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RESEARCH ARTICLE

A STUDY ON WATER QUALITY PARAMETERS OF DRINKING WATER OF RURAL AREAS OF NARWANA, HARYANA (INDIA)

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ABSTRACT

Water is an essential natural resource for sustaining life and environment but over the last few decades the water quality has been deteriorated due to its over exploitation. Water quality is essential parameter to be studied when the overall focus is sustainable development keeping mankind at the focal point. The present study was conducted to analyze the various parameters of under-ground water in rural areas of Narwana city, Haryana, India and to check its fitness for drinking. Physico-chemical parameters viz. TDS, pH, fluoride, nitrate, chloride, sulphate, hardness and alkalinity were investigated. The results were compared with drinking water quality standards prescribed by the Bureau of Indian Standards (BIS). Ground water sampling carried out in January 2015 to April 2015. Most of the water samples were found to have total dissolved solids, alkalinity and hardness values more than their permissible level. The high values of these parameters might have health complications and so they need attention. The above studies are helpful to understand the ground water quality and their subsequent fitness or unfitness of water for drinking domestic purpose at various sites undertaken. It is concluded that the water quality of water supply systems in different locations of Narwana is of medium quality and can be used for domestic use after suitable treatment. Suitable suggestions have been made to improve the quality of water.

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INTRODUCTION

The health burden of poor water quality is enormous. It is estimated that around 37.7 million Indians are affected by waterborne diseases annually, 1.5 million children are estimated to die of diarrhea alone and 73 million working days are lost due to waterborne disease each year. The resulting economic burden is estimated at $600 million per year. The problems of chemical contamination are also prevalent in India with 1, 95, 813 habitations in the country are affected by poor water quality. The major chemical parameters of concern are fluoride and arsenic. Iron is also emerging as a major problem with many habitations showing excess iron in the water samples. The pressures of development are changing the distribution of water in our country. The average availability of water is reducing steadily with the growing population and it is estimated that by 2020, India will become a water stressed nation. Groundwater is the major source of water in our country with 85% of the population dependent on it. (Giri and Singh, 2014; Rakib and Bhuiyan, 2014; Kriest and Oschlies, 2013) According to a report of "water aid" India has 16 per cent of the world's population and four per cent of its fresh water resources. Estimates indicate that surface and ground water availability is around 1,869 billion cubic meter (BCM) out of this, 40 per cent is not available for use due to geological and topographical reasons. Around 4,000 BCM of fresh water is available due to precipitation in the form of rain and snow, most of which returns to the seas via rivers. Ninety two per cent groundwater extracted is used in the agricultural sector; five and three per cent respectively for industrial and domestic sector. (Komala *et al*., 2013; Kumar and Chopra, 2012; Lansdown *et al*., 2012) Water is not only universal solvent but is one of the most indispensable resources and is the elixir of life. Water constitutes about 70% of the body weight of almost all living organisms. Life is not possible on earth without water. It exists in three states namely solid, liquid and gas. Water has neutral pH and it acts as a media for both chemical and biochemical reactions and also as internal as well as external medium for several organisms. About 97.3% of water on earth is salty and only 2.7% is present as fresh water out of

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which about 20% constitutes ground water. (Onda *et al*., 2012; Rai *et al*., 2012; Simpi, *et al*., 2011; Ensink *et al*., 2010) The negative effects on ground water quality are the results of man's activity at ground surface, unintentionally by agriculture, domestic and industrial effluents, unexpectedly by sub-surface or surface disposal of sewage and industrial wastes. The quality of ground water is of great importance in determining the suitability of particular ground water for a certain use (public water supply, irrigation, industrial applications, power generation etc.). The quality of ground water is the resultant of all the processes and reactions that have acted on the water from the moment it condensed in the atmosphere to the time it is discharged by a well. Therefore, the quality of ground water varies from place to place, with the depth of water table, and from season to season and is primarily governed by the extent and composition of dissolved solids present in it. A vast majority of ground water quality problems are caused by contamination, over-exploitation, or combination of the both. Most ground water quality problems are difficult to determine and hard to resolve. The solutions are usually very expensive, time taking and not always effective. Ground water quality is slowly but surely declining everywhere. Ground water pollution is intrinsically difficult to detect, since problem may well be concealed below the surface and monitoring is costly, time consuming and somewhat hit-or-miss by nature. The wide range of contamination sources is one of the many factors contributing to the complexity of groundwater assessment. It is important to know the geochemistry of the chemical-soil-groundwater interactions in order to assess the fate and impact of pollutant discharged on to the ground. (Kumar and Sinha, 2010; Gupta *et al*., 2009; Premlata, 2009; APHA, 2005)

Study Area & Sampling

Twenty water samples were collected in January 2015 to April 2015. These samples were collected in pretreated and labeled plastic bottles (1.5L) and were immediate preserved and analyzed following standard protocols given in APHA. (APHA, 2005) Each bottle was washed with 2% Nitric acid and then rinsed three times with distilled water. The sampling places are referred as stations (N_1-N_{14}). The different sampling locations are given in Table 1.

