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Assessment of Groundwater Quality Parameters of Zone 6 of Dhaka City

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Abstract–Most of the cities of Bangladesh are primarily based on groundwater source for water supply. The water can conveniently be collected by deep tube wells or by shallow tube wells and supplied to adjacent population without any major treatment. Generally better quality of water exists in the Dhaka city, the capital of Bangladesh. But water contamination in distribution lines may be attributed to leaks in old pipes and the nature of water supply. Drinking water criteria and standards have been developed by many countries in the world as well as by Bangladesh. The objective of this study was to analyze samples of deep aquifer ground water of zone 6 of Dhaka city and to ascertain the suitability for drinking and domestic purposes, comparing the obtained values with the standard ones. The analysis was done for total nine parameters - pH, color, turbidity, total solids or TS, total dissolved solids or TDS, total suspended solids or TSS, hardness, chloride and iron.

Keywords: Groundwater, Quality Parameters, Dhaka city.

Introduction

Parameters affecting quality of ground water are of great importance. As dependency on ground water continues to expand throughout the world, the necessity of ensuring ground water quality has become increasingly recognized. In Bangladesh about ninety percent of municipal water works are using ground water as a source of drinking water. The reason is this water requires no treatment for bacterial contamination and can be supplied directly. Ground water was treated as the best source of safe drinking water, before arsenic contamination was reported. However, 54 per cent of hand pump tube wells were found to have faecal contamination, due to poor wellhead design, faulty construction and management, but the aquifers themselves were not polluted [1].

Ground water contains minerals like iron, manganese and arsenic etc. of which iron is most commonly present in ground water of this country [2]. Particularly in the central parts of the country, iron concentration is much higher than the WHO and national recommended limits, but there are no known human health implications. Ground water abstracted from shallow aquifers by hand tube wells has received acceptance in rural areas for drinking purposes, but due to its high iron content, hardness, etc. people do not want to use hand tube well water for

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other domestic purposes like cooking, bathing and washing. The high iron in ground water makes the cooked food blackish in color and produces stains on utensils. The hard water requires more soap for washing [3]. Though the concentrations of major constituents of groundwater usually remain within permissible limits, some parameters exceed desirable limits due to hydrogeological conditions and even man made pollutions [4] - [5].

Groundwater quality is of great importance for various purposes. For this reason several research works have been done on various quality parameters. Assessment of groundwater samples from various methods usually indicates that groundwater is chemically suitable for drinking and agricultural uses [6]. It is very important to monitor whether all the parameters are within permissible limit or not, as just one parameter is enough to make groundwater unfit for drink [7].

The theme of the whole study was set based on the following objectives:

I. To analyze some samples of deep aquifer ground water of zone 6 of Dhaka city.

II. Comparing the values of the tested parameters with Bangladesh standard as per Table 1.

III. To ascertain the suitability of deep aquifer ground water of zone 6 of Dhaka city for drinking and domestic purposes.

The water quality standards for the tested parameters according to WHO and Bangladesh standards are detailed in the following table:

Table 1. Drinking Water Quality Standards [3]

Constituents/Characteristics	**WHO Guideline Values, 2004 (Health-Based Guidelines)**	**Bangladesh Standards**
pH		6.5-8.5
Color(Hazen Unit)	15	15
Turbidity(NTU)	5	10
TDS(mg/l)	1000*	1000
Suspended Solids(mg/l)		10
Hardness(mg/l $CaCO_3$)		200-500
Chloride(mg/l)	250*	150-600
Iron(mg/l)	0.3*	0.3-1.0

* Value designated only for aesthetical purposes. No health-based guideline value is proposed.

Methodology

A. Study Area Profile

The area under Dhaka Water Supply & Sewerage Authority (DWASA) is divided into several MODS Zones. To analyze the water quality parameters of MODS zone 6 of Dhaka city, samples were taken from the pump stations of DWASA of zone 6. There are total 86 pump stations in this zone, and samples were collected randomly from 22 pump stations. Water supply distribution map of Zone 6 found from DWASA is shown in Fig. 1.

