloride is leaching of sedimentary rock and salt deposits, sewage and industrial discharge, leachates from dumps and landfills and saltwater intrusion. Chloride is not harmful to people if it is not in high concentration but it affects the people who are suffering from heart and kidney disorders. Sudden increase of chloride may not have immediate effects but it indicates a connection with the source of contamination and will affect in the long run. It imparts a salty taste to drinking water. Chlorides also appear to exert a significant effect on the rate of corrosion of steel and aluminum and can therefore affect some metals used in water handling systems.

- **Total Iron** is indicated by a red or orange tinge in water. The source of iron could be from natural sources such as soil and rocks or from corroded water pipes. Sometimes decaying vegetable matter also contains organic iron. Often the fine dust settles leaving clear water at the top. This is known as soluble, reduced or "clear water iron". It is called "clear water iron" because the water out of the tap appears clear at first. After it settles and is exposed to the air, it becomes reddish-brown. Iron in the water may interfere with water treatment and may even support the growth of iron bacteria, iron algae. Iron bacteria produce a by-product Hydrogen Sulfide, which if bacteria are plentiful may impart a noticeable "rotten egg" smell to the water. Iron levels as low as 0.12mg/l may cloud the water and stain laundry and plumbing fixtures orange-brown.

  Though iron content in drinking water may not affect the human system as a simple dietary overload, but in the long run prolonged accumulation of iron in the body may result in haemochromatosis, where tissues are damaged. Iron may interfere with water treatment. During chlorination, iron combines with chlorine to form Ferric Chloride, which is not as effective as free chlorine in killing bacteria. Iron in levels above 5.0 mg/l may make the water taste and smell so bad as to render it undrinkable without treatment.

- **Faecal Coliform**, particularly E. Coli, Klebsiella, and Enterobacter, indicate that there are mammal or bird faeces in the water. The more mammals and birds are closely linked to our drinking water sources, the more likely it is that pathogens excreted along with their faeces can infect us. Human faeces are the biggest concern, because anything that infects one human could infect another.

  Ingesting faecal matter via contaminated water supply is a classic means for infections to spread rapidly. The more pathogens an individual carries, the more hazardous the faeces. Faecal Coliform bacteria flourish in the digestive tracts of humans. Some of these mutated organisms may cause diarrhea, nausea, vomiting, and, in the very old, very young, and the immuno-suppressed, may even cause death. As a secondary infection Faecal Coliform causes urinary tract infection, gastro-intestinal diseases, septicemia etc. If any faecal bacteria are present in drinking water samples, it is said to be non-potable.

Formatted

When is water safe to drink?

The Bureau of Indian Standards specifies two sets of standards for drinking water: one set sets out the "desirable" limits; while the other set gives the "permissible" limits. Water containing contaminants above the desirable level may be used for drinking purposes only if there is no alternative source of water. Water with contamination above the permissible limit is prohibited for drinking purposes by law.

2. Table: Indian Standards for Drinking Water Specification (IS 10500-1991)

Parameters	Desirable limit	Permissible limit (if there is no alternative source)
Chloride	250mg/l	1000mg/l
Fluoride	1mg/l	1.5mg/l
Total Iron	0.3mg/l	1mg/l
Nitrate	45mg/l	100mg/l
Faecal Coliform	Absent	Absent

Given the problems of supplies, distribution, and high potential of pollution leading to poor quality, these indicators can be handy in assessing the water quality and have been used for the present study.

The present study

The inception of the study

Hazards Centre of Sanchal Foundation has been working with several community groups and organizations in Delhi. These partner groups/organizations work mainly in slums and resettlement colonies and all those areas have been experiencing poor service of water supply regarding both quality and quantity. Thus the demand came from these community groups to check the quality of drinking water. A total of eleven JJ clusters and resettlement colonies approached Hazards Centre to conduct a scientific study on the quality of drinking water in their areas. So the Centre initiated the study involving the communities with the help of the organizations working with them so that the study could yield authentic information in respect of water supply and quality. For Hazards Centre, it was a continuation of our people-centred research.

Aim and Objective:

The aim of Hazards Centre is to support the communities to enhance their capacity to negotiate with supply agencies for the supply of clean drinking water. The objective of the study was to evaluate the quality of drinking water in slums and resettlement colonies of Delhi, where people were demanding better supplies. Water quality was assessed both qualitatively and quantitatively during pre-monsoon and monsoon seasons to compare the status of drinking water between the two. The study involved assessment of drinking water quality through chemical analysis of samples and information collection through interactions with the community.

Methodology

Study population and area:

Drinking water quality study was carried out in 11 substandard colonies of Delhi that includes 5 JJ clusters and 6 resettlement colonies (locations are shown in Map-1). The JJ clusters are Tigri, Kanakdurga, Indira Camp No. 1, Sant Ravidas Camp, and Indira Camp No. 5; the resettlement colonies are Bawana, Bhalaswa, Madanpur Khadar, Molarbund, Hastsal and Bakkarwala. A brief description of the areas is as follows:

(Maps for individual colonies are attached in **Annexure-II**)

Bawana: A resettlement colony to the north-west, where people from Yamuna Pushta, R.K.Puram, Ashok Vihar, Vikaspuri etc have been relocated. It came into being in 2004.

Bhalaswa: A resettlement colony, north of Jahangirpuri, where people from Rohini, Gautampuri (Yamuna Pushta) etc. have been relocated.

Madanpur Khadar: This is a five-year-old resettlement colony on the western bank of the Yamuna, where people from Alaknanda, Nehru Place, Raj Nagar etc have been resettled.

Molarbund: This is a resettlement colony located near Ali Gaon in the vicinity of Badarpur Thermal Power Plant on NH2, Delhi. Resettlement started at the end of 1999 and Gautampuri slum cluster behind AIIMS was the first cluster to be relocated to this place.

Tigri: This is a very old slum cluster near Ambedkar Nagar in the south. It is one of the biggest slums in Delhi and has a population of more than 50,000.

Kanakdurga: A very old slum cluster located in Sector 12, R.K.Puram, Delhi. There are approximately 1200 families and the majority of the residents are South Indians.

Indira Camp No.1: This was a very old slum cluster located in Vikaspuri, in west Delhi. It was demolished on the 4th of May 2006 and its residents were relocated to Bawana.

Sant Ravidas Camp: This was a very old slum cluster located in Vikaspuri that was also demolished on the 4th of May 2006 and the residents relocated to Bawana.

Indira Camp No.5: This is a very old slum cluster in Vikaspuri that still remains.

Hastsal: A resettlement colony near Uttam Nagar on the banks of Najafgarh drain and its residents were relocated from Pitampura etc.

Bakkarwala: A resettlement colony on the western periphery where people from Hauz Khas, Punjabi Bagh etc have been relocated.

1. Map: Location of slums and resettlement colonies in Delhi.

Map showing Resettlement Colonies and JJ Clusters in Delhi from where Drinking Water Samples were collected.

Selection of water samples:

Selection of the sampling sites was dependent on the available water sources and complaints coming from the users of different areas. Purposive sampling was done for available hand pumps, bore wells, and at different points of piped water supply system. Because of the variable problem areas, sources and large study area, study population could not be selected statistically and thus the selected sampling sites are not representative of the entire area. However, since the water supply source was the same for the entire population, our results are indicative of a much larger reality.

Water sampling was done during the pre-monsoon and monsoon seasons in the year 2005. The pre-monsoon samples were collected in the month of May and the monsoon samples were collected in the months of August and September. Sampling was done by the Hazards Centre team with the help of the community, and a total of 77 samples were collected from these colonies. Out of the 77 samples, 24 samples were collected in pre-monsoon season and 53 in the monsoon season. There is a difference in number of samples in the two seasons because pre-monsoon season samples were taken only from distribution points, while the monsoon samples were taken from the selected sources as well as distribution points in the area.

Water sources and means of supply:

The sources of drinking water included DJB ground water supply, DJB tanker supply; DJB piped water supply, DDA ground water supply, and ground water supply from private borings and hand pumps. Hand pump samples were collected depending upon the depth of the bore, while the piped water samples were collected at the source and at different points along the distribution system. Of the eleven study areas, four got their piped water supply from boring, five from reservoirs, and four from hand pumps and one each used tanker and Reverse Osmosis (RO) treated water. Hastsal has only hand pumps; Molarbund, Tigri and Indira Camp No-5 have only boring, while Indira Camp No-1, Kanakdurga and Bakkarwala had only piped water from reservoirs. All others have more than one source of water.

3. Table: Number of samples collected from various sources in slums during pre-monsoon season.

Slums	Sources (No. of samples)
Tigri	DJB borewell (3)
Kanakdurga	DJB Piped water (1)
Indira Camp No 1	DJB Piped water (1)
Sant Ravidas Camp	DJB borewell (1)
Indira Camp No 5	DJB Piped water (1)

4. Table: Number of samples collected from various sources in slums during monsoon season.

Slums	Sources (No. of samples)	
Tigri	DJB borewell (5)	private boring (2)
Kanakdurga	DJB piped water (3)	--
Indira Camp No 1	DJB borewell (3)	--
Sant Ravidas Camp	DJB piped water (4)	--
Indira Camp No 5	DJB borewell (3)	--

5. Table: Number of samples collected from various sources in resettlement colonies during pre-monsoon season.

Resettlement colonies	Sources (No. of samples)	
Bawana	Handpump (1)	MCD slumwing borewell (1)
Bhalaswa	DJB borewell (4)	--
Madanpur Khadar	Handpump (4)	--
Molarbund	MCD slumwing borewell (2)	--
Hastsal	Handpump (1)	DDA borewell (2)
Bakkarwala	DJB borewell (1)	--

6. Table: Number of samples collected from various sources in resettlement colonies during monsoon season.

Resettlement colonies	Sources (No. of samples)	
Bawana	Handpump (1)	MCD slumwing borewell (4)
Bhalaswa	DJB borewell (5)	DJB tanker (1)
Madanpur Khadar	Handpump (3)	DDA reverse osmosis plant (3)
Molarbund	DJB borewell (8)	--
Hastsal	DJB Piped water (1)	DDA borewell (3)
Bakkarwala	DJB Piped water (4)	--

Laboratory testing of samples:

The samples were tested in the Centre itself, using a water quality testing kit and methods developed by the People's Science Institute, Dehradun, where both chemical and biological parameters were considered. For chemical monitoring the parameters tested were chlorides, fluorides, nitrates and total iron. For biological monitoring presence of faecal coliform was tested. The method of analysis of the aforesaid parameters using the water testing kit was as follows.

Chloride concentration was assessed by using titrimetric method called Mohr's method. Nitrate and total iron concentration were determined by using colour-forming reagents to develop colour, which was compared with a standard colour chart. Flouride was determined by Scot modification method, which shows colour difference for above and below permissible level concentrations of fluoride in water. The presence of faecal coliform in the samples was detected by applying FC media to observe the growth of faecal coliform, which is indicated through colour change within a given period of time.

Qualitative data on people's exposures and perceptions:

All information regarding the physical qualities of the water supplied, its timings, its regularity and its distribution were collected through interviewing people and through group discussions and observations. People also participated in mapping the area and its water supply giving the information of sources and specific authorities responsible for provisioning.

Report preparation:

We have attempted to prepare this report in as comprehensive a manner as possible, but using simpler and commonly understood scientific language. The data generated from analysis of the samples and the results have been presented both statistically and graphically, so that the results can be easily grasped. Comparisons are done for pre-monsoon and monsoon samples as well as between different sources and settlements. The activists from the community prepared maps of different water sources and distribution points for their respective colonies. This has enhanced the capacity of the community groups to comprehend the nature and methodology used for the study and shall, hopefully, enable them to use the results for bringing about required changes in the water supply and distribution system.

Results and Analysis

Qualitative analysis

The qualitative explorations with communities on the quality of water they receive brought forth common and specific area-wise issues.

The commonly prevalent problems regarding water supply faced by the communities of the eleven study areas are:

- The actual water supply available to the residents is sporadic and the flow is inadequate.
- There is a lack of piped water supply in resettlement colonies and the distribution of groundwater is without proper treatment.
- There is no establishment of new water treatment plants to meet the demand.
- The old distribution system is poorly maintained. Leakages in the existing water supply pipes pave the way for the contaminants in the surrounding area to enter the system.
- The flow of water is without adequate pressure, because of which sewage ingress takes place from the neighbouring sewer line when the pressure inside the pipe reduces.
- The supply of water doesn't follow specific timings.
- The water distributed from DJB bore wells and tankers are of poor quality.
- There is a shortage of water supply taps for the large population that is being served.
- Water supply by the tankers is contaminated and insufficient.
- Inadequate supply of treated water compels people to use the untreated contaminated groundwater, and makes them vulnerable to various health hazards.
- Privatisation through private bore wells has already increased the cost. Further privatisation of DJB will force the poor to use whatever untreated water is available.
- The falling ground water level in Delhi has become a matter of concern as deterioration in quality is also taking place.