Table 1. Sampling site, sources, code & depth of water samples

S. No.	Sampling Site	Sources	Code
01	Amarsar	Hand-Pump	N_1
02	Badanpur	Hand-Pump	N_2
03	Badowala	Hand-Pump	N_3
04	Barta	Bore-Well	N_4
05	Belarkha	Hand Pump	N_5
06	Bhikewala	Hand-Pump	N_6
07	Bhana-Brahaman	Hand-Pump	N_7
08	Bidhrana	Hand-Pump	N_8
09	Dablain	Hand-Pump	N_9
10	Dandoha	Hand-Pump	N_{10}
11	Badowala	Hand-Pump	N_{11}
12	Amargarh	Hand-Pump	N_{12}
13	Darodhi	Hand-Pump	N_{13}
14	Dhakal	Hand-Pump	N_{14}

MATERIALS AND METHODS

Twenty samples were collected from hand pumps, tube wells from villages, temples, nearby power house, park, bus stand, juggi cluster and different factories. These samples were analyzed for various physicochemical parameters and some heavy metals. The procedure followed for the analysis was from standard method (APHA). All water samples were collected in the polypropylene bottles which were properly washed with 2 % nitric acid and subsequently with double distilled water. Chemicals used in the analysis were Qualigens Excela R grade acids Indicators are of super pure grade. Atomic Absorption Spectrophotometer (model 3100) Perkin Elemer USA was used for determination of heavy metals. Hydrogen ion concentration (pH), total dissolved solids (TDS) and conductivity were measured using pH, TDS and Conductivity meter respectively. Total Alkalinity (TA) was estimated titrimetrically using hydrochloric acid. Total hardness (TH) and Calcium (Ca^{2+}) were analyzed titrimetrically using standard Disodium ethylene diammine tetraacetate (Na_2EDTA) salt. Magnesium (Mg^{2+}) was determined taking the difference between total hardness (TH) and (Ca^{2+}) values. Chloride (Cl^-) was estimated using standard silver nitrate ($AgNO_3$) while Sulphlate (SO_4^{2-}) was analyzed with the help of spectrophotometer. Dissolved Oxygen (DO) and (BOD) biological oxygen demand were analyzed titrimetrically using standard sodium thiosulphate ($Na_2S_2O_3$) solution.

RESULTS AND DISCUSSION

The respective values of all water quality parameters in the water samples are illustrated in Table-3. All the results are compared with standard permissible limit recommended by the Bureau of Indian Standards (BIS), Indian Council of Medical Research (ICMR) and World Health Organization (WHO), depicted in Table 2.

pH

pH is used to determine the acidity or alkalinity of water and the concentration of hydrogen ions in the water. Long term exposure to pH beyond the permissible limit affects the mucous membrane of cells. The pH value of all groundwater samples is found to be in the range of 7.00 to 8.45. The highest value of 8.45 is observed at station N_{11} whereas the lowest value of 7.00 is observed at station N_2. In terms of pH value, the groundwater samples are well within the acceptable limit of WHO. There is no anomalous change in the groundwater samples.

Electrical conductivity

Electrical conductivity is the measure of capacity of a substance to conduct the electric current where dissolved ions are the conductors. Most of the salts in water are present in their ionic form and capable of conducting current. Conductivity is a good indicator to assess groundwater quality. EC is an useful parameter of water quality for indicating salinity hazards.

In the study area, EC values varied between 0.3μS/cm to 3.5μS/cm. The major positively charged ions are sodium, (Na^+) calcium (Ca^{+2}), potassium (K^+) and magnesium (Mg^{+2}) contribute in the electrical conductivity of water.