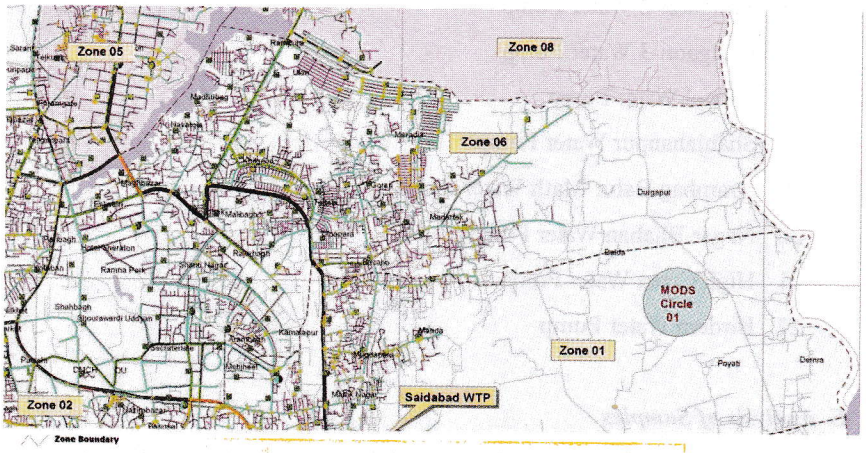

Fig.1. Water supply distribution map of Study Area (source: DWASA, 2011)

B. Collection Points and Designation

To assess the chemical criteria of groundwater of the selected area, water from total 22 pump stations were collected. Each sample were analyzed for nine parameters and presented in a tabular form. To make data handling easier, the collection points were designated with 1-22. The pump location and respective designations are listed below:

1 PG Hospital "C" Water Pump

2 Circuit House "C" Water Pump

3 Bijoynagar "C" Water Pump

4 Shegunbagicha "A" Water Pump

5 New Eskaton "A" (Old Passport Office) Water Pump

6 Dhaka Medical Water Pump

7 Rajarbag Old-1 "A" Water Pump

8 Fakirapul "A" Water Pump
9 Mogbazar Wireless "C" Water Pump
10 AGB Colony (SOC) Water Pump
11 Mogbazar Dilu Road "C" Water Pump
12 Kakrail Water Pump
13 Siddheswari Girls' School Water Pump
14 Viqarunnisa Water Pump
15 Khilgaon-2 Water Pump
16 Khilgaon-3 Water Pump
17 Polwel Water Pump
18 Shahjahanpur Water Pump
19 Arambag Balur Math Water Pump
20 Nagar Bhaban Water Pump
21 High Court Water Pump
22 Birdem Water Pump

C. Analysis of Samples

Analysis of the collected samples was done at the Environmental Engineering Laboratory, Bangladesh University of Engineering and Technology (BUET), Dhaka. The analysis was done for total 9 parameters - pH, color, turbidity, total solids or TS, total dissolved solids or TDS, total suspended solids or TSS, hardness, chloride, iron. For the first three pumps we took two samples for analysis. But the variation was so trivial that we could easily ignore them, and further decided to take one sample from one point to analyze.

The pH of all tested samples was determined following the electrochemical method, where a pH meter was used to take the reading directly. Even if the water is not harmful due to the presence of color, people for aesthetic reasons do not prefer it. The color test was done using Spectrophotometer (HACH, DR 4000U). This test measures (inversely) an optical property of water sample which result from the absorption of light (having specific wave length) by the soluble color substances present in water. Turbidity of the samples was measured by DR LANGE Turbid meter.

