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SEASONAL VARIATIONS IN PHYSICO-CHEMICAL PARAMETERS OF GROUND-WATER IN SAMBA DISTRICT (J&K), INDIA

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ABSTRACT

Water quality is an important criterion for determining the suitability of water for human consumption and for various other uses. In this work various physico-chemical parameters viz. pH, turbidity, total dissolved solids (TDS), electrical conductivity (EC), total alkalinity (TA), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), chloride (Cl^{-}), sodium (Na^{+}), potassium(K^{+}), sulphate (SO_4^{2-}), phosphate (PO_4^{3-}) and fluoride (F^{-}) of samples of groundwater sources of the study area were investigated from April 2011 to March 2012. The results obtained were compared with WHO (1997) and BIS (2012) standards set for drinking water quality. The studied groundwater samples were found suitable for drinking.

INTRODUCTION

About 71% of the area of earth is covered with water. Groundwater which is available to us in the form of bore wells, dug wells and hand pumps is considered the safest and unpolluted source of drinking water. Majority of Indian population depend on groundwater as an important source of drinking water supply (Agrawal 2010). However, human activities like urbanization and industrialization have resulted in groundwater pollution.

Regular monitoring of groundwater is important to ascertain its quality and availability of water. The present study was undertaken to investigate groundwater quality of Samba city and adjoining areas of district Samba, J&K India for drinking purposes in view of the desirable and permissible limits set for drinking water by the World Health Organization (WHO 1993) and Bureau of Indian Standards (BIS) (2012).

MATERIALS AND METHODS

Study Area

Samba, a new district established in the year 2006, is situated on Jammu-Pathankote National Highway 1A, approximately 44 Km from Jammu city. It is located in the south-western part of the J&K State between latitudes 32.46' – 32.75'N and longitudes 74.90' – 75.26'E with average elevation of 384 meters (1259 feet). It has subtropical to moist temperate climate with an average temperature of 2-20^{0}C in winter and 30- 47^{0}C in summer. The area receives average annual rainfall of about 1116 mm and enjoys the SW, NW-SE type of monsoon (Jasrotia and Kumar 2014). The study area falls in the sub-mountainous region at the foothills of the Himalayas. Dug wells, tube wells and hand pumps in the studied area are the major sources of groundwater for domestic, agricultural and industrial requirements. In some areas, it even meets the municipal water supply requirements also.

Sampling

The groundwater samples were collected from dug wells, tube wells and hand pumps during summer, monsoon, autumn, winter and spring from the study area. Study was carried out from April 2011 to March 2012.

The groundwater samples were collected in plastic bottles from ten different stations and transported to laboratory for analysis of physico-chemical parameters using standard method (APHA 1998). The analyzed water parameters were pH, turbidity, total dissolved solids (TDS), electrical conductivity (EC), total alkalinity, total hardness, calcium (Ca^{2+}), magnesium (Mg^{2+}), chloride (Cl^{-}), sodium (Na^{+}), potassium (K^{+}), sulphate (SO_4^{2-}), phosphate (PO_4^{3-}) and fluoride (F^{-}). The studied physicochemical parameters of groundwater were compared with the prescribed standard recommended for drinking water by World Health Organization (WHO 1993) and Bureau of Indian Standard (BIS 2012).

The pH of the samples was determined using digital pH meter, turbidity by turbidity meter and conductivity by conductivity meter. Calcium, magnesium and total hardness were determine by EDTA titriometry method, chlorides by argentometry titrimetry method, total dissolved solids by gravimetric method and total alkalinity by titrimetry method, sulphate by nephalometry, nitrite and phosphates by spectrophotometer and fluoride by colorimetric method.

The study was conducted during summer (April to June 2011), monsoon (July and August 2011), autumn (September and October 2011), winter (November to January 2011-12) and spring (February and March 2012). The values of physico-chemical parameters are reported in Table 1.

RESULTS AND DISCUSSION

Physico-chemical characteristics of groundwater samples have considerable variations. The results are given in Table-1 and the standard limits for drinking water are given in Table 2.

pH is the negative logarithm of hydrogen ion concentration. It is influenced not only by the reaction of carbon dioxide but also by organic and inorganic solutes present in water. Change in pH also affects other physicochemical parameters (Wetzel 1975). pH recorded during studied periods ranged between 7.1 to 8.59 (Table 1) which is within the maximum desirable limit of (WHO 1997) and (BIS 2012) (Table 2).

