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Hydro-chemical Survey of Groundwater of Delhi, India

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Abstract: The physicochemical parameters and trace metal contents of water samples from Delhi were assessed. A total of 20 water samples were collected from boring, tube well and hand pump and analyzed for the various physicochemical parameters like pH, conductivity, total dissolved solid, total alkalinity, Ca^{2+} and Mg^{2+} hardness, chloride ion, dissolved oxygen, biochemical oxygen demand, sulphate and heavy metal contents like Cu, Cr, Cd, Co, Zn and Ni. The results were compared with BIS standards for drinking water. The quality of water samples under study were within the maximum permissible limits. Therefore, the groundwater samples are fit for human consumption without prior treatment.

Keywords: Physicochemical parameters, Trace metals, BIS limits, Groundwater, Delhi.

Introduction

Groundwater is water that occupies the pores or crevices in sand, sandstone, limestone and other rocks¹. The crucial role which groundwater plays as a decentralized source of drinking water for millions of rural and urban families cannot be overstated. According to some estimates, it accounts for nearly 80 percent of the rural domestic water needs and 50 percent of the urban water needs in India².

In Delhi, drinking water supply is not from single source. Sixty eight percent of the population is getting supply from water of Yamuna River. Groundwater has also other sources like tube wells, hand pump and boring³. But the quantity of good quality fresh groundwater available for the use without depleting our stores or damaging the environment is much less. This means that it is very important to protect these resources from pollution as most of the times groundwater is directly used. Business owners, municipalities and the public should understand that contamination can enter the groundwater from many routes⁴.

The resulting groundwater contamination plumes may extend several hundred meters or even further away from the source of pollution. As groundwater move both vertically and horizontally in response to gravity and hydraulic pressure.

As the assessment of groundwater quality has not been given due importance, water borne diseases have become very common. About 80 percent of the diseases in the world are due to poor quality of drinking water⁵. The focus and purpose of the present monitoring exercise was to assess the degree of contamination level in groundwater of Delhi.

The study area

Location & climate

The study area spreads in an area of 1,483 sq Km (573 sq mile), of which 783 sq Km (302 sq mil) is designated rural and 700 sq Km (270 sq mil) as urban lying between latitude 28.38⁰ N and longitude 77.12⁰ E with an expected population of 17.5 million by the end of the 10th five year plan.

Climate of Delhi is semi-arid with high variation between summer (25 to 46 °C) and winter (22 to 5 °C) temperatures. Summers are long, from early April to October, with the monsoon season in between. The average rainfall is approximately 714 mm (28.1 inches).

Physiogeography

Two prominent features of the geography of Delhi are the Yamuna flood plain and the Delhi ridge. The low lying Yamuna flood plains provide fertile alluvial soil derived from the adjacent quartzite ridge, suitable for agriculture. However, these plains are prone to recurrent floods. This area is also called Khadar. Reaching up to a height of 318 m (1043 ft), the ridge forms the most dominating physiographic feature in this region. It originates from the Aravalli Range and consists of quartzite rocks in the south and encircles the west, northeast and northwest parts of the city. Leaving aside the Yamuna flood plain (khadar) and the ridge, the entire area of the national capital territory of Delhi is categorized as Bangar or the plain. A major proportion of the area of Delhi is plain and on this are located Delhi, New Delhi and Delhi cantonment along with a vast stretch of numerous villages. The land of the plain is mostly fertile. Most of the city, including New Delhi, lies west of the river. East of the river is the urban area of Shahdara. Delhi falls under seismic zone-IV, making it vulnerable to major earthquakes.

Soil classification & distribution

The soils of the Delhi area are mostly light with subordinate amount of medium texture soils. The light texture soils are represented by sandy, loamy, sand and sandy loam; whereas medium texture soils are represented by silty loam. The soils that occur in all the blocks are generally suitable for irrigating moderately salt resistant crops such as wheat, barley and mustard.

Methodology

Twenty samples were collected from tube wells, hand pumps and borings that draw water from groundwater. These were analyzed for major ion chemistry, employing the standard methods⁶ (APHA).

Hydrogen ion concentration (pH), total dissolved solid (TDS) and conductivity were measured, using pH, TDS and conductivity meters respectively.