Table 2. Analytic methods, BIS, ICMR & WHO parameters for the drinking water

S. No.	Parameters	Methods Employed	Prescribed by				
			BIS (IS 10500-91)		ICMR		WHO
			Desirable Limit	Max. permissible Limits	Desirable Limit	Max. permissible limits	
1	pH	Digital pH Meter	6.5 − 8.5	No relaxation	7.0 – 8.5	6.5 – 9.2	6.5 – 8.5
2	TDS (mg/L)	Digital TDS Meter	500	2000	500	1500-3000	1000
3	TH as $CaCO_3$ (mg/L)	Titrimetric (EDTA)	300	600	300	600	500
4	Ca^{2+} (mg/L)	Titrimetric (EDTA)	75	200	75	200	200
5	Mg^{2+} (mg/L)	Titrimetric (EDTA)	30	100	50	-	50
6	Cl^- (mg/L)	Titrimetric ($AgNO_3$)	250	1000	200	1000	200
7	Turbidity NTU	Nephelometry	1	5	1	5	5
8	SO_4^{2-} (mg/L)	Spectrometric method	200	400	200	400	400
9	NO^{3-} (mg/L)	Spectrometric method	45	100	20	100	10
10	PO_4^{3-} (mg/L)	Spectrometric method	-	-	-	-	-
11	Na/K (mg/L)	Flame photometer	-	-	-	-	200/15
12	Fe^{3+} (mg/L)	Spectrometric method	0.3	1.0	0.1	1.0	1.0
13	F^- (mg/L)	APHA-Method	1.0	1.5	1	1.5	1.5
14	As (mg/L)	APHA-Method	0.0	0.05	0.0	0.05	0.05

Table 3. Chemometric parameters of groundwater from different locations in Narwana, Haryana (India)

Site → / Param (↓)	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}	N_{13}	N_{14}
pH	7.62	7.00	7.61	8.35	7.61	7.43	7.35	7.4	7.70	7.23	8.45	7.90	7.4	7.5
T (°C)	27.2	27.6	25.3	25.9	26.0	27.8	27.5	27.4	27.4	27.3	27.9	27.9	27.0	27
EC	0.73	2.36	1.16	0.56	0.65	1.09	0.77	3.5	0.3	2.67	2.0	1.87	1.31	1.9
TDS	471.0	152	740	387	323	740	520	1780	187	1360	1150	120	828	1060
TH	408.0	1500	500	310	280	730	180	1140	210	1050	760	120	610	720
Ca^{2+}	81.6	280	102	66	56	156	38	232	42	225	156	25	124	144
Mg^{2+}	49.8	145.8	59.5	40.9	34.0	94.7	23.08	136.1	25.5	137.3	89.9	15.8	75.3	87.5
TB	1.0	15.0	4.0	1.0	0.0	2.0	0.0	12.0	1.0	0.0	2.0	0.0	0.0	3.0
TA	290	525	380	200	166	390	370	270	190	350	725	120	330	610
HCO_3^-	290	525	280	178	160	350	305	270	190	350	725	120	330	610
CO_3^{2-}	0.0	0.0	0.0	18.0	0.0	0.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cl^-	75	550	440	190	65	220	85	415	15	630	400	25	250	270
F^-	0.5	1.5	0.5	4.5	0.0	2.5	5.5	3.0	0.0	2.5	2.5	0.0	3.5	3.0
Fe^{3+}	0.0	0.12	0.23	0.0	0.0	0.2	0.3	0.4	0.3	0.5	0.0	0.3	0.2	0.3
Na^+	54.2	63.0	68.6	108.3	25.1	146.4	195.8	390	23.2	273.0	290	15.0	184.7	210
K^+	17.8	9.6	42.0	9.4	6.0	13.4	7.5	2.5	6.9	39.1	1.8	5.4	39.2	39.8
SO_4^{2-}	256	480	202	64.0	127	198	304	405	182	236	212	96	105	213
NO_3^-	23.8	44.3	56.0	42.0	13.0	24.9	6.9	16.0	4.5	28.0	15.9	3.0	6.3	15.0
PO_4^{3-}	0.31	0.3	0.0	0.0	0.75	0.91	0.98	1.23	0.8	1.0	0.6	0.7	0.7	0.6

Abbreviations: EC - Electrical Conductance; TDS -Total Dissolved Solids; TH - Total Hardness; TK - Total Alkalinity; TB -Turbidity; ppm - Parts Per Million.

Total dissolved solids (TDS)

In present study, the groundwater samples showed variation of TDS between 120 and 1780 mg/L. For domestic uses, the maximum permissible limit of total dissolve solids is 1000 mg/L (prescribed by WHO). The maximum value of 1780 mg/L is recorded at station N_8 and minimum value of 120 mg/L is recorded at station N_{12}. Hence all the groundwater samples are not saline except water of station N8, N10, N11 and N14. An elevated level of TDS, by itself, does not indicate that the water poses a health risk. The concentration of dissolved ions may cause the water to be corrosive, salty or brackish taste, result in the scale formation.