Turbidity of studied samples ranged from 2.05 NTU to 7.4 NTU (Table 1) but station no. 3 and 4 recorded values 6.85 NTU and 7.4 NTU, respectively which is above the maximum desirable limit. Barring two stations (no. 4 and 5) during monsoon, rests of the studied values were well within prescribed maximum permissible limit (Table 2).

Total Alkalinity is a measure of the capacity of water to neutralize acids. It is an important parameter for survival of fish and aquatic life being buffers against frequent pH changes (Capkin et al. 2006). The higher value of alkalinity indicates presence of carbonate and bicarbonate and hydroxides in high level in river water (Girija et al. 2007). The alkalinity of groundwater fluctuated from 113 mg/L to 442.33 mg/L during the studied period. It varied from 125.67-308.33 mg/L to 139-290.50 mg/L in summer and monsoon (Table 1). During winter (125-387.50 mg/L), autumn (131.33-442.33 mg/L) and spring (113-320 mg/L) variations were recorded in the observed values (Table 1). The observed values of total alkalinity were found slightly above maximum desirable limit but well within maximum permissible standard (Table 2).

Total dissolved solids (TDS) indicate salinity in water (Singh and Kumar 2004). TDS values ranged from 251.40 mg/L to 625.33 mg/L and were maximum during winter and minimum in spring (Table 1). Waters with high total dissolved solids generally are inferior in palatability and may induce unfavourable physiological reaction in the transient consumer and gastro intestinal irritation (Shanker et al. 2008). Observed values of TDS were found within maximum permissible standard (Table 2).

Electrical Conductivity (EC) is a measure of the capacity of water to conduct electric current. EC reflects the total amount of total dissolved solids (TDS). The electrical conductivity was found varying from 207.5 µS/cm and 775.67µS/cm in studied groundwater samples (Table 1).

Calcium and Magnesium

The summation of calcium and magnesium hardness is considered as total hardness of water (Siddiqui and Waseem 2011). Ca^{2+} is an essential element for humans and helps in maintaining the structure of plant cells and soils. Mg^{2+} is an important constituent of bones and helps in normal metabolism of Ca^{2+}. In this study calcium concentration observed was higher than that of magnesium. The estimated Ca^{2+} contents in water samples ranged from 29.60 to 309.47 mg/L, while Mg^{2+} concentration varied from 7.95 to 56.93 mg/L (Table 1). The observed values of Ca^{2+} and Mg^{2+} were found well within prescribed standard (Table 2).

Total Hardness

Generally, the quantity of divalent ions such as calcium and magnesium in water measures the total hardness. It is measured in terms of total hardness and calcium hardness. Total hardness varied from 157.5 to 495.67mg/L (Table 1), and was found within permissible limits (Table 2). Hardness has no ill effects on health but it can make water unsuitable for domestic and industrial use (Nirmala et al. 2012). It plays important role in decreasing the toxic effects of harmful elements (Rajankar et al. 2013).

Sodium (Na^+) and Potassium (K^+)

The observed values of alkali earth metals varied from 13.10 to 32.76 mg/L for sodium and 4.87 to 8.95 mg/L for potassium (Table 1). Sodium is naturally found in the ground water. Potassium in groundwater is due to rainwater, weathering of potash silicate minerals and application of

Table 1. Seasonal variations in physicochemical parameters of groundwater in Samba district Avg± SD)