The area-specific problems faced by the communities are as follows:

- The inhabitants of **Bawana** revealed that the DJB bore well water that they receive is not of good taste because of some 'dawai' (probably chemicals used for water purification), so they prefer water from private hand pumps.
- Source of drinking water in **Bhalaswa** is DJB bore well and tanker. The visual quality of water is very bad. The tanker supply sometimes contains oil, paints and dead organisms like rats, lizards etc. Leachate from the nearby landfill is probably entering

the ground water. People are suffering from various diseases; especially children are having stomach problems, leading even to death.

- In **Madanpur Khadar**, the source of water is hand pumps situated in front of most of the houses with water at a depth of 50-70 ft. There are three DDA water treatment plants. The treatment of water is carried out by reverse osmosis process. The water from this plant is able to cater to only those people who live near the plant.
- The source of drinking water in **Molarbund** is DJB bore well. There are handpumps in the area but most of them are not working. Due to limited supply of water, quarrels at the point of water collection are common.
- DJB piped water is supplied in **Bakkarwala**. Mixing of the supply water with sewage is probably due to leakage in the pipes. When there is inadequate supply of water, then the water retreat in the pipe during low pressure, creating a vacuum in the pipe that sucks in sewage from the surrounding soil through leakages.

Quantitative Analysis:

Quantitative analysis was conducted by testing the water samples for the parameters: chloride, fluoride, nitrate, total iron and faecal coliform in the respective colonies. The analysed data are tabulated in the comprehensive table in **Annexure-I** for both the seasons and all colonies. The summary results are depicted in the following Table 7.

7. Table: Summary of results of drinking water quality monitoring in both pre-monsoon and monsoon season ('S' is slum; 'R' is resettlement colony):

No.	Area of sampling	Source of water (no. of samples; pre-monsoon + monsoon)	Pre-monsoon observation	Monsoon observation	Potability
1.	**Bawana (R)**	▪ Slum wing bore well (1+4). ▪ Hand pump (1+1).	▪ Chloride is above desirable limit in slum wing bore well sample. ▪ Fluoride is above permissible limit in one sample. ▪ Total iron is also above the permissible limit. ▪ Faecally contaminated.	▪ Fluoride is above permissible limit. ▪ Total iron is also above permissible limit. ▪ Faecally contaminated.	▪ Both pre-monsoon and monsoon samples are non-potable.
2.	**Bhalaswa (R)**	▪ DJB bore well (4+5). ▪ DJB tanker (0+1)	▪ Chloride is above desirable limit. ▪ Total iron is above permissible limit. ▪ Faecally contaminated.	▪ Chloride is above the desirable limit in three DJB bore well samples. ▪ Fluoride is permissible in three DJB bore well	▪ Both pre-monsoon and monsoon samples are non-potable.

Contd.

				samples ▪ Total iron is above the permissible limit. ▪ One DJB bore well sample is faecally contaminated.	
3.	**Madanpur Khadar (R)**	▪ Handpump (3+3). ▪ DDA supply with Reverse Osmosis treatment (1+3).	▪ Chloride is above desirable limit in one hand pump sample. ▪ Total iron is above permissible limit. ▪ Two hand pump samples are faecally contaminated.	▪ Chloride is above desirable limit in two hand pump samples. ▪ Total iron is above permissible limit. ▪ Faecally contaminated.	▪ Both pre-monsoon and monsoon samples are non-potable.
4.	**Molarbund (R)**	▪ DJB bore well (2+8).	▪ Chloride is above desirable limit. ▪ Total iron is above permissible limit. ▪ Faecally contaminated.	▪ Chloride and nitrate are above desirable limit in two DJB bore well samples. ▪ Total iron is above permissible limit in one DJB bore well sample. ▪ Four DJB bore well samples are faecally contaminated.	▪ Pre-monsoon samples are non-potable. ▪ Four monsoon samples are potable and four are non-potable.
5.	**Tigri (S)**	▪ DJB bore well (3+5). ▪ Private bore well (0+2).	▪ Chloride and nitrate are above desirable limit in two DJB bore well samples. ▪ Total iron is above permissible limit in two DJB bore well samples. ▪ Two DJB bore well samples are faecally ▪ contaminated.	▪ Nitrate is above desirable limit ▪ Total iron is above permissible limit in four DJB bore well and two private bore well samples. ▪ Four DJB bore well samples are faecally contaminated.	▪ One pre-monsoon sample is potable and two are non-potable. . ▪ All monsoon samples are non-potable.
6.	**Kanakdurga (S)**	▪ DJB piped water supply (1+3).	▪ Chloride and total iron is above desirable limit. ▪ Faecally contaminated.	▪ Total iron is above desirable limit. ▪ Faecally contaminated.	▪ Both pre-monsoon and monsoon samples are non-potable.
7.	**Indira Camp No.1 (S)**	▪ DJB bore well (1+3)	▪ Chloride is above desirable limit. ▪ Total iron is above the permissible limit. ▪ Faecally contaminated.	▪ Total iron is above the permissible limit in two DJB bore well samples. ▪ Two DJB bore well samples are faecally contaminated.	▪ Pre-monsoon sample is non-potable. ▪ One monsoon sample is potable and two are non-potable.

Contd.

8.	**Sant Ravidas Camp (S)**	▪ DJB piped water supply (1+4)	▪ Chloride is above desirable limit. ▪ Total iron is above the permissible limit. ▪ Faecally contaminated.	▪ Fluoride is above permissible limit in two samples. ▪ Total iron is above the permissible limit in one sample. ▪ Two samples are faecally contaminated.	▪ Pre-monsoon is non-potable. ▪ Two monsoon samples are potable and two samples are non-potable.
9.	**Indira Camp No.5, Vikaspuri (S)**	▪ DJB bore well (2+3)	▪ Chloride is above desirable limit. ▪ Total iron is above the permissible limit. ▪ One sample is faecally contaminated.	▪ Total iron is above the permissible limit. ▪ Faecally contaminated.	▪ Both pre-monsoon and monsoon samples are non-potable.
10.	**Hastsal (R)**	▪ DDA bore well (2+3). ▪ DJB piped water supply (0+1). ▪ Hand pump (1+0).	▪ Total iron is above the permissible limit. ▪ One DDA bore well and hand pump faecally contaminated.	▪ Total iron is above the permissible limit in three DDA bore well samples. ▪ Two DDA bore well samples are faecally contaminated	▪ Pre-monsoon samples are non-potable. ▪ One DJB piped water monsoon sample is potable and three DDA bore well samples are non-potable
11.	**Bakkarwala (R)**	▪ DJB piped water supply (1+4)	▪ Chloride is above desirable limit. ▪ Total iron is above the permissible limit. ▪ Faecally contaminated.	▪ Total iron is above the permissible limit. ▪ Faecally contaminated.	▪ Both pre-monsoon and monsoon samples are non-potable.

The quantitative analysis indicates that, out of 77 water samples tested in both the seasons, only 9 water samples are fit for drinking purpose whereas 68 water samples are contaminated either chemically or biologically and are not fit for drinking. Most of the samples are faecally contaminated; iron is also found in high quantities. There is also the presence of fluoride above the limits in a few samples. Details about the water samples are elaborated below according to their sampling seasons.

Seasonal variations of quality:

Pre-monsoon results: During the pre-monsoon season that is in the month of May 2005, 24 samples of water were collected from various sources in 11 slums and resettlement colonies where only one sample is found to be potable. The results illustrate that, in most of the areas, levels of iron are significantly high. 20 samples contain total iron more than 3mg/l and 3 are in the range of 1-3mg/l; all of them are above the permissible limit and only one DJB sample from Tigri has total iron within the permissible limit. In 2 water samples of DJB bore well supply, we have found nitrate levels more than the desirable limit i.e. above 45mg/l. However, it should be noted that adverse effects of nitrate on human health can be seen at concentrations of 10mg/l. 2 DJB bore well samples, 2 MCD bore well samples and 1 hand pump sample contain nitrate in the range of 10-45mg/l. Chloride levels in the 24 tested samples are within the permissible limit while 19 of them are above the desirable limit. Fluoride is above the permissible limit in one of the analysed samples where the source is a DJB bore well. Most of the water samples are found faecally contaminated. Out of the total 24 samples tested, 17 samples are faecally contaminated.

Monsoon results: During the monsoon season, in the months of August and September 2005, a total of 53 drinking water samples were collected from 11 different slums and resettlement colonies where only 8 water samples were found to be potable.

The results of bacteriological analysis (faecal coliform test) show that out of 53 samples tested, 36 samples are faecally contaminated. The chemical analysis is also important because when chemical compounds are present even at low levels, but for long periods of time, they can lead to severe health ailments. The chemical analysis shows that chloride in 7 samples, nitrate in 9 samples, and total iron in 12 samples are above the desirable limit, while fluoride in 8 samples, and total iron in 37 samples are above the permissible limit.

From these bacteriological and chemical analysis results it can be concluded that the water provided to the slums and resettlement colonies, from both public and private sources, is not at all fit for drinking.

In all collection points and sources, contamination was significant in all samples. In some cases the contamination is above the permissible limits in the sample collected from the source (1st point of the system), while no contamination of that particular pollutant may be found in the sample collected from another point of the same distribution system. This may be due to dilution and settling of some contaminants in the water.

Supply and Quality of water source-wise:

The following tables show the maximum water supply and its quality from the most prevalent sources present in the areas. It reflects that the maximum supply of drinking water is provided by Delhi Jal Board (8.Table). There is no significant variation in quality because the sample from DDA, MCD slum-wing and private sources show 100% contaminated water whereas only few samples of DJB shows potable water (9.Table).

8. Table: Maximum supply of water from various sources

Area-wise distribution of sources of water.	DJB	MCD Slum-wing	DDA	Private
Maximum supply	9	2	2	4

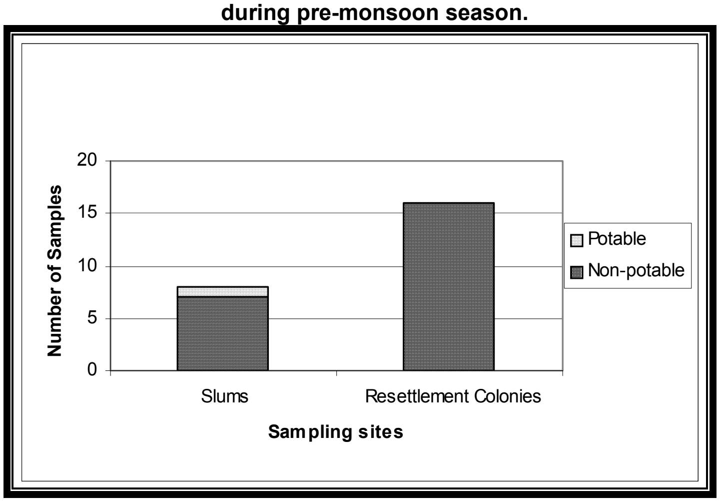
9.Table: Quality of water source-wise in both the seasons

Sources		DJB	MCD slum-wing	DDA	Private
Quality of samples in percentage	Pre-monsoon	92% non potable	100% non potable	100% non potable	100%non potable
	Monsoon	78% non potable	100% non potable	100% non potable	100% non potable

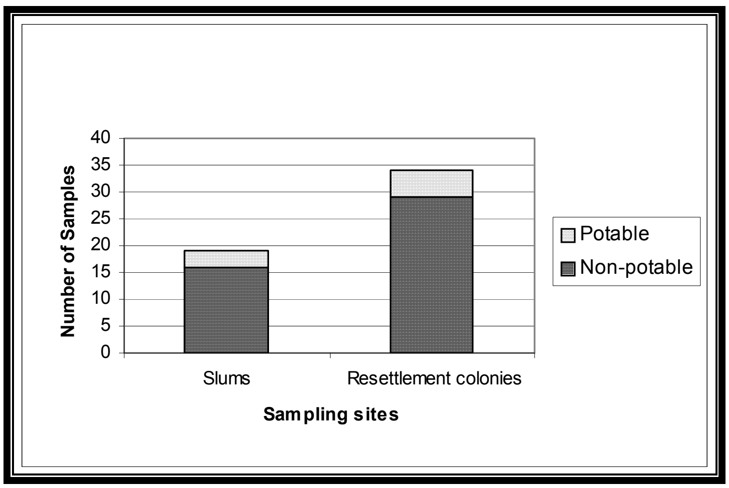
Water quality in Slums and Resettlement colonies

A comparison was done regarding the water quality of slums and resettlement colonies with the help of graphs. This clearly depicts that the water quality of the resettlement colonies is not better than that of the slums; instead in many cases it is worse. The pre-monsoon results show that there is not a single potable sample in the resettlement colonies, while the monsoon results show potable samples but in meagre quantities. This explodes the myth underlying the resettlement policy that the people in slums are being evicted so as to give them a better quality of life in the resettlement colonies.