Total alkalinity (TA) were estimated titrimetrically using HCl. Total hardness (TH) and calcium (Ca²⁺) were analyzed titrimetrically using standard EDTA. Magnesium (Mg²⁺) was

computed taking the difference between TH and Ca^{2+} values. Chloride (Cl^-) was estimated using standard AgNO_3 titration while sulphate (SO_4^{2-}) were analyzed with the help of spectrophotometer⁷.

Dissolved oxygen (DO) and biochemical oxygen demand (BOD) were analyzed titrimetrically using standard sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3$) solution. For copper, chromium, cadmium, cobalt, zinc and nickel determination in water samples an air acetylene flame was used and the analysis was carried out using Atomic Absorption Spectrophotometer (AAS), Perkin Elmer model 3100. All glassware used for the analyses were carefully cleaned with nitric acid followed by thorough rinsing with double distilled water before use. All reagents used were of analytical grade. Double distilled water was used throughout the study.

Results and Discussion

The monitoring started with collection and assessment of water sample from the site of collection by measuring the temperature of the sample ranging from 27-32°C with day temperature 26 °C (min) to 38 °C (max). All the readings are given in Table 1.

Table 1. The results of various physicochemical analyses of groundwater samples of Delhi.

S.No	Sampling Point	Type	pH	EC	TDS	Alkalinity	Ca^{2+}	Mg^{2+}	Cl^-	DO	BOD	SO_4^{2-}
1	Sultanpuri	B	7.4	1.06	310	440	126	66	93.18	7.14	1.86	17
2	Mandi	B	7.6	2.27	642	480	112	26	350.56	9.69	0.44	49
3	Chattarpur	B	7.4	0.722	236	430	92	38	31.06	7.85	1.46	14
4	Bhati Gao	B	7.3	0.812	237	350	108	44	39.93	8.97	1.66	14.5
5	Fatehpur Beri	HP	7.4	0.991	294	480	178	34	62.125	8.46	1.86	10.5
6	Alipur	HP	7.4	3.42	970	360	200	220	536.93	8.87	1.04	66.5
7	Singhola	HP	7.6	3.24	879	460	178	248	448.18	6.12	2.99	62.5
8	Lampur	TW	7.5	4.4	1250	450	176	188	674.5	7.44	2.58	66
9	Singhu border	TW	7.3	2.4	650	350	96	214	301.75	8.26	2.17	58.5
10	Bhakhtawar pur	TW	7.4	4.42	1250	310	234	216	931.87	8.36	1.76	68
11	Burari	HP	7.3	2.45	685	400	150	146	381.62	7.95	2.48	67.5
12	Matiala	B	7.5	2.68	737	330	140	100	612.37	9.08	2.07	43
13	Nawada	B	7.7	2.33	642	590	48	178	257.37	6.22	3.9	62.5
14	Yamuna Vihar	HP	7.8	0.954	254	350	52	90	31.06	7.32	0.816	39.5
15	Mangolpuri Ind	HP	7.8	2.91	757	650	74	68	417.12	3.16	3.02	71
16	Karala	B	7.8	2.6	687	520	74	140	257.37	5.5	1.22	72.5
17	Kanjhawala	HP	7.7	0.711	190	260	96	22	26.26	2.85	0.52	46
18	Khod Punjab	HP	8.5	1.35	362	470	12	10	53.25	4.08	3.59	65
19	Qutab Garh	HP	8.2	5.16	1430	860	10	12	860.87	4.38	2.95	73.5
20	Bawana	HP	7.6	3.13	831	750	54	70	394.93	3.16	0.96	69.5

B = Boring, TW = Tube Well, HP = Hand Pump Except pH & EC (mS/cm) all units are in ppm

The groundwater sample shows pH values from 7.26 to 8.46 lying within the recommended values (6.5 to 8.5) for domestic use. The conductivity was found to be varied from 0.711 - 5.16 (mS/cm) as shown in Figure 1.