S. No.	Parameter	Station	Summer		Monsoon		Autum		Winter		Spring	
			Range	Avg±SE	Range	Avg±SE	Range	Avg±SE	Range	Avg±SE	Range	Avg±SE
1	pH	1	7.76-7.8	7.75±0.04	7.13-7.48	7.31±0.18	7.45-7.67	7.56±0.11	7.25-7.65	7.41±0.15	7.13-7.28	7.205±0.08
		2	8.50-8.64	8.59±0.05	7.47-7.62	7.55±0.07	7.36-7.42	7.39±0.03	7.51-7.92	7.76±0.16	7.53-7.71	7.62±0.09
		3	7.80-8.60	8.17±0.23	7.46-8.30	7.88±0.42	7.29-7.62	7.46±0.17	7.32-7.74	7.47±0.16	7.2-7.29	7.245±0.04
		4	7.31-7.59	7.41±0.09	7.16-7.56	7.36±0.20	7.2-7.4	7.30±0.10	7.1-7.57	7.52±0.28	7.18-7.39	7.285±0.10
2	Conductivity (µS/cm)	1	258-326	291.67±19.63	274-368	321.00±47.00	380-423	401.50±21.50	412-475	448.00±20.65	392-430	411±19.00
		2	352-472	399.67±36.77	369-450	409.50±40.50	362-485	423.50±61.50	340-372	353.00±11.90	368-423	395.50±27.50
		3	403-975	519.33±80.95	369-439	404.00±35.00	391-686	538.50±147.50	635-872	775.67±88.08	639-667	653±14.00
		4	215-296	246.33±25.12	189-226	207.5±18.50	209-356	282.50±73.50	227-493	366.33±94.36	265-324	294.5±29.50
3	TDS (mg/l)	1	375-439.6	400.23±19.94	287-328.4	307.70±20.70	267.2-343	305.10±37.90	286-379.5	330.60±33.16	226.8-291.3	259.05±32.25
		2	326-383	350.33±16.97	290-361	325.50±35.50	387-451	419.00±32.00	312-418	363.00±37.56	352-396	374.00±22.00
		3	296-394	334.33±30.23	212-375	293.50±81.50	320-492	406.00±86.00	593-642	625.33±19.80	459-597	528±69.00
		4	349-494.1	404.87±45.31	297.4-399	348.2±50.80	237.6-265.2	251.40±13.80	232-298	275.27±26.51	289-307	298±9.00
4	Turbidity (NTU)	1	2.4-5.9	3.97±1.03	5.4-5.6	5.50±0.10	4.2-4.8	4.50±0.30	3.6-4.6	4.17±0.36	3.6-4.5	4.05±0.45
		2	2.5-3.4	2.84±0.28	3.1-2.4	2.75±0.35	2.3-3.6	2.95±0.65	1.82-2.6	2.31±0.30	1.7-2.4	2.05±0.35
		3	2.9-3.5	3.17±0.18	6.3-7.4	6.85±0.55	4.2-5.6	4.90±0.70	3.2-5.2	3.93±0.78	3.8-4.5	4.15±0.35
		4	3.4-5.2	4.27±0.52	7.3-7.5	7.4±0.10	5.3-8.4	6.85±1.55	3.6-4.6	4.27±0.41	4.3-5.1	4.7±0.40
5	Total Alkalinity (mg/l)	1	150-216	179.67±19.34	140-195	167.50±27.50	160-175	167.50±7.50	140-186	163.67±16.28	129-157	143±14.00
		2	121-130	125.67±2.60	138-140	139.00±1.00	114-140	127.00±13.00	119-153	131.33±13.31	102-124	113.00±11.00
		3	221-250	238.67±8.95	284-297	290.50±6.50	384-391	387.50±3.50	428-459	442.33±11.05	312-327	319.5±7.50
		4	247-368	308.33±34.94	234-294	264±30.00	376-381	378.50±2.50	227-430	352.67±77.63	268-372	320±52.00
6	Total Hardness (mg/l)	1	142-182	162.50±15.92	222-261	241.50±19.50	134-235	184.50±50.5	125-213	173.00±31.50	139-176	157.5±18.50
		2	258-309	284.33±14.75	241-265	253.00±12.00	317-390	353.50±36.5	357-425	394.33±24.39	392-416	404.00±12.00
		3	281-385	344.67±32.21	295-363	329.00±34.00	369-470	419.50±50.50	431-540	495.67±40.50	358-462	410±52.00

Contd...