2. Fig: Quality of drinking water in slums and resettlement colonies during pre-monsoon season.



3. Fig: Quality of drinking water in slums and resettlement colonies during monsoon season.



Discussion

People in the sub-standard colonies are conscious about the quality of water that they receive but need the support of concerned organizations to provide technical information. The same authority, which provides clean treated and piped water to the upper and middle classes, provides bore well water and untreated reservoir water to the lower classes. Delhi's ground water is highly polluted and therefore, if boring and untreated reservoirs continued to be the sources of water for a large section of the population, the problem of ill-health will only get worse. What is called for is expansion of water treatment plants and improved supply by introducing better methods of regulating water use by the rich. This study highlights the plight of those who invest their small savings to create private facilities in the sub-standard settlement areas. There is a notion that the water provided to the resettlement colonies is of better quality than the water provided to the slums, which is also claimed by the government agencies. The results of this study challenge that perception.

What can people do?

Know your water suppliers and about testing the water:

Anyone can collect a water sample and supply it to DJB laboratory for testing, if the water supplier is a government agency. If impurity of water can be observed visually or can be known form analysis done in a scientific laboratory or by the community itself using domestic water testing kit, anyone can approach the respective concerned department for rectification of the water supply and quality of supplied water in the area. It is therefore important to know the water supplier in your area, who may be Delhi Jal Board or MCD slum wing or DDA or any private authority. Information about testing of water and water supply can also be obtained from concerned government agencies through Right to Information Act. The list of concerned authorities to complain to about water quality can be known from the table attached in the **Annexure IV.**

Safer ways for collecting and storing drinking water:

Key factors in the provision of safe household water include the conditions and practices of water collection and storage and the choice of water collection and storage containers or vessels. Increased risks of waterborne infectious diseases result from inadequately stored water, compared to water stored in an improved vessel (safe storage), treated in the home to improve microbial quality, or consumed from a quality source without storage. Higher levels of microbial contamination and decreased microbial quality are associated with storage vessels having wide openings (e.g., buckets and pots), vulnerability to introduction of hands, cups and dippers that can carry faecal contamination, and lack of a narrow opening for dispensing water. Other factors contributing to greater risks of microbial contamination of stored water are higher temperatures, increased storage times, higher levels of airborne particulates, inadequate hand washing and the use of stored water to prepare foods that also become microbiologically contaminated and contribute to increased infectious disease risks. For piped water supply, precaution in collecting water should be taken by leaving the water to flow for a few seconds, which can be used for other domestic purposes other than drinking; then only water should be collected for drinking purpose. Even for hand pumps, water should be collected after pumping out for 20-30 seconds. **Drinking water should be always stored in thoroughly washed non-reactive containers like stainless steel, glass, fibreglass, earthen pots etc**.

Treatment of water:

There are several sophisticated methods of water purification like Distillation, Reverse osmosis, Ion exchange, Blending, Electro dialysis, Catalytic filtration etc. but purification is often difficult, expensive and, not fully effective. Hence, prevention is the best way to ensure clean water. The onus to ensure potable water supply clearly lies on the supplier. This should, therefore, be the first demand on the government, which acts both as supplier as well as regulator. However, until community pressure builds up on the government, poor communities can treat the water to some extent by using low cost physical methods, such as sedimentation, filtration, boiling or heating, and exposure to sunlight (UV irradiation and heating), and the chemical methods of coagulation or adsorption with alum, lime, plant extracts, carbon (charcoal), and clay, and exposure to germicidal metals such as silver and copper. Other methods of disinfecting water include pasteurising and treating with ozone, but all these are usually less practical than chlorination or not readily available. Sterilization (boiling water vigorously) removes biological contamination to some extent. Disinfecting reduces the concentration of organisms to safe levels. Chlorination, distillation, or boiling for 15 minutes are the usual methods used to purify water for household use. For acquiring ground water with less concentrations of nitrate and fluoride from bore wells and hand pumps, the pumping of water from deeper aquifers can be done. Deflouridation of water can also be done through methods like Activated Alumina, Nalgonda process and Clay-Clay column deflouridators.

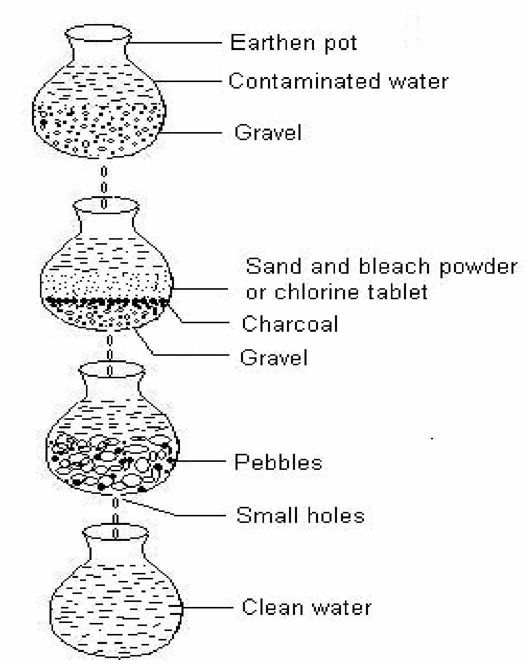
Ceramic filters: Water can be purified by allowing it to pass through a ceramic filter element, which restricts the suspended particulates. These are also called candle filters. Disinfection of such water should be done separately by chlorination or ultra-violet treatment.

Boiling: Boiling of water makes water free from some pathogens, germs, spores, worm eggs etc. Boiling should be done for 3-5 minutes. The lost taste of boiled water can be regained through stirring and vigorous shaking after cooling, which aerates the water.

Metal contact: Keeping water in Copper vessels and Silver coated containers for a few hours acts as a germicide, which destroys some pathogens and reduces the growth of some biological contaminants.

Chlorination: Chlorination in both municipal systems and households can disinfect water. Household systems commonly use household bleach. Chlorination does not remove nitrates or other chemicals, but may oxidize organics and some minerals such as iron. Using a carbon filter (charcoal or activated carbon filter) after chlorination will remove any excess chlorine and chlorinated chemicals.

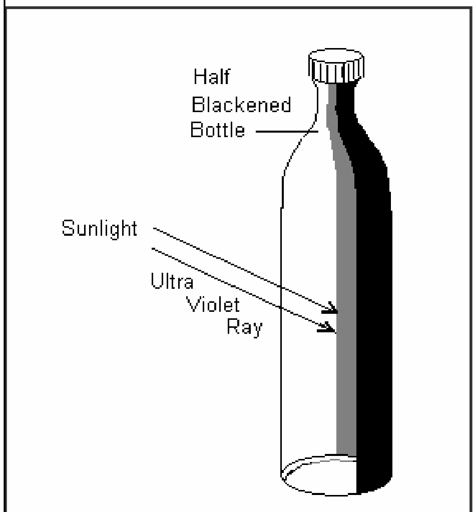
4. Fig: Sand filter for household purification of drinking water.



Sand filter: Four earthen pots with 2-3 small holes at the bottoms are necessary for construction of this type of filter. The pots can be placed in a stand as in the **Fig 4.3**. The first pot is half filled with a layer of gravels and water to be filtered is poured into it. The second pot has two layers of sand and gravels. Bleaching agents/ chlorine is mixed in the sand layer and another thin layer of charcoal is sandwiched between the two layers of sand and gravel. The third pot is half filled with pebbles and water passes through it to reach the fourth pot as filtered water.

Solar Disinfections: Ultra violet rays from the sun are used to inactivate and destroy pathogens in water. In the case of solar or heat treatments, the vessel must be capable of withstanding high temperatures, and depending on the type of solar treatment, they must allow the penetration of UV radiation and/or the absorption of heat energy. Water in transparent containers should be kept in sun light for 4-5 hours. The heat gain from sunlight can be increased by keeping water in half blackened bottle, where the transparent side faces the sun light and the other side restricts the sunlight from exiting out from the bottle.

5. Fig: Glass bottle for solar disinfections



"Common Man's Water Filter" *(Courtesy: Sustainable Strategy for human Settlement Design, www.anangpur.org)***:**

The cost of this filter is Rs 600 and anyone can develop this type of filter to generate potable water at any household. This type of filter purifies water in natural ways avoiding the chemical additives and removes hardness, coliform bacteria and arsenic. It consists of four copper vessels, placed one on the top of the other. Each of the three containers has a hole of 1.5mm diameter at its bottom and the vessel at the bottom won't be punctured. The first vessel, where impure water is poured, contains coconut shells' charcoal. The second vessel is filled with small marble chips up to $3/4^{th}$ of the space. The third container is filled with white sand. Water is allowed to pass through the three phases of purifications and is collected at the bottom vessel, which contains a few silver coins. The silver metal works as disinfectant even in low temperature. The same type of filter can be developed using bamboo column, wherever resource is available, instead of the copper vessels.

The study and future perspectives: This study on quality of water in the eleven sub-standard settlements of Delhi evaluates the unsatisfactory status of water quality available in those areas. This report may help different community groups and organizations as a technical input to argue for sound supply of good quality water, and also to adopt a comprehensive approach to the management of drinking water. This study may also encourage other community groups to adopt such studies by themselves in other areas. Hazards Centre would like to carry out more widespread studies on water quality involving the population who are actually affected by problems regarding water quality as well as quantity. Future studies will possibly include intensive focus on availability, distribution systems, polluting sources etc, which will help to produce drinking water treatment and management options for the deprived sectors.

Annexure I

10. Table: Results of pre-monsoon samples (the parameters that are above permissible limit are in bold font).

Sl No.	Sampling site	Date of collection	Time of collection	Source of water	Parameters					Potability
					Chloride (mg/l)	Fluoride	Nitrate (mg/l)	Total Iron (mg/l)	Faecal Coliform	
1.	Bawana block-B (R)	12. 05.05	2:15pm	Slum wing bore well	620	**Above permissible limit**	1-10	**1-3**	Absent	**Non potable**
2.	Bawana block-B	12. 05.05	2:20 pm	Hand pump	245	Within permissible limit	1	**3**	**Present**	**Non potable**
3.	Bhalaswa block-B 4 (R)	12. 05.05	3:00 pm	DJB bore well	425	Do	1-10	**>>3**	**Present**	**Non potable**
4.	Bhalaswa block-B 4 (R)	12. 05.05	3:10 pm	DJB bore well	760	Do	1-10	**>>3**	**Present**	**Non potable**
5.	Bhalaswa block-B 4 (R)	12. 05.05	3:15 pm	DJB bore well	280	Do	1	**>>3**	**Present**	**Non potable**
6.	Bhalaswa block-B 4 (R)	12. 05.05	3:20 pm	DJB bore well	420	Do	0	**>>3**	**Present**	**Non potable**
7.	Madanpur khadar pocket-A 1 (R)	13. 05.05	12:45 pm	Hand pump 70 ft.	240	Do	<1	**>3**	**Present**	**Non potable**
8.	Madanpur khadar pocket-A 2 (R)	13. 05.05	12:50 pm	Hand pump 50 ft.	240	Do	0	**>>3**	Absent	**Non potable**
9.	Madanpur khadar pocket-A 2 (R)	13. 05.05	12:55 pm	Hand pump 60 ft.	320	Do	<1	**1-3**	**Present**	**Non potable**
10.	Madanpur khadar pocket-D 2 (R)	13. 05.05	1:10 pm	DDA reverse osmosis plant	220	Do	<1	**>3**	Absent	**Non potable**
11.	Molarbund phase-2B (R)	13. 05.05	1:40 pm	MCD slum wing bore well	340	Do	10-45	**>>3**	**Present**	**Non potable**
12.	Molarbund block-B (R)	13. 05.05	1:45 pm	MCD slum wing bore well	380	Do	10-45	**>3**	**Present**	**Non potable**
13.	Tigri block-B (S)	13. 05.05	2:50 pm	DJB bore well	260	Do	45-100	0.1-0.3	Absent	*Potable
14.	Tigri block-G (S)	13. 05.05	2:55 pm	DJB bore well	180	Do	>45	**>3**	**Present**	**Non potable**
15.	Tigri block-E (S)	13. 05.05	3:10 pm	DJB bore well	340	Do	10-45	**>>3**	**Present**	**Non potable**
16.	Kanakdurga (S)	09.05.05	11.00 am	DJB piped water supply	320	Within permissible limit	1-10	**1-3**	**Present**	**Non potable**
17.	Indira camp no.1, Vikashpuri (S)	12. 05.05	11:55 am	DJB bore well	320	Do	1-10	**>>3**	**Present**	**Non potable**
18.	Sant Ravi Das Camp, Vikashpuri (S)	12. 05.05	11:20 am	DJB piped water supply	600	Do	1-10	**>>3**	Absent	**Non potable**

19.	Indira Camp no.5, Vikashpuri (to the rear of Lok Vihar Apt.) (S)	12. 05.05	12:10 pm	DJB bore well	740	Do	10-45	**1-3**	**Present**	**Non potable**
20.	Indira Camp no. 5, Vikashpuri (S)	12. 05.05	11:40 am	DJB bore well	560	Do	1	**>>3**	Absent	**Non potable**
21.	Hastsal J J colony, block-A (R)	12. 05.05	12:45pm	DDA bore well	640	Do	1-10	**>3**	Absent	**Non potable**
22.	Hastsal J J colony, block-C (R)	12. 05.05	12:50 pm	DDA bore well	540	Do	1-10	**>>3**	**Present**	**Non potable**
23.	Hastsal J J colony, block-C (R)	12. 05.05	12:45 pm	Hand pump	440	Do	10-45	**1-3**	**Present**	**Non potable**
24.	Bakkarwala block-D (R)	12. 05.05	1:20 pm.	DJB piped water supply	280	Do	1-10	**>>3**	**Present**	**Non potable**

* Potable in case there is no alternate source of water.