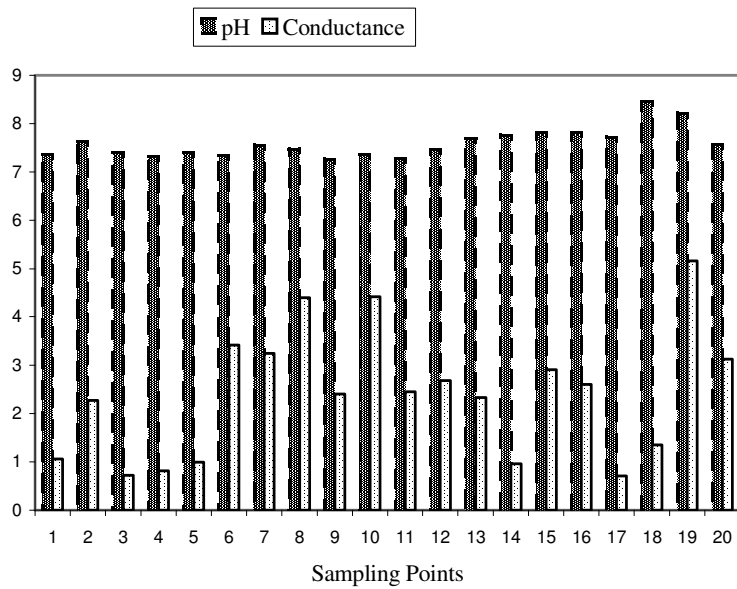


Figure 1. pH and conductance of various groundwater samples collected from Delhi.

Total hardness (Ca^{2+} plus Mg^{2+}) of the samples falls in the different categories. Majority of which (11%) belong to very hard category having TH more than 180 ppm. 7% of the samples fall under hard water 120-180 ppm and rest 10% falling to soft water category (0-60 ppm) not even a single sample has hardness in medium range 60-120 ppm. If we see Ca^{2+} and Mg^{2+} only two samples are within permissible limit of 75 and 30 ppm respectively.

Total alkalinity values changed from 260-860 ppm (Figure 2). All the water samples were found above maximum desirable limit of 200 ppm, but only 15% shows values above permissible limit *i.e* 600 ppm and the rest comprising 85% are within permissible limits.

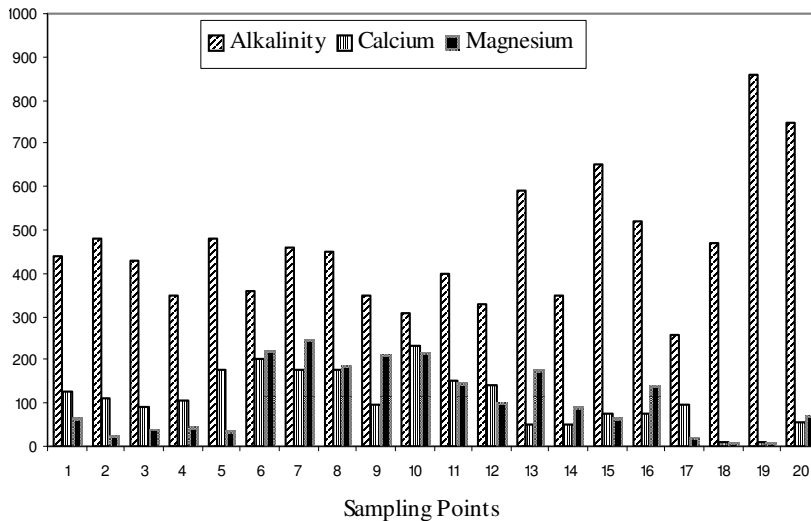


Figure 2. Alkalinity and Hardness of various groundwater samples collected from Delhi.

Figure 3 shows the too high contents of dissolved oxygen which is an indication of organic pollution and the values ranged from 2.85 at kanjhawala to 9.69 at Mandi with the variation of BOD values of 0.44 at Mandi and 3.90 of Nawada water sample.

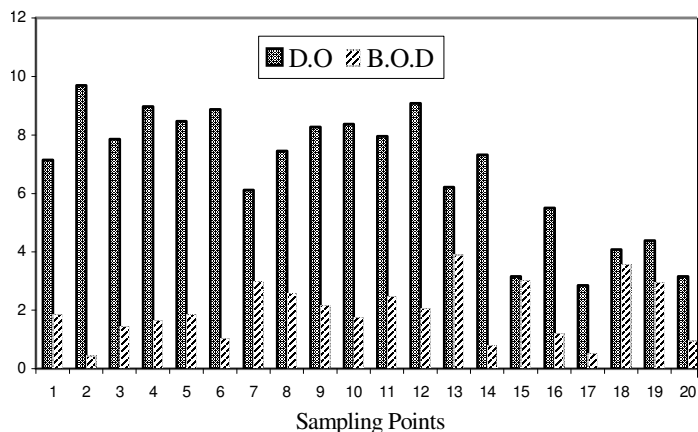


Figure 3. D.O and B.O.D values of various groundwater samples collected from Delhi.