Total Solids (TS), Total Dissolved Solids (TDS) and Total Suspended Solids (TSS): Total Solids (TS) refer to the matter that remains as residue upon evaporation and drying at 103 to 105 °C. Total solids (TS) include total suspended solids (TSS) - the portion of total solids retained by a filter, and total dissolved solids (TDS) - the portion that passes through the filter. The TS, TDS

and TSS were measured using the following equations:

Total solids, TS (mg/l) = mg of solids in the beaker x 1000 / (volume of sample)

Total Dissolved Solids, TDS (mg/l) = mg of solids in the beaker x 1000 / (volume of sample)

Total Suspended Solids, TSS (mg/l) = TS (mg/l) - TDS (mg/l).

Hardness is usually expressed in terms of $CaCO_3$. In laboratory, total hardness was determined by the EDTA Titrimetric Method. The EDTA Titrimetric Method involves the use of solutions of ethylenediaminetetraacetic acid (EDTA) or its sodium salt as the titrating agent. The Eriochrome Black T dye serves as an excellent indicator to show when all the hardness ions have been complexed. A buffer solution was used to attain a pH close to 10.0.

The chloride concentration of the samples was determined by the Mohr Method. In Mohr method the chloride of the sample is determined by titration with a standard silver nitrate solution in the presence potassium chromate indicator. The "Standard Method" recommends a 0.0141 N silver nitrate solution which corresponds to an N/71 solution or a solution in which each milliliter is equivalent to 0.50 mg of chloride ion.

Iron creates problems in public water supplies. The problems are most critical for ground water. Iron interferes with laundering operations, imparts objectionable stains to plumbing fixtures and causes difficulties in distribution systems by supporting growths of iron bacteria. Iron also imparts a taste to water, which is detectable at very low concentrations.

Iron may be present in two forms, namely the reduced form (ferrous, $Fe2^+$) and the fully oxidized form (ferric, $Fe3^+$). Ferric iron is seldom found in true solution in natural waters, unless they are highly acidic, because of the formation of insoluble ferric hydroxides. Ferrous iron is more likely to be found in true solution, although it is easily oxidized to the ferric state and precipitated in alkaline waters as ferric hydroxide. Ferric iron was determined by producing a red-colored iron compound, ferric thiocyanite, by the addition of potassium thiocyanite.

$$Fe3^+ + 3KCNS = Fe(CNS)_3 + 3K^+$$

The quantity of ferric iron was determined by comparison with the red color produced by standard iron solutions.

Results

Samples were collected from 22 pump stations of MODS Zone 6 of Dhaka city. Results are shown in Table 2. The water quality parameters are listed under the name column Parameter. The range of different parameters for 22 samples is shown in Fig. 2 to Fig. 10.

Table 2. Test Results of Samples

Parameters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
pH	7.11	6.66	6.82	6.19	5.96	6.52	5.79	6.78	6.49	5.88	7.03	6.98	6.36	6.15	6.33	7.93	6.02	6.55	5.98	6.03	6.31	6.10
Color(Pt-Co)	50	11	4	30	5	12	7	14	32	51	5	36	13	26	14	17	21	11	25	18	27	19
Turbidity(NTU)	7.72	2.88	4.22	0.40	3.75	2.79	4.31	3.89	2.83	6.66	2.91	7.84	3.02	6.91	5.88	3.24	7.32	2.94	0.98	1.87	3.51	3.76
TS(mg/l)	5.79	5.64	5.41	5.46	5.64	9.08	5.91	8.46	5.91	5.67	7.98	5.09	6.31	5.49	9.06	5.61	5.27	6.39	5.91	6.36	5.11	5.42
TDS(mg/l)	5.38	5.53	5.38	5.45	5.61	9.00	5.75	8.32	5.75	5.56	7.87	5.00	6.05	5.31	9.03	5.34	5.06	6.12	5.88	6.32	5.08	5.10
TSS(mg/l)	0.41	0.11	0.03	0.01	0.03	0.08	0.16	0.14	0.16	0.11	0.11	0.09	0.26	0.18	0.03	0.27	0.21	0.28	0.03	0.03	0.03	0.32
Hardness (mg/l $CaCO_3$)	112	104	124	34	118	226	98	104	44	92	108	134	118	106	120	54	88	116	48	86	116	64
Chloride(mg/l)	8	10.01	16.02	66.07	78	50.055	17.28	15.33	67.25	18.39	12.25	67.91	19.22	12.35	44.09	65.02	18.29	49.34	21.26	12.39	11.79	46.79
Iron(mg/l)	0.70	0.30	1.00	0.02	0.02	0.02	0.02	0.02	1.00	0.60	0.02	0.02	0.30	0.02	0.02	0.02	0.30	0.02	0.02	0.02	0.02	0.02

N.B.: Numbers 1-22 designate pumps as indicated in the previous section.