11. Table: Results of monsoon samples (the parameters that are above permissible limit are in bold font).

Sl No	Sampling site	Date of collection	Time of collection	Source of water		Parameters					Potability
				Source	Distribution point	Chloride	Fluoride	Nitrate (mg/l)	Total Iron (mg/l)	Faecal Coliform	
1.	Bawana Block – E/112 (R)	30.08.05	4.50 p.m	MCD slum wing bore well.	1st point	80	**Above permissible limit.**	1	**>3**	**Present**	**Non potable**
2.	Bawana, in front of slum office (lal ghar) (R)	30.08.05	5.10 p.m		2nd point	100	**-do-**	1	**3**	**Present**	**Non potable**
3.	Bawana Block – B/66 (R)	30.08.05	5.20 p.m	MCD slum wing bore well	1st point	130	**-do-**	1	**3**	**Present**	**Non potable**
4.	Bawana Block – C/57 (R)	30.08.05	5.50 p.m	MCD slum wing bore well	1st point	90	**-do-**	1-10	**3**	Absent	**Non potable**
5.	Bawana Block – D (infront of the temple) (R)	30.08.05	6.10 p.m	Hand pump	1st point	112	**-do-**	1-10	**>3**	**Present**	**Non potable**
6.	Bhalaswa Block -A2/7 (R)	11.08.05	2.30 p.m	DJB bore well	1st point	380	**Above permissible limits**	0	**>3**	Absent	**Non potable**
7.	Bhalaswa Block -A2/67 (R)	11.08.05	2.34 p.m		2nd point	360	**-do-**	<1	**3**	Absent	**Non potable**
8.	Bhalaswa Block-A3 /36 (R)	11.08.05	2.40 p.m		3rd point	180	Within permissible limits	<1	**3**	Absent	**Non potable**
9.	Bhalaswa Block -B4/469 (R)	11.08.05	2.45 p.m		4th point	162	-do-	-	**>3**	**Present**	**Non potable**

10.	Bhalaswa Block -B4/8 (near Ankur)	11.08.05	2.48 p.m		5th point	604	**Above permissible limits**	<1	**>3**	Absent	**Non potable**
11.	Bhalaswa (R)	11.08.05	2.50 p.m	DJB tanker	Tanker	62	Within permissible limits	<1	**>3**	Absent	**Non potable**
12.	Madanpur Khadar Phase-II, pocket-D	21.09.05	12.30 p.m	DDA reverse osmosis plant	-	180	-do-	<1	**>>>3**	**Present**	**Non potable**
13.	Madanpur Khadar Phase-II, pocket-A/41 (R)	21.09.05	12.40 p.m	DDA reverse osmosis plant	-	190	-do-	<1	**3**	**Present**	**Non potable**
14.	Madanpur Khadar (in front of A1/226) (R)	21.09.05	12.48 p.m	DDA reverse osmosis plant	-	240	-do-	1	**>>>3**	**Present**	**Non potable**
15.	Madanpur Khadar Pocket – A1/151 (R)	21.09.05	1.00 p.m	Hand pump	1st point	300	-do-	<1	**>3**	**Present**	**Non potable**
16.	Madanpur Khadar Pocket – A1/920 (R)	21.09.05	1.10 p.m		2nd point	220	-do-	<1	**>3**	**Present**	**Non potable**
17.	Madanpur Khadar Pocket – B1/498 (R)	21.09.05	1.20 p.m		3rd point	280	-do-	<1	**>3**	**Present**	**Non potable**
18.	Molarbund Block-B/745 (R)	02.08.05	1.30 p.m	DJB bore well	1st point	200	-do-	10-45	**1-3**	**Present**	**Non potable**
19.	Molarbund Block-B/949 (R)	02.08.05	1.33 p.m		2nd point	252	-do-	10-45	0.7-1	**Present**	**Non potable**
20.	Molarbund Block-B/73 (R)	02.08.05	1.38 p.m	DJB bore well	1st point	110	-do-	10-45	0.3-0.7	**Present**	**Non potable**
21.	Molarbund Block-A/820 (R)	02.08.05	1.45 p.m		2nd point	115	-do-	10-45	0.3-0.7	Absent	* Potable
22.	Molarbund Block -A/877 (R)	02.08.05	1.50 p.m	DJB bore well	1st point	180	-do-	45-100	0.7-1	Absent	* Potable
23.	Molarbund (in front of dhobi) (R)	02.08.05	1.53 p.m		2nd point	185	-do-	45-100	1	**Present**	**Non potable**
24.	Molarbund Block -B/13 (R)	02.08.05	2.00 p.m	DJB bore well	1st point	262	-do-	10-45	0.1-0.3	Absent	*Potable
25.	Molarbund Block-B/183 (R)	02.08.05	2.05 p.m		2nd point	200	-do-	10-45	0.1-0.3	Absent	*Potable
26.	Tigri Block – A/198 (S).	02.09.05	1.30 p.m	Private bore well	1st point	140	Within permissible limit	>45	**>>3**	Absent	**Non potable**
27.	Tigri Block – A/198 (S).	02.09.05	1.40 p.m		2nd point	118	-do-	>45	**>3**	Absent	**Non potable**
28.	Tigri Block – F/292 (S).	02.09.05	1.50 p.m	DJB bore well	1st point	225	-do-	>45	**1**	**Present**	**Non potable**
29.	Tigri Block – F/310 (S).	02.09.05	2.04 p.m		2nd point	192	-do-	>45	**3**	Absent	**Non potable**

30.	Tigri Block – F/656 (S).	02.09.05	2.15 p.m	DJB bore well	1st point	180	-do-	>45	**>3**	**Present**	**Non potable**
31.	Tigri Block – F/406 (S).	02.09.05	2.20 p.m		2nd point	170	-do-	>45	**>>3**	**Present**	**Non potable**
32.	Tigri Block – I/20 (S).	02.09.05	2.30 p.m	DJB bore well	1st point	200	-do-	>45	**>>3**	**Present**	**Non potable**
33.	Kanakdurga Sector – 12 (S)	30.07.05	2.30 p.m	DJB piped water supply	1st point (source)	200	Within permissible limits	1-10	0.7 - 1	**Present**	**Non potable**
34.	Kanakdurga Block – A/690 (S)	30.07.05	2.35 p.m		2nd point	180	-do-	1-10	0.3-0.7	**Present**	**Non potable**
35.	Kanakdurga Block – S/108 (S)	30.07.05	2.40 p.m		3rd point	103	-do-	1-10	0.1-0.3	**Present**	**Non potable**
36.	Indira Camp No.1 (near the church), Vikashpuri (S)	30.08.05	11.10 a.m	DJB bore well	New connection (2-3yrs)	150	Within permissible limits	>1	**3**	**Present**	**Non potable**
37.	Indira Camp No.1 (near the church) Vikashpuri, (S)	30.08.05	11.12 a.m		Old connection	120	-do-	1	0.1	Absent	*Potable
38.	Indira Camp No.1 (besides Anandkunj), Vikashpuri (S)	30.08.05	11.18 a.m		New connection	105	-do-	1	**3**	**Present**	**Non potable**
39.	Sant Ravidas Camp (near the temple), Vikashpuri (S).	30.08.05	11.45 a.m	DJB piped water supply, K.G-I line	1st point	96	**Above permissible limits**	1	**3**	**Present**	**Non potable**
40.	Sant Ravidas Camp, Block-A/84, Vikashpuri (S).	30.08.05	11.50 a.m		2nd point	105	**-do-**	1	1	**Present**	**Non potable**
41.	Sant Ravidas Camp, Kislay, Vikashpuri (S).	30.08.05	12.05 p.m	DJB piped water supply, K.G-II line	1st point	160	Within permissible limits	1	1	Absent	* Potable
42.	Sant Ravidas Camp (near bijlighar), Vikashpuri (S).	30.08.05	12.10 p.m		2nd point	110	-do-	1-10	1	Absent	* Potable
43.	Indira camp no. 5, (near DJB pump) Vikashpuri (S).	30.08.05	12.15 p.m	DJB bore well	1st point	260	-do-	10-45	**3**	**Present**	**Non potable**
44.	Indira camp no. 5, 120/423 Vikashpuri, (S).	30.08.05	12.20 p.m		2nd point	240	-do-	10-45	**3**	**Present**	**Non potable**
45.	Indira camp no. 5, JJ-61 Vikashpuri (besides the market) (S).	30.08.05	12.28 p.m		3rd point	210	-do-	10-45	**3**	**Present**	**Non potable**
46.	Hastsal (near DDA pump house) (R)	30.08.05	1.00 p.m	DDA bore well	1st point	220	-do-	1-10	**>3**	Absent	**Non potable**
47.	Hastsal, Block -D/1050 (R)	30.08.05	1.05 p.m		2nd point	180	-do-	1-10	**3**	**Present**	**Non potable**
48.	Hastsal, Block -B/440 (R)	30.08.05	1.15 p.m		3rd point	144	-do-	1-10	**>3**	**Present**	**Non potable**
49.	Vikasnagar,	30.08.0	1.30 p.m	DJB	-	100	-do-	<1	1	Absent	* Potable

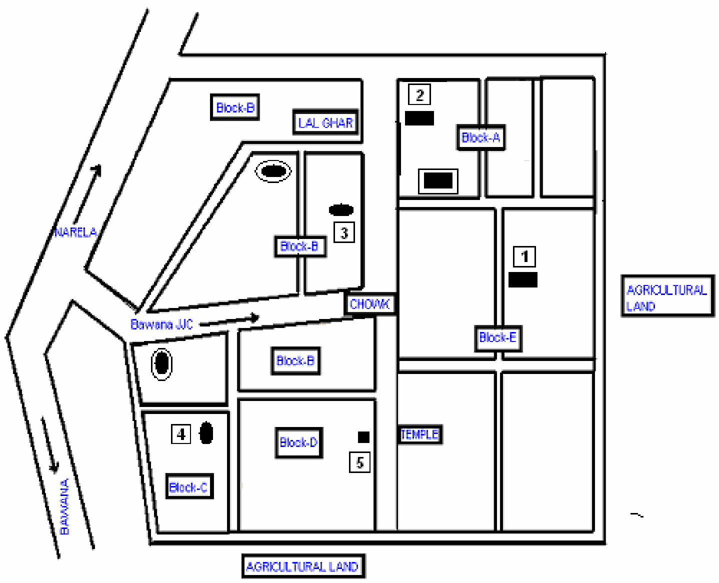
	Hastsal (R)	5		piped water supply							
50.	Bakkarwala Block - B/90 (R)	30.08.05	2.20 p.m	DJB piped water supply	1st point	80	-do-	1	**>>3**	**Present**	**Non potable**
51.	Bakkarwala Block - D/108 (R)	30.08.05	2.40 p.m		2nd point	72	-do-	1	**>>3**	**Present**	**Non potable**
52.	Bakkarwala Block- C/471 (near primary school) (R)	30.08.05	3.00 p.m		3rd point	96	-do-	1	**>3**	**Present**	**Non potable**
53.	Bakkarwala Block - D/425 (R)	30.08.05	3.10 p.m		4th point (pipe broken)	98	-do-	1	**>3**	**Present**	**Non potable**

*potable in case there is no alternate source of water.

Annexure II

In **Bawana,** drinking water is supplied from ground water sources and is mostly polluted with fluoride and iron. Among the five samples collected, four have faecal contamination.