According to the TDS classification, the majority of the samples (85%) are fresh water with TDS less than 1000 ppm. The remaining samples (15%) are of brakish type with TDS greater than 1000 ppm. But only 25% are found within the BIS standard drinking water desirable limit of 300 ppm. A relationship between TDS and anion concentration (Cl) was observed in the performed experiment which is shown in Figure 4. In most of the cases when Cl⁻ ion concentration is more the TDS is also more. Cl⁻ ion was found high in Qutab garh sample as 860.87 ppm TDS was also reported high as 1430 ppm. Bhakhtawarpur water sample have high values of 931 ppm Cl⁻ ion and 1250 ppm TDS. Some sites like Yamuna Vihar and Chattarpur show Cl⁻ ion conc. as 31.06 ppm, while TDS is 254 and 236 ppm respectively. At Kanjhawala Cl⁻ and TDS were reported as 26.26 ppm and 190 ppm respectively. The values of Cl⁻ ion are under desirable limits of 250 ppm.

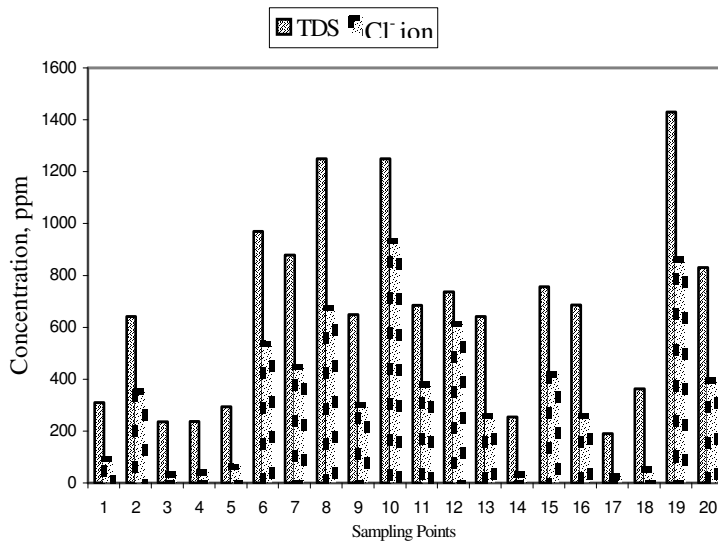


Figure 4. TDS and Cl⁻ ion values of various groundwater samples collected from Delhi.

The highest sulphate value was recorded at Qutab Garh (73.5 ppm) and the lowest at Fatehpur Beri (10.5 ppm). The desirable limits of sulphate are 250 ppm (Figure 5).

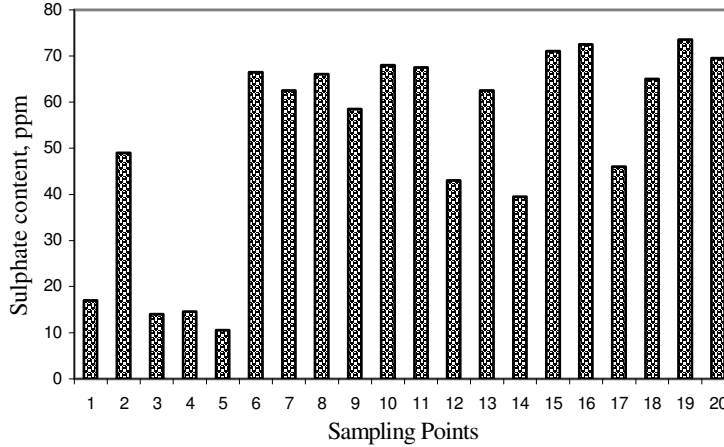


Figure 5. Sulphate content of various groundwater samples collected from Delhi.

The concentration of heavy metals in water samples are given in Table 2. Cu concentration ranged from 0.04 to 0.01 ppm. Out of the trace metals, Zn is always in abundance in water with values ranging from 2.56 – 0.04 ppm.

Table 2. Concentration of heavy metals in groundwater samples of Delhi.