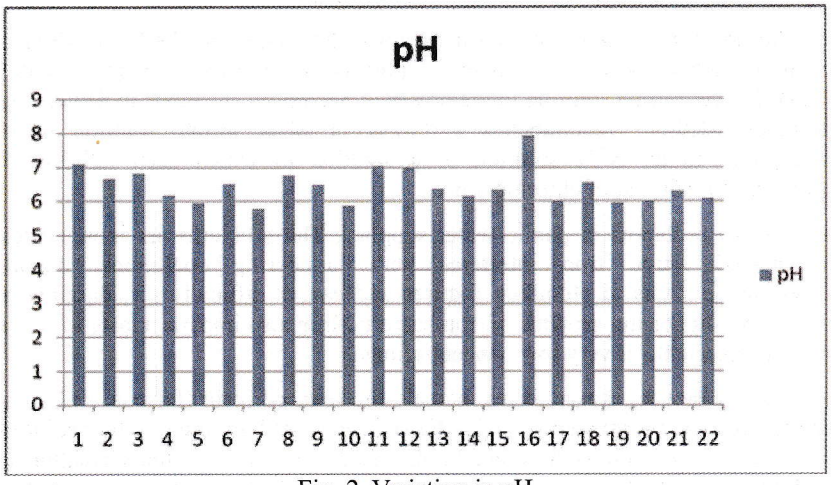

Fig. 2. Variation in pH

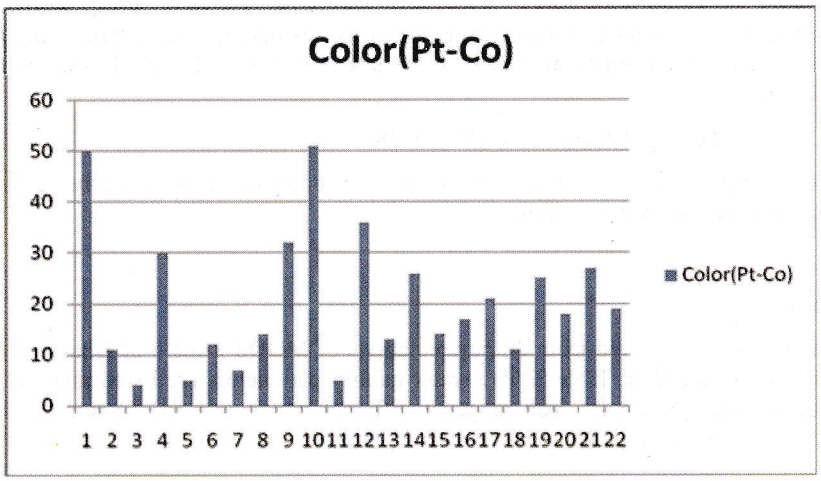

Fig. 3. Variation in Color

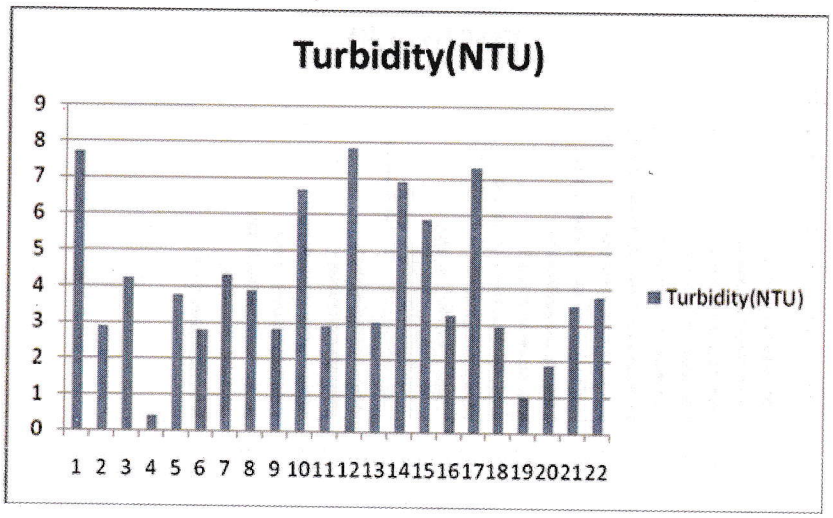

Fig. 4. Variation in Turbidity

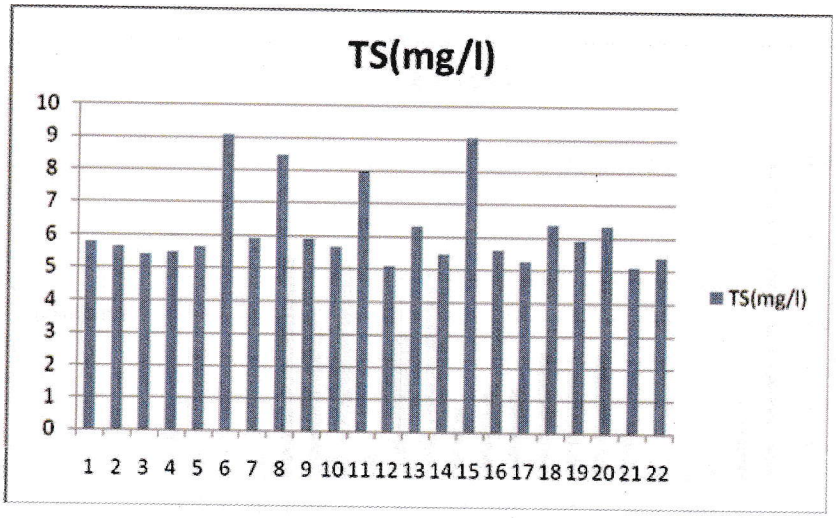

Fig. 5. Variation in TS

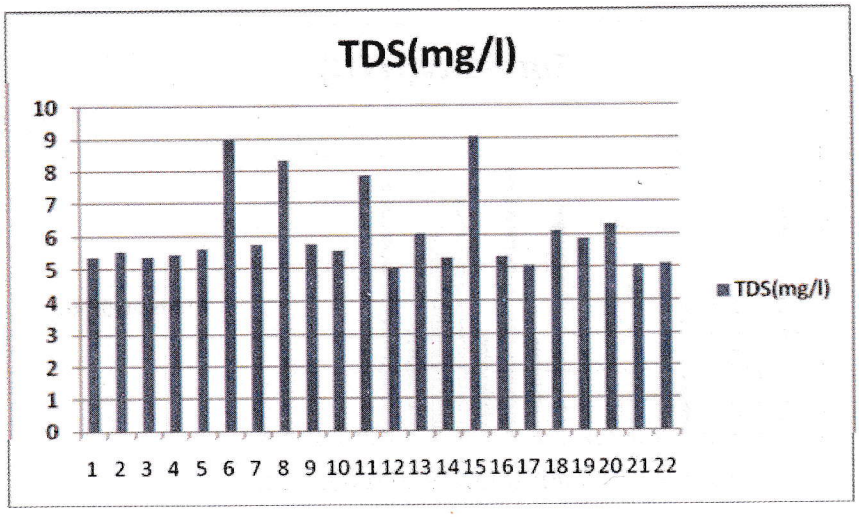

Fig. 6. Variation in TDS

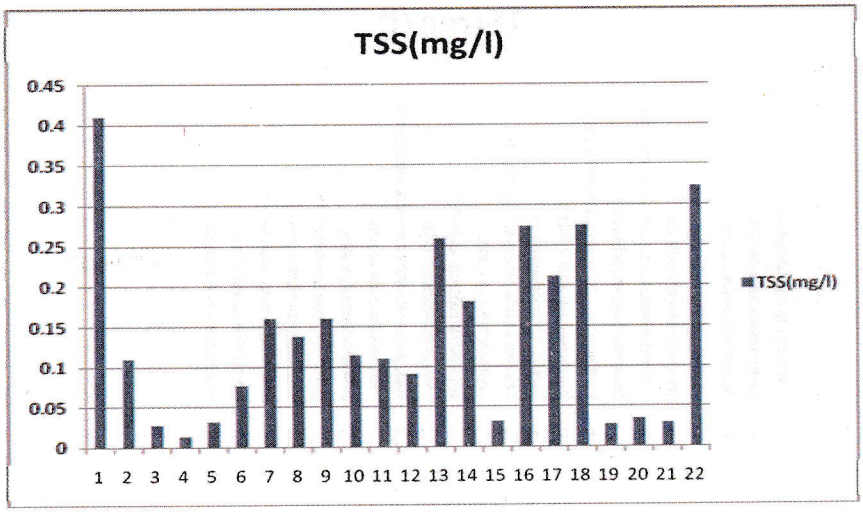

Fig. 7. Variation in TSS

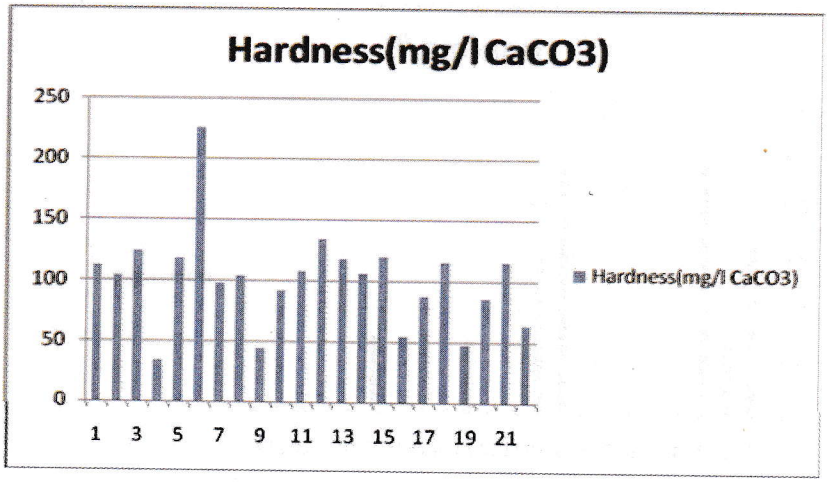

Fig 8. Variation in Hardness

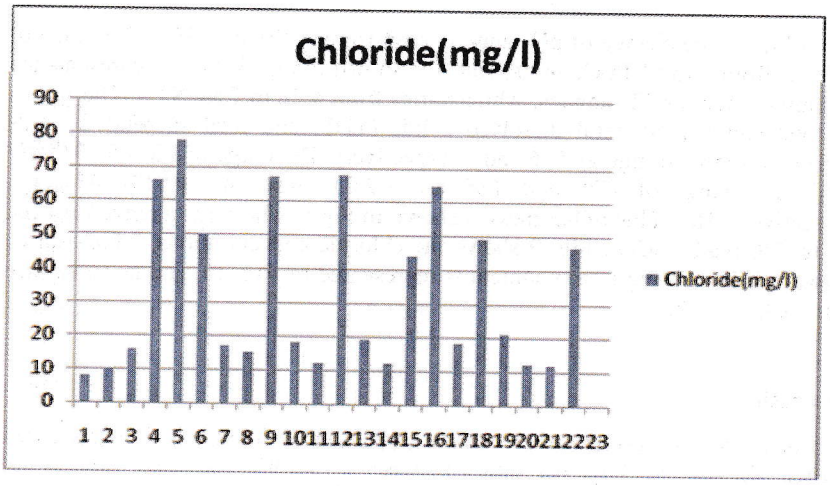

Fig. 9. Variation in Chloride

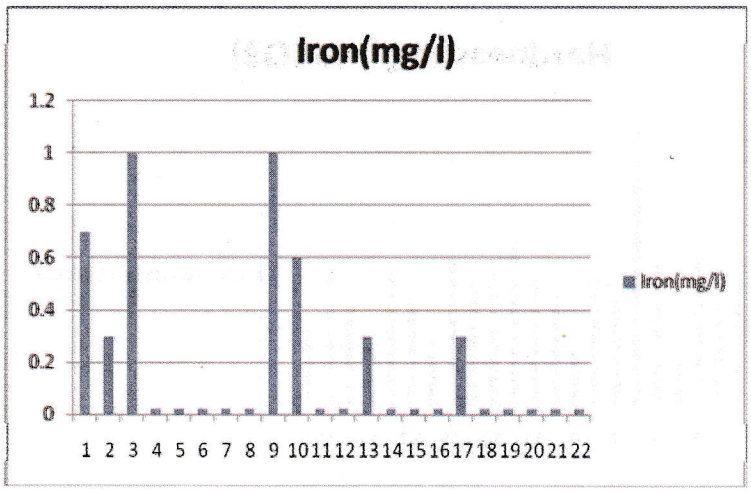

Fig. 10. Variation in Iron

From Fig. 2, the change of pH range is seen from 5.791 to 7.933. The range of color is from 4 to 51 Pt-Co units, which is shown in Fig. 3. Fig. 4 represents the turbidity range for 22 samples, which