2. Map: Sampling sites and analysis results in Bawana



	1	2	3	4	5
Chloride (ppm):	80	100	130	90	112
Fluoride (ppm):	>1.5	>1.5	>1.5	>1.5	>1.5
Nitrate (ppm) :	<45	<45	<45	<45	<45
Total iron (ppm):	>3	3	3	3	>3
Faecal coliform:	present	present	present	absent	present

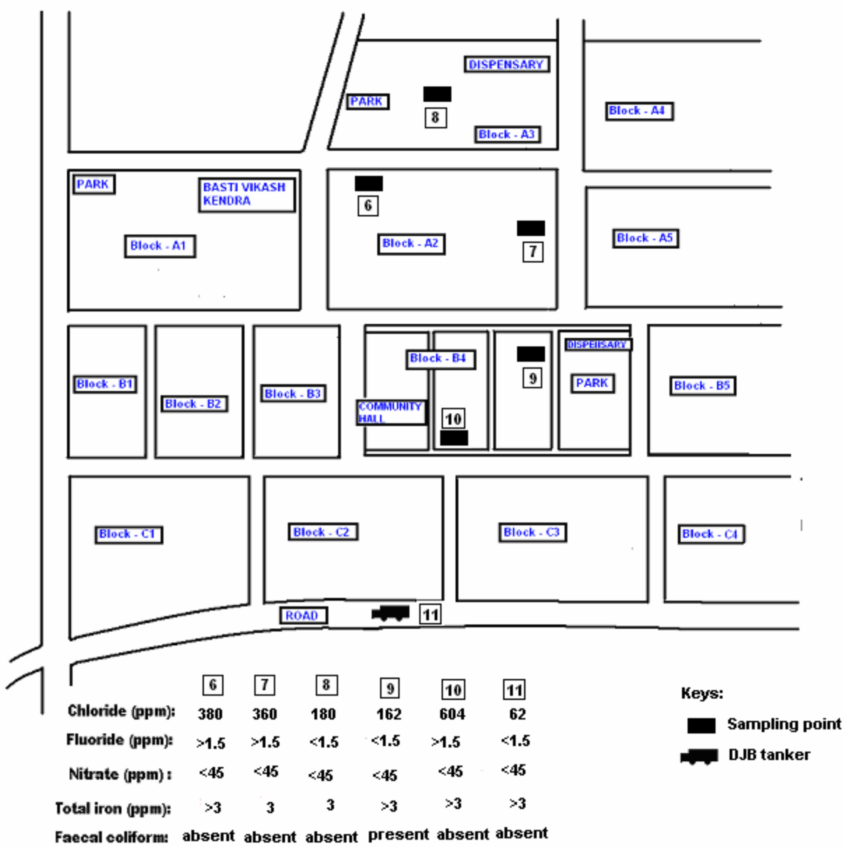
Keys:

- Boring, MCD slum wing, Block - A
- Sampling point, Block - A & E
- Boring, MCD slum wing, Block - B
- Sampling point, Block - B
- Boring, MCD slum wing, Block - C
- Sampling point, Block - C & D
- Handpump

Map(1): Water Sample Collection Site and Monitoring Results in Bawana

In **Bhalaswa,** all the five collection taps of the same boring show varied range of chloride concentrations and sample no. 16 shows a very high level (>600ppm). Three samples show fluoride concentration above the permissible limit, which is alarming. There is no problem of nitrate contamination, but all the samples have iron concentration above the permissible limit and even the DJB water supplied by the tanker has iron above the permitted value. One ground water sample shows faecal contamination.

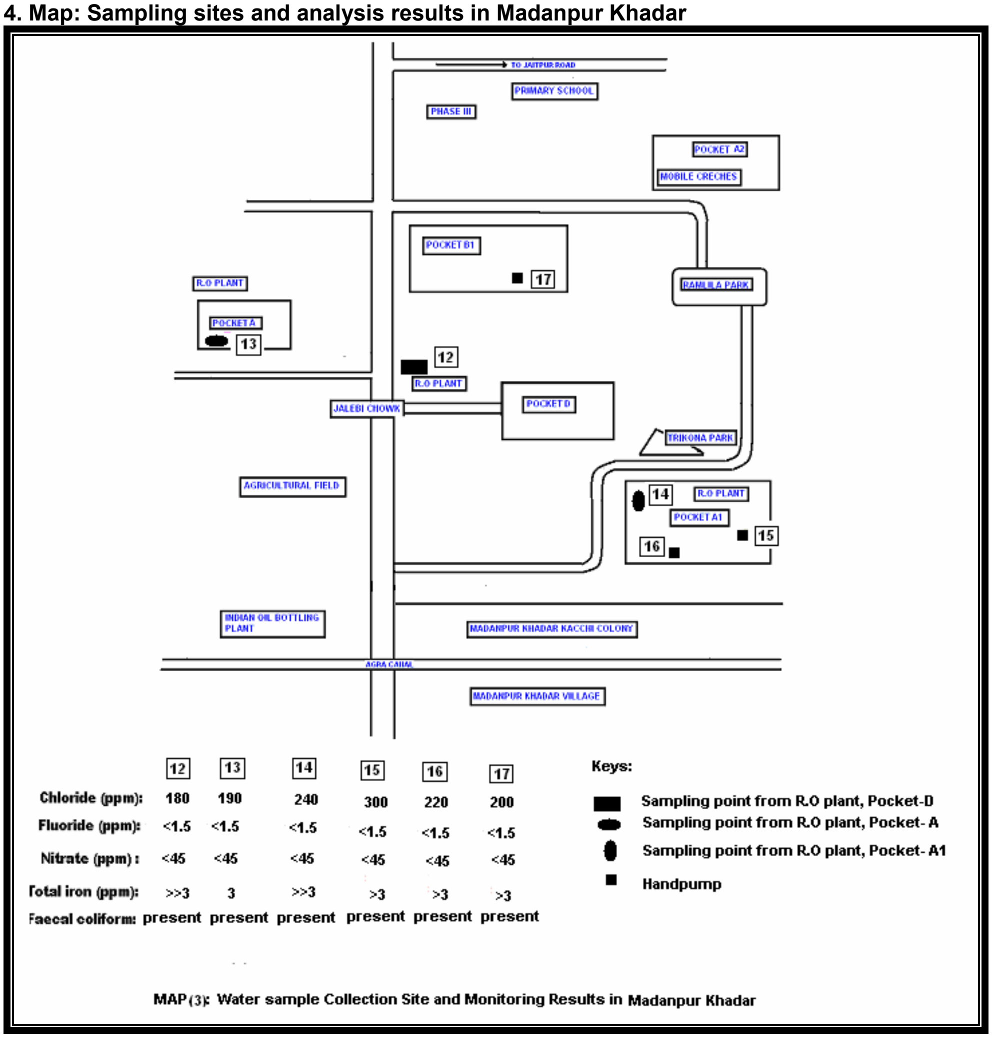
3. Map: Sampling sites and analysis results in Bhalaswa



MAP (2): Water sample Collection Site and Monitoring Results in Bhalaswa

In **Madanpur Khadar**, all the six samples including the reverse osmosis plant samples collected are faecally contaminated and have very high levels of total iron concentration. Two samples have chloride above the desirable limit.

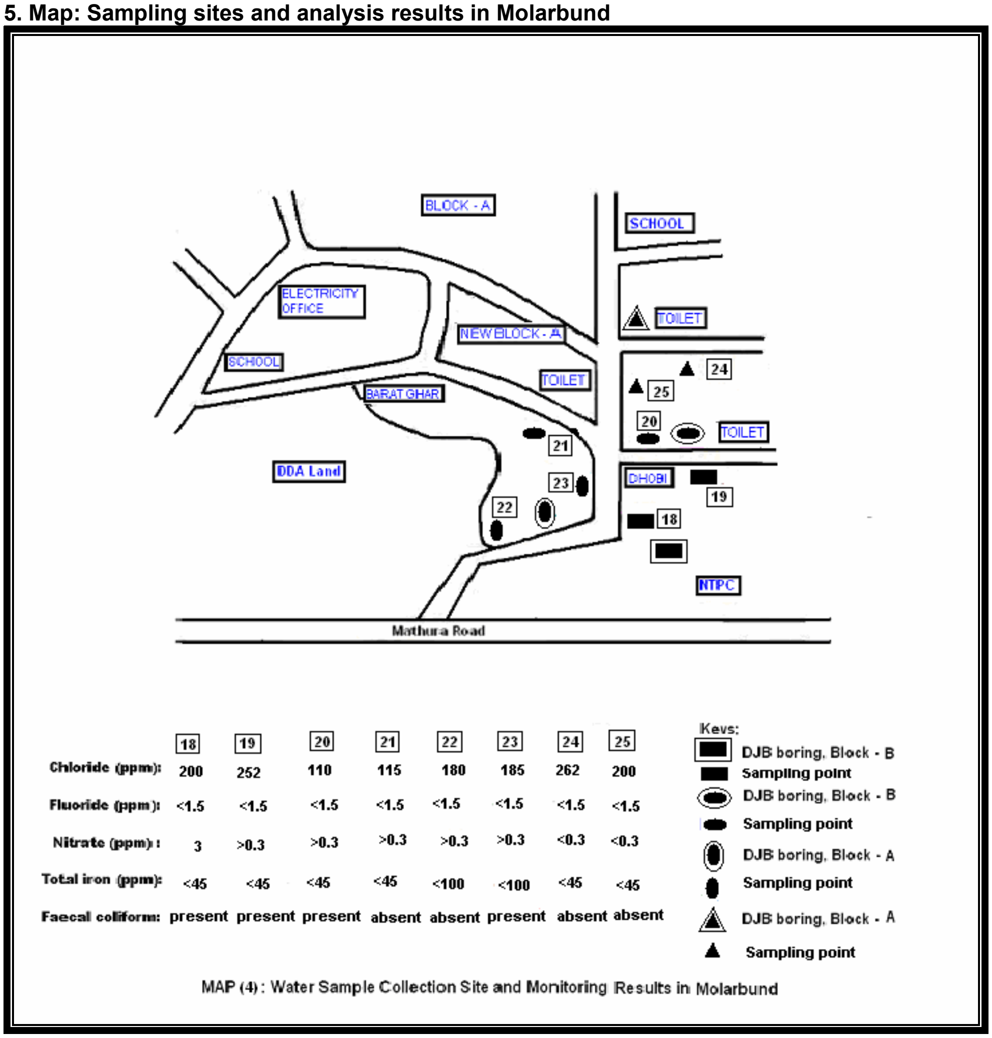
4. Map: Sampling sites and analysis results in Madanpur Khadar



MAP(3): Water sample Collection Site and Monitoring Results in Madanpur Khadar

In **Molarbund**, one distribution system shows faecal contamination at the first distribution point itself, but not at the 2nd point. The 3rd boring (DJB), which is located in Block-A, shows nitrate concentration above the desirable limit. The 1st point in Block-B (1st boring) shows very high level of iron that may be coming from the bore pipe itself.

5. Map: Sampling sites and analysis results in Molarbund

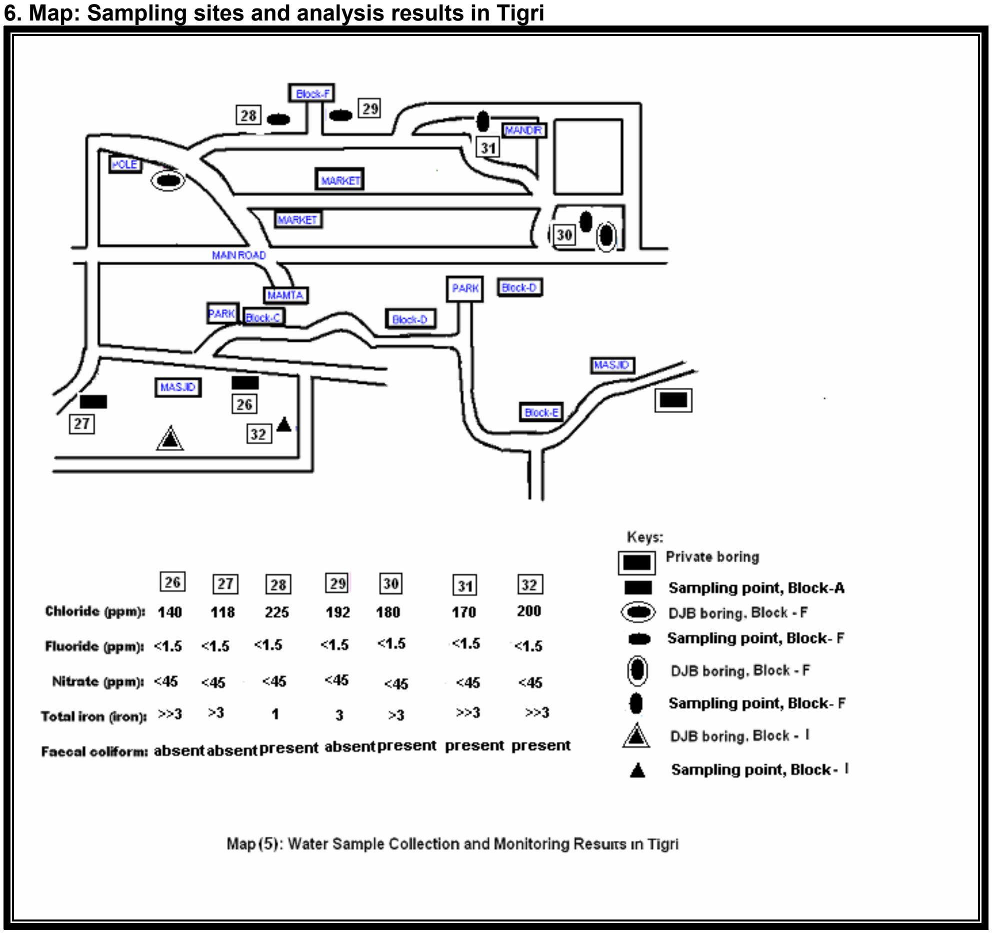


	18	19	20	21	22	23	24	25
Chloride (ppm):	200	252	110	115	180	185	262	200
Fluoride (ppm):	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Nitrate (ppm):	3	>0.3	>0.3	>0.3	>0.3	>0.3	<0.3	<0.3
Total iron (ppm):	<45	<45	<45	<45	<100	<100	<45	<45
Faecal coliform:	present	present	present	absent	absent	present	absent	absent

MAP (4): Water Sample Collection Site and Monitoring Results in Molarbund

In **Tigri**, all the samples from the private and DJB borings show nitrate concentration above the desirable limit and iron above the permissible limit. The private boring samples don't show faecal contamination whereas three samples (out of four) of DJB boring show faecal contamination.