S.No	Sampling Point	Cu ppm	Cr ppm	Cd ppm	Co ppm	Zn ppm	Ni ppm
1	Sultanpuri	BDL	BDL	BDL	0.05	0.05	0.04
2	Mandi	0.01	BDL	BDL	0.08	0.12	0.07
3	Chattarpur	BDL	BDL	0.03	0.07	0.05	0.06
4	Bhati Gao	BDL	BDL	BDL	0.07	0.54	0.07
5	Fatehpur Beri	0.03	BDL	BDL	0.08	2.56	0.14
6	Alipur	BDL	BDL	BDL	0.09	0.18	0.11
7	Singhola	BDL	BDL	BDL	0.12	1.44	0.08
8	Lampur	BDL	BDL	BDL	0.16	0.12	0.1
9	Singhu border	BDL	BDL	BDL	0.12	0.05	0.1
10	Bhakhtawar pur	BDL	BDL	BDL	0.2	0.07	0.12
11	Burari	BDL	BDL	BDL	0.14	0.05	0.09
12	Matiala	0.01	BDL	BDL	BDL	0.06	0.12
13	Nawada	BDL	BDL	BDL	BDL	0.06	0.09
14	Yamuna Vihar	BDL	BDL	BDL	0.03	0.2	0.09
15	Mangolpuri Ind	BDL	BDL	BDL	0.03	0.29	0.08
16	Karala	BDL	BDL	0.01	0.01	1.18	0.1
17	Kanjhawala	0.04	BDL	BDL	BDL	0.08	0.09
18	Khod Punjab	0.01	BDL	BDL	BDL	0.07	0.11
19	Qutab Garh	BDL	BDL	BDL	0.04	0.27	0.15
20	Bawana	BDL	0.01	BDL	0.03	0.04	0.16

BDL= Below Detection Limit

The highest concentration of Zn was recorded at Fateh Pur Beri (2.56 ppm) but the value falls within permissible limit of 15 ppm according to BIS. Co was under detection limits and the values varied from 0.2 to 0.01 ppm and in some cases as zero. Cr was not detected in almost all the samples except in one sample of Bawana as 0.01 ppm which is well within BIS Maximum Desirable Limit of 0.05 ppm. Cd was detected only in two samples as 0.03 and 0.01 ppm at chattarpur and Karala respectively. The concentrations in all the remaining samples were below detection limit of the instrument. Ni was recorded with the maximum value of 0.16 ppm and the minimum value of 0.04 ppm (Figure 6).

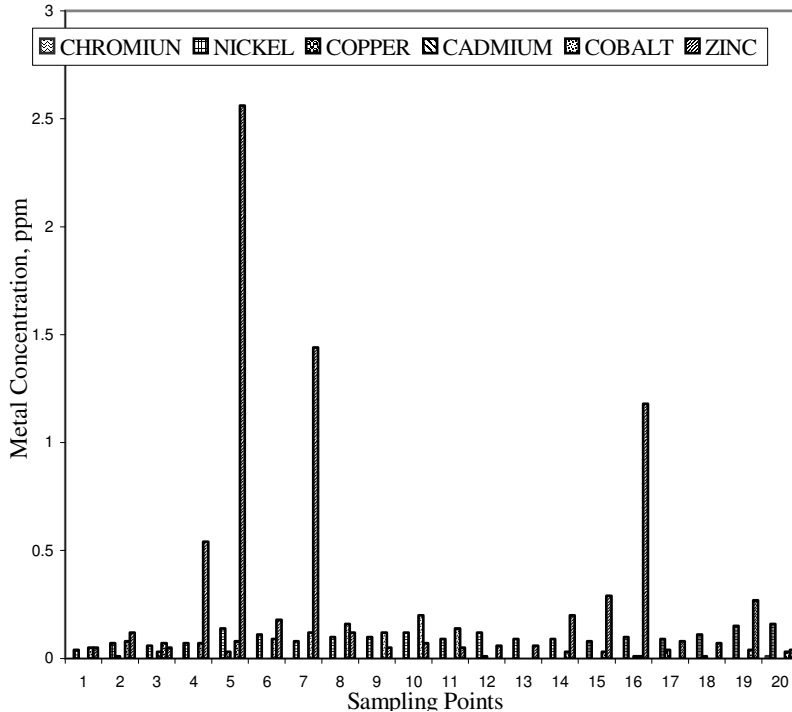


Figure 6. Heavy Metal content (ppm) in various groundwater samples of Delhi.

Conclusion

The present investigation has led us to conclude that the quality of water samples subjected to study was acceptable for majority of physicochemical parameters as it falls within the maximum permissible limits of drinking water of BIS. Among heavy metals Zn, Ni, & Co were found more than Cu, Cr & Cd. From the findings it may be concluded that the groundwater samples are fit for human consumption without prior treatment.

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