Total hardness (TH)

The present study showed that the total hardness analyzed in the water samples were found in the range of 120 to 1500 mg/L. However, the WHO guideline value (total hardness range: 300-600 mg/L) indicates that several samples particularly N_2, N_6, N_8 N_{10}, N_{11} N_{13}, N_{14} exceeded the maximum limit for drinking water. Calcium content of water in the present study was found in the range of 25 to 280 mg/L. Similarly, Mg content varied from 15.8 to 145.8 mg/L. Ca and Mg are both essential minerals for the living organisms. Recommendations have been made for the maximum and minimum levels of calcium (75 – 200 ppm) and magnesium (~50 ppm) in the drinking water.

Total alkalinity (TA)

The total alkalinity of the water samples showed variation from 120 to 725 mg/L. Water of sampling sites N_5, N_9 and N_{12} recorded normal values and within the guideline as recommended by WHO for total alkalinity (200 mg/L). Total alkalinity in natural water is attributed to bicarbonate. Very high value of alkalinity for water of sampling site N_{11} is due to high bicarbonate (725 ppm) and sulphate contents in the reported sample.

Chloride/Fluoride

The chloride content in the present study was found in the range of 15 to 630 mg/L. Chloride concentration higher than 200 mg/L is considered to be risky for human consumption and causes unpleasant taste of water. In some water samples fluoride concentrations were found higher than the permissible range 0.6 – 1.5 mg/L. The observed range of the fluoride level in the study area was found 0.0 mg/L to 5.5 mg/L. Very high level of fluoride in the study areas (N_4, N_6, N_7, N_8, N_{10}, N_{11}, N_{13}, and N_{14}) might be due to the presence of fluoride bearing minerals in the region. Some cases of dental or skeletal Fluorosis were observed in the study area of some villages.

Nitrate

The nitrate ion in the present study was found in the range of 3.0 to 56.0 mg/L. Nitrate values are commonly reported as either nitrate or as nitrate-nitrogen (NO_3-N). The maximum contaminant level (MCL) in drinking water as nitrate is 45 mg/L, whereas the MCL as NO_3-N is 10 mg/L. The MCL is the highest level of NO_3 or NO_3-N that is allowable in public drinking water supplies by the U.S. Environmental Protection Agency (EPA). High nitrate levels in water can cause methemoglobinemia or blue baby syndrome, a condition found especially in infants less than six months. The stomach acid of an infant is not as strong as in older children and adults. This causes an increase in bacteria that can readily convert nitrate to nitrite. Very high value of nitrate in the water sample of Nehru Park is due to high value of potassium nitrate.

Iron (Fe^{3+})

Iron content in the present study was found within the guideline value as recommended by NDWQS and WHO. The study revealed that all sampling sites contained the metal content in the normal range of 0.0 to 0.5 mg/L. Iron is one of the most abundant elements in nature ranking fourth by weight. All kinds of water including groundwater have appreciable quantities of iron. Although the metal has got little concern as a health hazard but is still considered as a nuisance in exceeding quantities for domestic as well as industrial uses.

Sodium/potassium ions

The value of sodium in the drinking water samples was found in the range from 15.0 to 390.0 mg/L. All samples except N_8, N_{10} & N_{11} are within the range given by WHO and BIS (200 mg/L). Potassium values ranged between 1.8 to 42.0 mg/L. The permissible limit of WHO is 15 mg/L. In healthy individuals, high levels of potassium (up to 3700 mg/day) possess no harmful effects because potassium is rapidly excreted. A very high dose of potassium results in chest tightness, nausea, vomiting, diarrhea, hyperkalemia, shortness of breath and heart failure.

Sulphate

Natural water contains sulphate ions and most of these ions are also soluble in water. Many sulphate ions are produced by oxidation process of their ores. They are also present in industrial wastes. The quantity of sulphate in the water samples was measured by UV Spectrophotometer. As per IS: 10500-2012, the desirable limit for sulphate is 200mg/L and the permissible limit is 400mg/L.

Phosphate

Phosphorus is an essential plant nutrient and most often controls plant growth. Normally ground water contains only a minimum phosphorus level because of the low solubility of native phosphate minerals and the ability of soils to retain phosphate.

Turbidity

Suspension of particles in water interfering with passage of light is called turbidity. Turbidity is caused by wide variety of suspended particles. Turbidity can be measured either by its effect on the transmission of light which is termed as turbidity metry or by its effect on the scattering of light which is termed as Nephelometry. As per IS: 10500-2012, the acceptable and permissible limits are 1 and 5 NTU respectively

Conclusion

The present work is an attempt to assess the drinking water quality. Most of the samples analyzed were found contaminated either due to one or more parameters. Only pH and iron values of all the samples were in the permissible range. Certain parameters in all samples crossed the WHO.

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