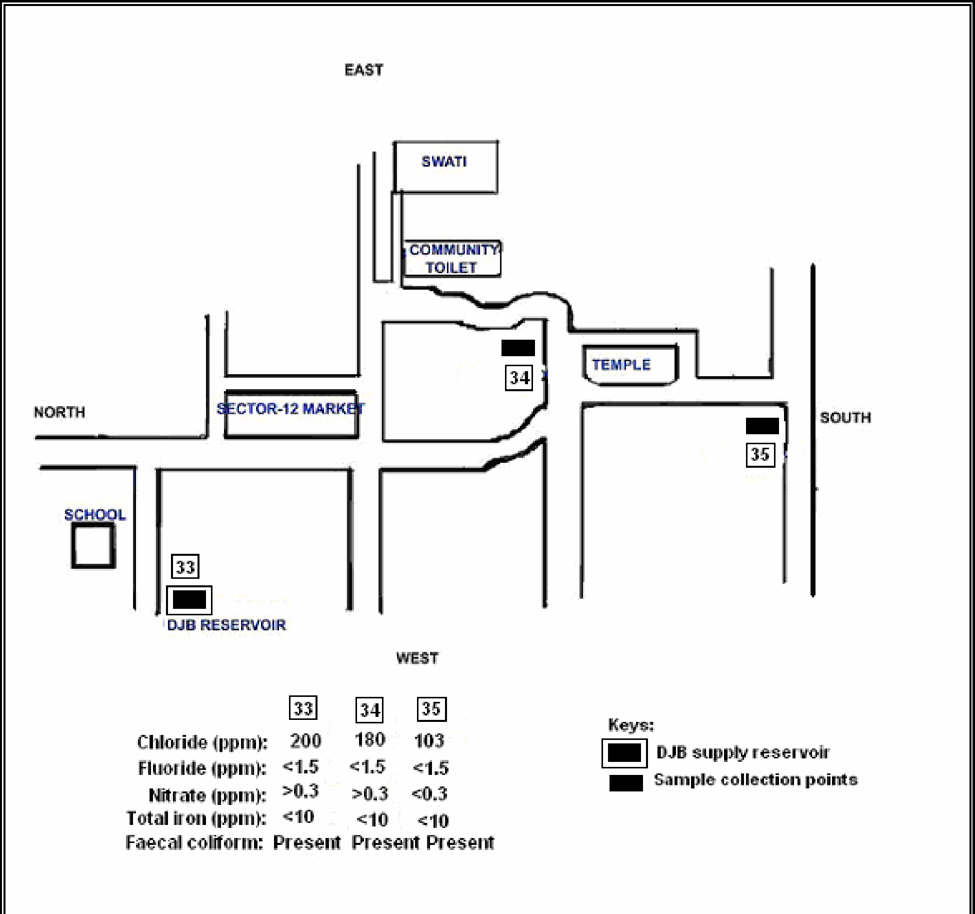
6. Map: Sampling sites and analysis results in Tigri



Map (5): Water Sample Collection and Monitoring Results in Tigri

In **Kanakdurga**, faecal contamination is observed through out the whole distribution system, including the storage reservoir in which the treated surface water [once again, you have to clarify what this “surface water” is, what is the source] is stored. Variation of total iron concentration at different points may be due to the old rusted distribution tap.

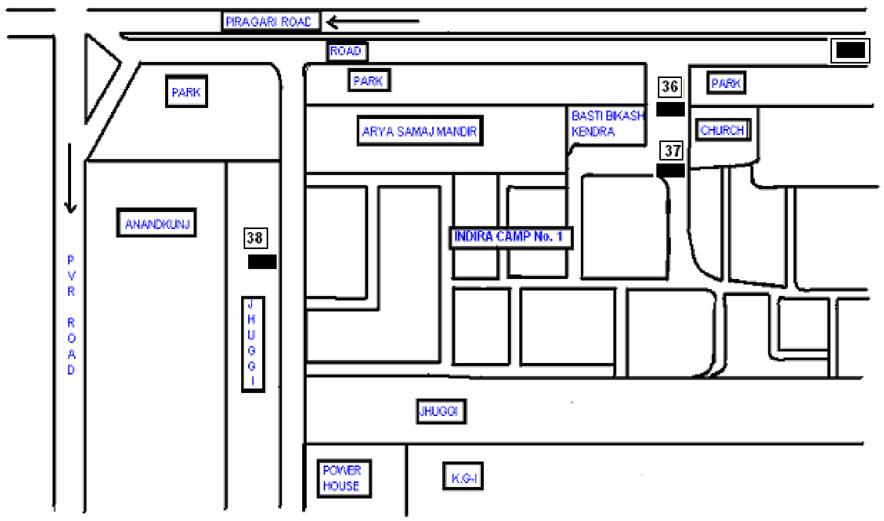
7. Map: Sampling sites and analysis results in Kanakdurga



MAP (6) : Water Sample Collection Sites and Monitoring Results of Monsoon Sampling in Kanakdurga

In **Indira Camp No.1** of Vikaspuri, two samples show high levels of iron and the presence of faecal coliform and only one sample of this camp is analysed as being potable.

8. Map: Sampling sites and analysis results in Indira Camp No.1



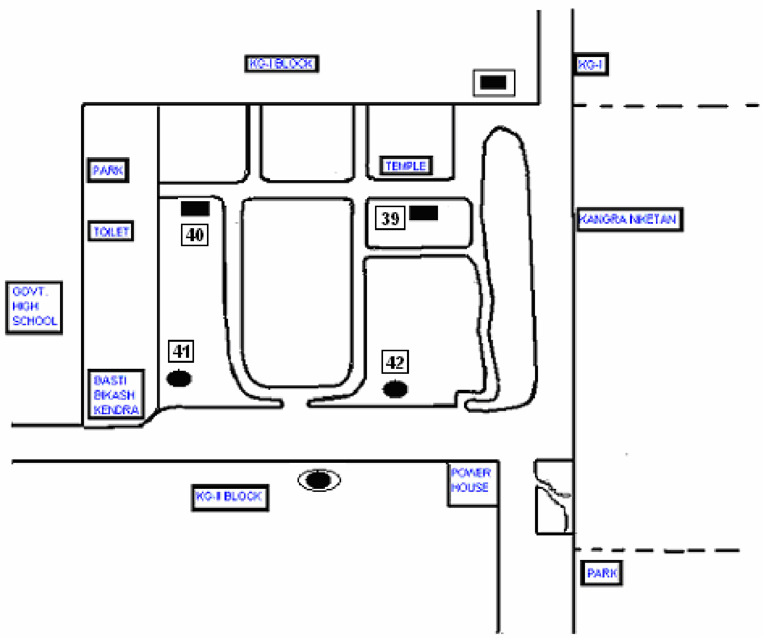
	36	37	38
Chloride (ppm):	150	120	105
Fluoride (ppm):	<1.5	<1.5	<1.5
Nitrate (ppm):	<45	<45	<45
Total iron (ppm):	3	0.1	3
Faecal coliform:	present	absent	present

Keys:
- DJB supply reservoir
- Distribution points

MAP(7) : Water Sample Collection Site and Monitoring Results in Indira Camp No. 1

In **Sant Ravidas Camp**, Vikaspuri two samples from KG-I line of DJB supply show faecal contamination, fluoride above the permissible limit, and iron above the desirable limit. The KG-II line does not show any contamination of chloride, fluoride, nitrate, and faecal coliform but one sample shows iron above the desirable limit and the other above the permissible limit.

9. Map: Sampling sites and analysis results in Sant Ravidas Camp



	39	40	41	42
Chloride (ppm):	96	105	160	110
Fluoride (ppm):	>1.5	>1.5	<1.5	<1.5
Nitrate (ppm):	<45	<45	<45	<45
Total iron (ppm):	1	1	1	3
Faecal coliform:	present	present	absent	absent

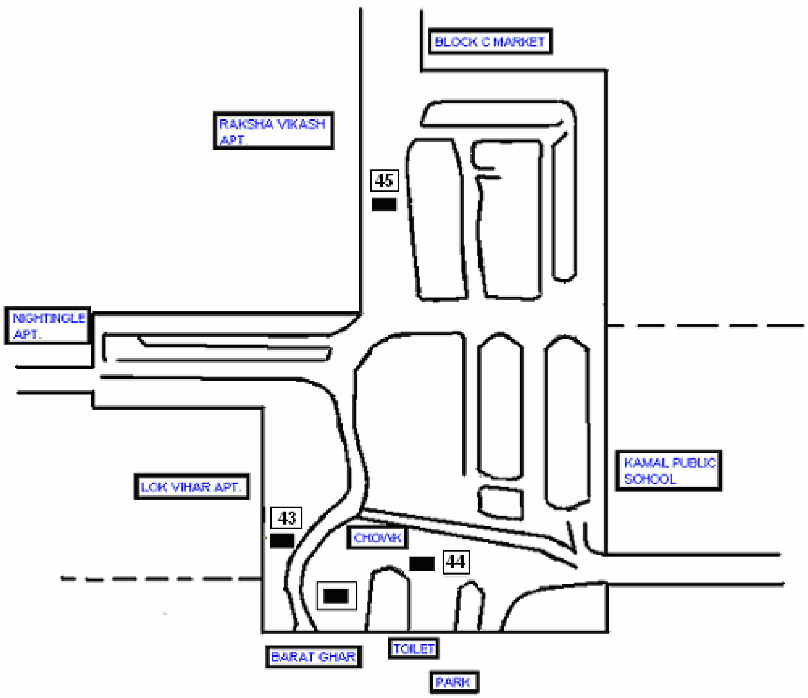
Keys

- DJB supply, KG-I line
- Sampling point, KG-I line
- DJB supply, KG-II line
- Sampling point, KG-II line
- Handpump

MAP (8): Water Sample Collection Site and Monitoring Results in Sant Ravidas Camp

In **Indira Camp No.5** samples were collected from three distribution points connected to a DJB borewell where high concentration of iron and faecal contamination was observed.

10. Map: Sampling sites and analysis results in Indira Camp No.5



	43	44	45
Chloride (ppm):	260	240	210
Fluoride (ppm):	<1.5	<1.5	<1.5
Nitrate (ppm):	<45	<45	<45
Total iron (ppm):	3	3	3
Faecal coliform:	present	present	present

Keys:

DJB boring

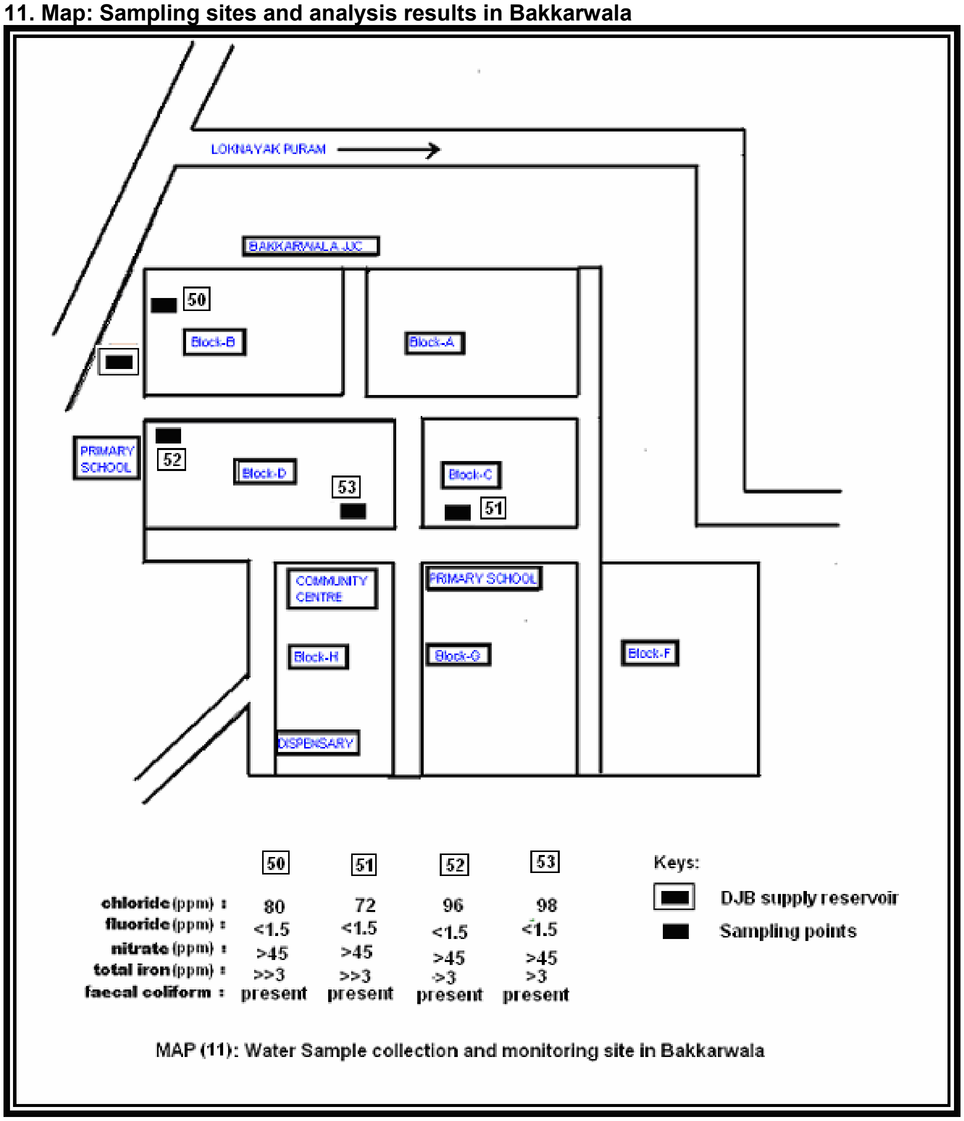
Sampling point

MAP (9): Water Samples Collection Site and Monitoring Results in Indira Camp No.5

In **Hastsal,** all the three samples of the single groundwater source show high levels of iron and presence of faecal bacteria in two samples but not at the source. (Map is not available).