varies from 4.22 to 7.84 NTU. The values of total solids (TS), total dissolved solids (TDS) and total suspended solids (TSS) are shown in figures 5, 6 and 7 respectively. The range of TS is 5.09-9.077 mg/l. The range of TDS and TSS are 5-9.031 mg/l and 0.013-0.41 mg/l, respectively. The value of hardness is shown in Fig.8, which has a range between 34 to 226 mg/l $CaCO_3$. Fig. 9 shows the chloride concentrations, which varies between 8-50.055 mg/l. Iron content is represented by Fig. 10, and its values are from 0.02-1 mg/l.

Discussion

The obtained test results were compared to Bangladesh Standard as discussed earlier. The samples have pH values between 5.79-7.93. The upper limit is not exceeded, but the lower range is a little bit down, indicating slightly acidic property of the water sample collected from Rajarbag Old-1 "A" Water Pump and Mogbazar Dilu Road "C" Water Pump. This may be due to the presence of excess CO_2. Color of the samples was well above the prescribed limit in some of the cases. Higher concentration of dissolved solids along with the presence of iron compounds may cause the excessive level of color. But the turbidity fell within the limit. Values of total dissolved solids and total suspended solids were within the satisfactory level. Again the samples have a moderate hardness except for one case when total hardness was 226 mg/l (as $CaCO_3$). Chloride concentration was a maximum of 78 mg/l, well below permissible limit. The iron content ranges between 0.02-1 mg/l, fitting well within the tolerable limit.

Conclusions

Almost all the parameters were well within the range. Although color of the samples was well above the guideline value, it has no adverse effect on human health. The general taste of water was good. Low Iron content makes the water aesthetically pleasant to the consumers. So it can be concluded that, water abstracted from deep aquifers of Zone 6 is suitable for domestic and drinking purposes.

Recommendations

Seasonal and yearly variation of ground water level of zone 6 was not covered in this paper. Future works can be done to know the depletion pattern as well as the season wise concentrations of water quality parameters. The microbiological parameters (Total Coliform and Faecal Coliform) can also be assessed because these parameters are directly related to health issues. Future researchers can also conduct surveys to get consumers' comments about the water.

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