In **Bakkarwala**, water collected from four distribution points of the DJB supply reservoir shows high levels of iron and the presence of faecal coliform at all the points. This reflects that the water is contaminated everywhere and not fit for consumption.

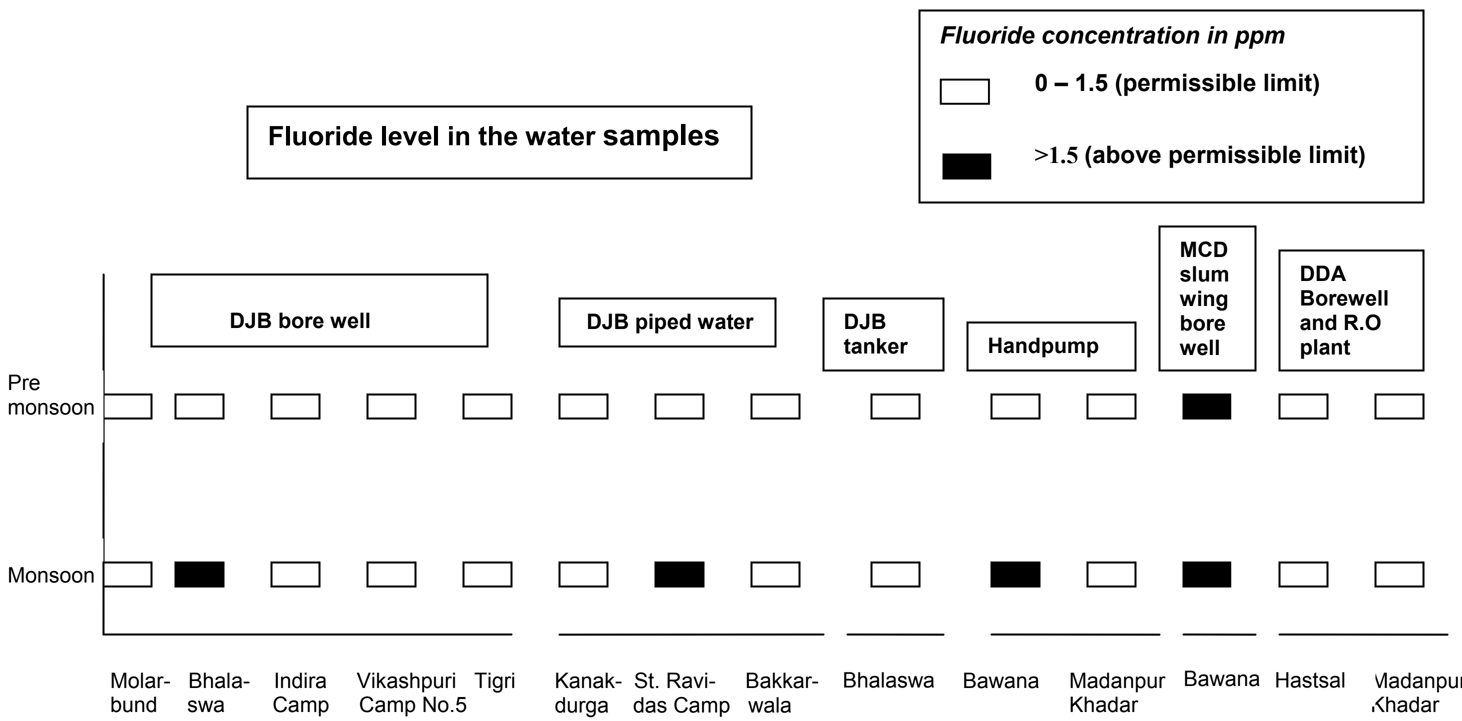
11. Map: Sampling sites and analysis results in Bakkarwala

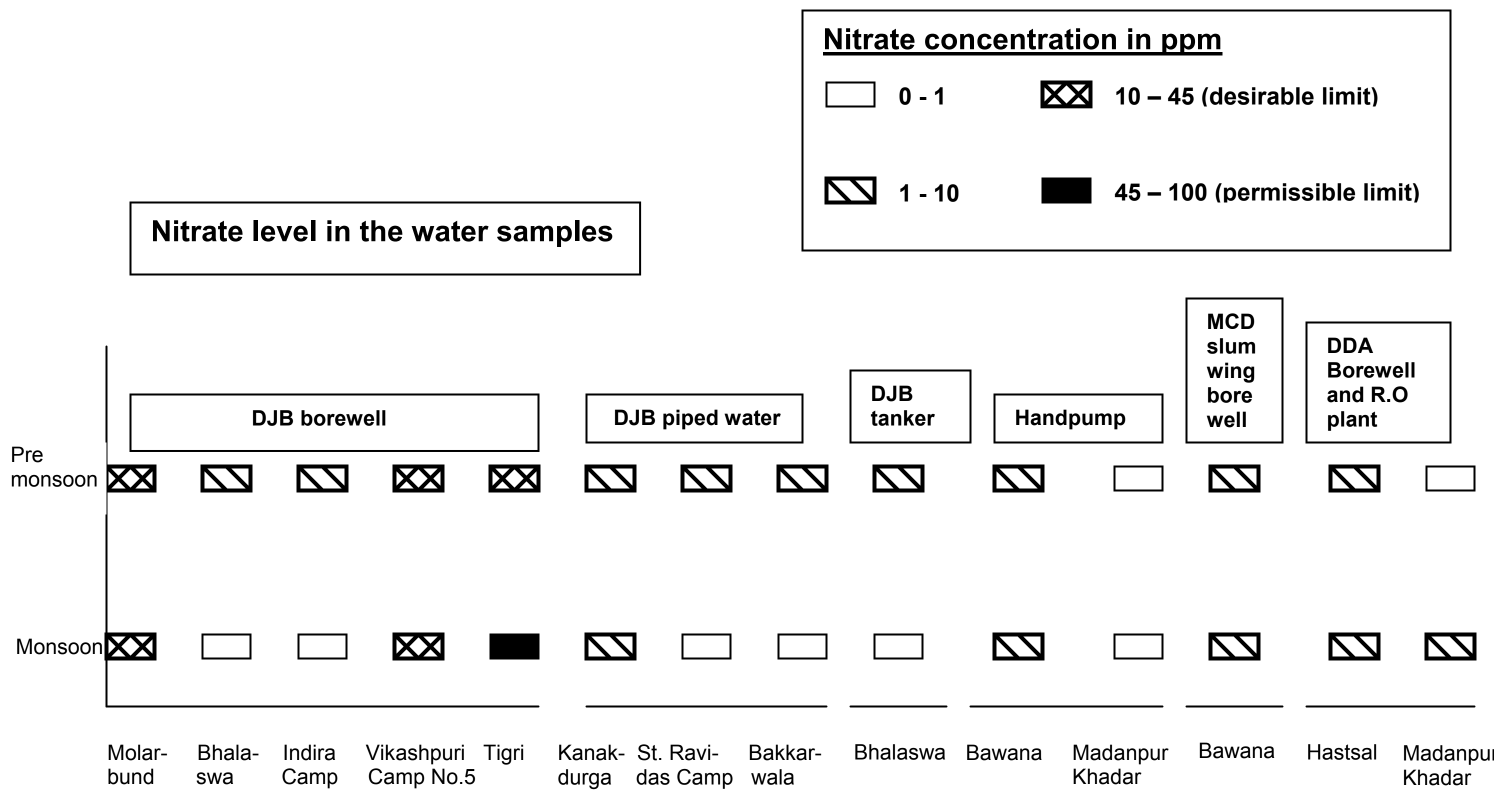


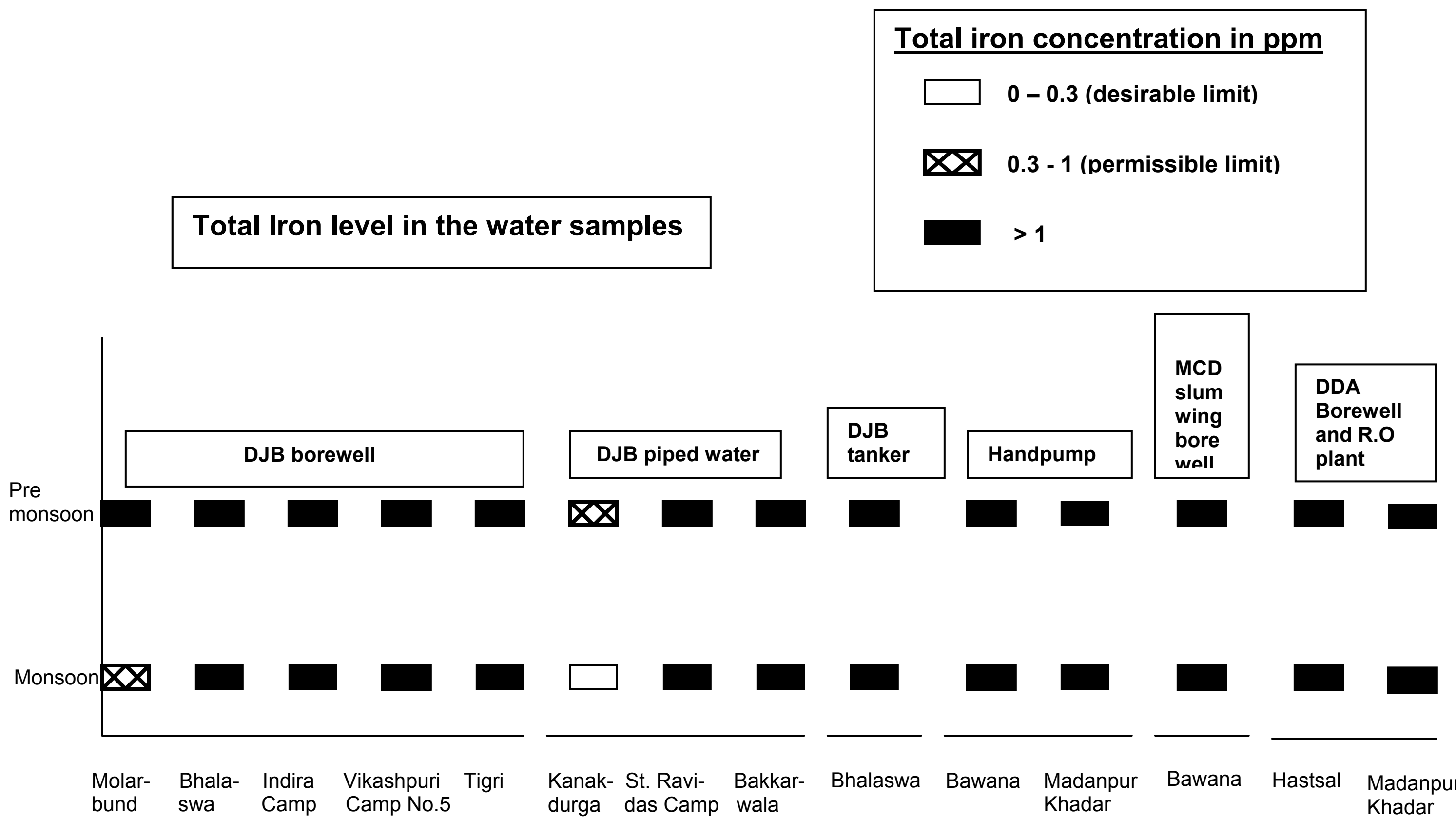
MAP (11): Water Sample collection and monitoring site in Bakkarwala

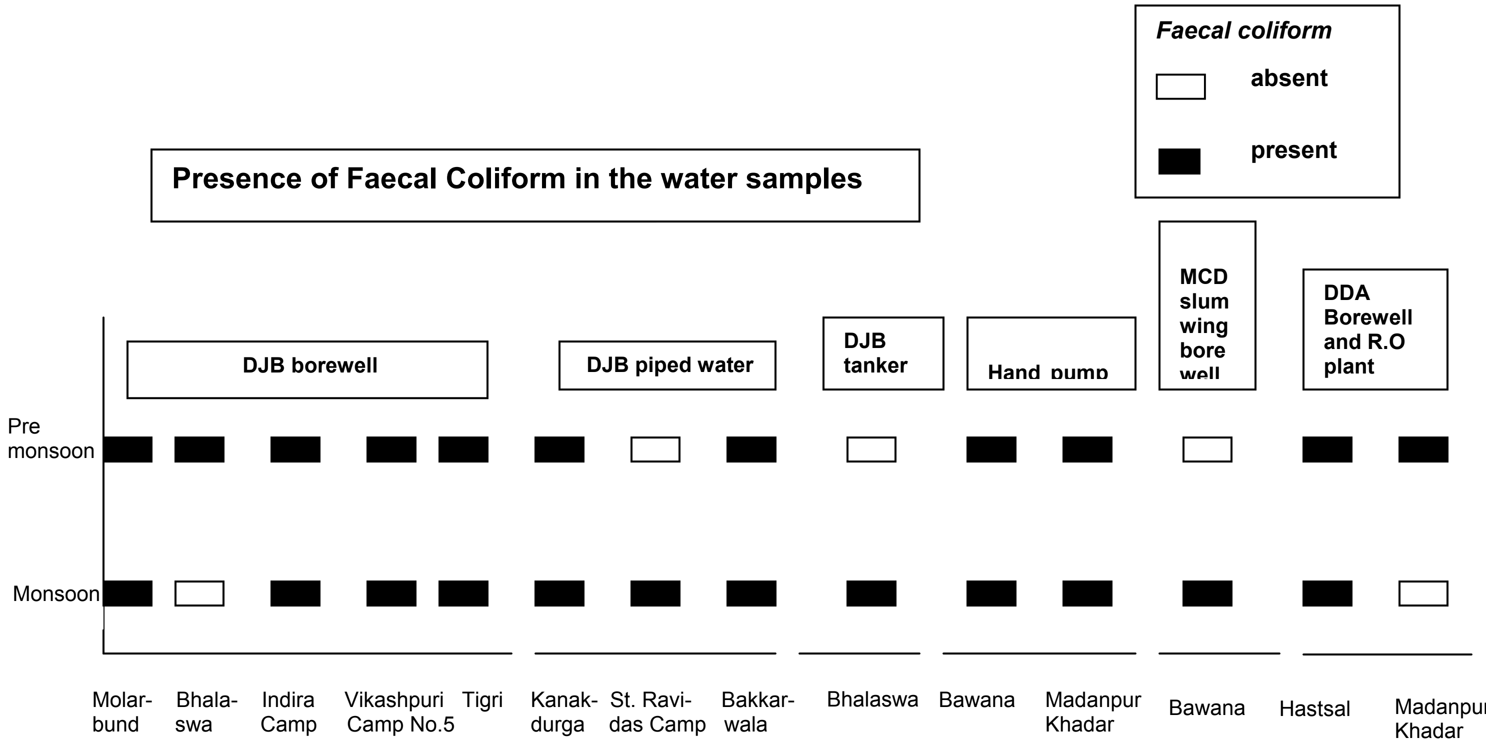
Annexure III

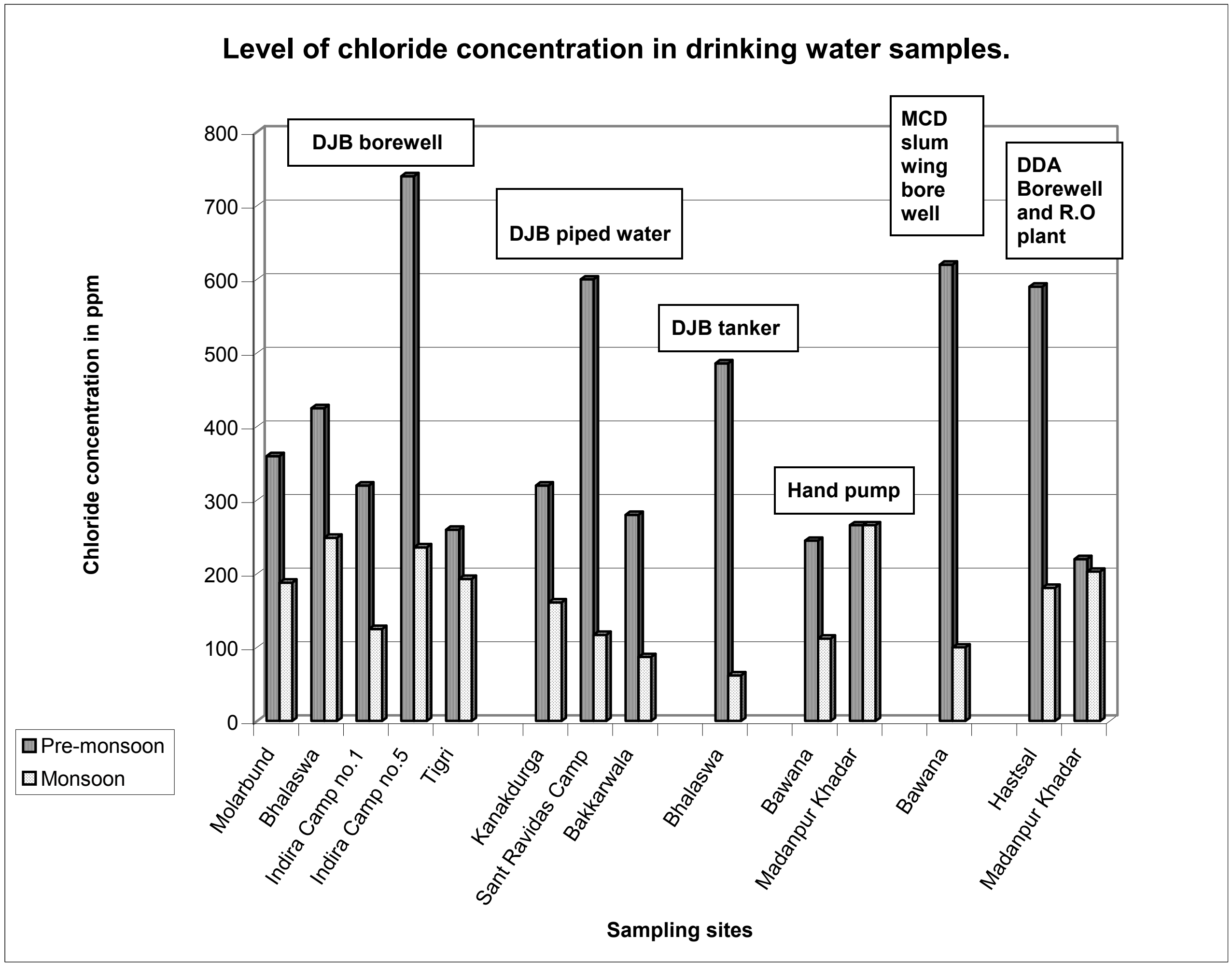
Diagrammatic representation of pre-monsoon and monsoon season samples




Nitrate concentration in ppm
0 - 1
10 – 45 (desirable limit)
1 - 10
45 – 100 (permissible limit)
Nitrate level in the water samples
DJB borewell
DJB piped water
DJB tanker
Handpump
MCD slum wing bore well
DDA Borewell and R.O plant
Pre monsoon
Monsoon
Molar-bund
Bhala-swa
Indira Camp
Vikashpuri Camp No.5
Tigri
Kanak-durga
St. Ravi-das Camp
Bakkar-wala
Bhalaswa
Bawana
Madanpur Khadar
Bawana
Hastsal
Madanpur Khadar


Total iron concentration in ppm
0 – 0.3 (desirable limit)
0.3 - 1 (permissible limit)
> 1
Total Iron level in the water samples
DJB borewell
DJB piped water
DJB tanker
Handpump
MCD slum wing bore well
DDA Borewell and R.O plant
Pre monsoon
Monsoon
Molar-bund
Bhala-swa
Indira Camp
Vikashpuri Camp No.5
Tigri
Kanak-durga
St. Ravi-das Camp
Bakkar-wala
Bhalaswa
Bawana
Madanpur Khadar
Bawana
Hastsal
Madanpur Khadar


Faecal coliform
absent
present
Presence of Faecal Coliform in the water samples
DJB borewell
DJB piped water
DJB tanker
Hand pump
MCD slum wing bore well
DDA Borewell and R.O plant
Pre monsoon
Monsoon
Molar-bund
Bhala-swa
Indira Camp
Vikashpuri Camp No.5
Tigri
Kanak-durga
St. Ravi-das Camp
Bakkar-wala
Bhalaswa
Bawana
Madanpur Khadar
Bawana
Hastsal
Madanpur Khadar


Level of chloride concentration in drinking water samples.
Chloride concentration in ppm
800
700
600
500
400
300
200
100
0
DJB borewell
DJB piped water
DJB tanker
Hand pump
MCD slum wing bore well
DDA Borewell and R.O plant
Pre-monsoon
Monsoon
Molarbund
Bhalaswa
Indira Camp no.1
Indira Camp no.5
Tigri
Kanakdurga
Sant Ravidas Camp
Bakkarwala
Bhalaswa
Bawana
Madanpur Khadar
Bawana
Hastsal
Madanpur Khadar
Sampling sites

Annexure IV

A.4.1 List: Addresses of government agencies concerned for water quality of the 11 areas covered under this study.

Water sources	Complains for water related problems	
	Location	Office Address
DJB	Bhalaswa	ZE (North-West)-IV, Burari, (O) 27677877
	Hastsal, Vikaspuri, Bakkarwala	ZE, West-III Twin Tank Paschim Vihar Ph-III (O) 25471004
		ZE, (South-West-I) D-Block, Janakpuri (O) 28525659
	Madanpur Khadar, Molarbund and Tigri	ZE, South West-I Mehrauli (O) 26644688
		ZE(South-III) Near A-Block, Greater Kailash-I, Opp Sadiq nagar (O) 29238543
		ZE(South)-IV ,Sarita Vihar(O)-29941458
DDA	Madanpur Khadar	Deputy Director, DDA, Khelgaon, New Delhi-110016
	Hastsal	Deputy Director, DDA, Dwarka Zone, Manglapuri, New Delhi
MCD slum wing	Slum and JJ Department, MCD, Punarvas Bhawan, ITO, New Delhi – 110002, Ph: 011-23378574.	

Bibliography

Blueprint For An Apartheid City (2005), Hazards Centre, New Delhi.

Cunningham, Willams P. and Barbara W. Saigo (2003). *Environmental Science: A Global Concern,* The McGraw Hill Companies, New York.

Dara, S. S. (2002). *Environmental Chemistry and Pollution Control*, S. Chand and Company Limited, New Delhi.

Dilli Kiski Hai (2003), Hazards Centre, New Delhi.

Duggal, K. N. (2000), *Elements of Environmental Engineering*, S. Chand and Company Limited, New Delhi.

Economic Survey of Delhi, 2001-2002.

Emergency Treatment of Drinking Water at Point of Use, WHO/SEARO Technical Notes for Emergencies.

Jerry, A. Nathanson (2006). *Basic Environmental Technology*, Prentice-Hall of India Private Limited, New Delhi.

Nag, A. (2006). Analytical Techniques in Agriculture, Biotechnology and Environmental Engineering, Prentice-Hall of India Private Limited, New Delhi.

Private Supply of Water in India, A report by Centre for Civil Society.

Santra, S.C (2001). *Environment Science*, New Central Book Agency Private Limited, Kolkata.

Sharma, B.K. (2001). *Environmental Chemistry*, Goel Publishing House, Meerut.

Tyagi, O.D. and M. Mehra (1996). *Environmental Chemistry*, Anmol Publications Private Limited, New Delhi.

Water Sanitation and Health, A Fact Sheet by Hazards Centre, New Delhi.

www.delhijalboard.nic.in

www.delhigovt.nic.in/dda.asp

www.epa.gov

www.who.int

www.bis.org.in

www.dph.state.ct.us

www.anangpur.org

For further details, information, and assistance:

Please contact
Hazards Centre
92 H, Pratap Market
Munirka
New Delhi 110067
26187806, 2671424, haz_cen@vsnl.net