		4	149-275	207.33±36.37	246-329	287.5±41.50	396-407	401.50±5.50	263-399	346.00±51.47	282-375	328.5±46.50
7	Calcium (mg/l)	1	31-48	37.67±5.24	46-55	50.50±4.50	53-80.8	66.90±13.90	67.4-71.2	69.60±1.39	41.5-51.3	46.4±4.90
		2	113-129	129.00±9.24	109-182	145.50±36.50	115-119	117.00±2.00	100-131	119.67±12.09	95-102	98.50±3.50
		3	174-196	185.33±6.36	183-231	207.00±24.00	248-320	284.00±36.00	94.4-431	309.47±132.07	105-112	108.5±3.50
		4	23-35.6	29.60±3.65	49.5-50.42	49.96±0.46	76-84	80.00±4.00	49-52	50.73±1.10	47-63	55±8.00
		1	7.3-8.3	8.33±0.61	6.7-9.2	7.95±1.25	11.61-14.27	12.94±1.33	13.1-18.8	14.84±2.43	10.8-15.7	13.25±2.45
8	Magnesium (mg/l)	2	16.82-25.47	20.64±2.55	17.45-22.5	19.98±2.52	26.2-37.5	31.85±5.65	31.4-41.62	36.84±3.64	25.3-29.51	27.41±2.10
		3	24.5-39.6	30.30±4.70	18.9-23.6	21.25±2.35	24.5-49.2	36.85±12.35	55.6-57.98	56.93±0.86	46.2-51.4	48.8±2.60
		4	7.6-9.4	8.47±0.52	11.9-14.3	13.1±1.20	13.8-15.7	14.75±0.95	11.7-17.4	15.13±2.14	10.6-12.4	11.5±0.90
		1	16.3-17.3	16.93±0.32	11.6-14.6	13.10±1.50	22.6-25.2	24.05±1.45	21.4-25.8	23.93±1.61	20.9-21.6	21.25±0.35
9	Sodium (mg/l)	2	24.8-35.9	29.40±3.34	28.1-35.47	31.79±3.68	29.82-35.7	32.76±2.94	31.62-32.45	30.86±1.47	18.95-22.53	20.74±1.79
		3	12.1-18.3	15.23±1.79	19.8-20.5	20.15±0.35	22.9-23.8	23.35±0.45	21.7-32.4	26.73±3.80	27.4-28.8	28.1±0.70
		4	15.8-18.3	16.90±0.74	18.3-19.2	18.75±0.45	22.2-26.5	24.35±2.15	21.3-25.1	22.63±1.51	19.2-24.5	21.85±2.65
		1	4.1-5.8	5.03±0.50	5.3-6.5	5.9±0.60	4.7-5.2	4.95±0.25	5.3-8.4	6.87±1.10	5.2-6.9	6.05±0.85
10	Potassium (mg/l)	2	6.52-7.25	6.86±0.21	5.71-7.38	6.55±0.84	4.9-5.72	5.31±0.41	6.41-8.32	7.41±0.68	4.27-8.58	6.43±2.16
		3	4.5-5.4	4.93±0.26	5.4-6.9	6.15±0.75	5.1-6.3	5.70±0.60	6.8-8.4	7.57±0.57	6.2-7.4	6.8±0.60
		4	4.5-5.4	4.87±0.27	5.2-6.3	5.75±0.55	8.5-9.4	8.95±0.45	5.2-7.7	6.57±0.90	6.3-6.9	6.6±0.30

Contd...

11	Chloride (mg/l)	1	13.9-17.4	15.30±1.07	13.7-16.5	15.10±1.40	21.5-24.6	23.05±1.55	20.5-28.4	24.90±2.85	32.2-50.3	41.25±9.05
		2	15.32-18.76	17.76±1.23	16.25-21.9	19.08±2.83	13.47-20.6	17.04±3.57	13.75-18.21	15.49±1.69	16.51-19.7	18.11±1.60
		3	14.5-19.2	17.37±1.45	12.8-16.7	14.75±1.95	16.3-20.2	18.25±1.95	24.8-27.5	26.27±0.97	18.2-21.4	19.8±1.60
		4	15.3-19.4	16.87±1.28	19.4-23.7	21.55±2.15	24.9-31.4	28.15±3.25	25.5-33.5	29.00±2.89	23.8-24.2	24±0.20
12	Fluoride (mg/l)	1	0.02-.05	0.03±0.01	0.01-0.02	0.02±0.01	0.02-0.04	0.03±0.01	0.01-0.05	0.03±0.01	0.021-0.036	0.02±0.01
		2	0.042-0.35	0.15±0.10	0.048-0.071	0.06±0.01	0.05-0.07	0.06±0.01	0.03-0.06	0.05±0.01	0.04-0.07	0.06±0.02
		3	0.043-0.08	0.06±0.01	0.04-0.06	0.05±0.01	0.05-0.09	0.07±0.02	0.04-0.06	0.04±0.01	0.04-0.28	0.16±0.12
		4	0.02-0.03	0.03±0.01	0.05-0.07	0.06±0.01	0.06-0.08	0.07±0.01	0.01-0.04	0.02±0.01	0.017-0.024	0.02±0.004
13	Sulphate (mg/l)	1	42.7-56.5	47.57±4.47	47.8-59.6	53.70±5.90	87.5-102.6	95.05±7.55	38-128.6	96.10±35.66	21.4-26.5	23.95±2.55
		2	24.6-41.5	32.87±4.88	30-52	41.00±11.00	44-60.5	52.25±8.25	53.62.81	70.21±10.31	25.76-36.5	31.13±5.37
		3	19.3-24.5	21.77±1.51	13.8-17.5	15.65±1.85	24.6-29.8	27.20±2.60	43-71	59.61±10.40	59.8-66.2	63±3.20
		4	35.8-58.5	45.30±6.81	37.6-68.1	52.85±15.25	92.6-134.6	113.60±21.00	77-128	105.87±18.50	90-112.8	101.4±11.40
14	Phosphate (mg/l)	1	0.02-0.03	0.02±0.004	0.04-0.041	0.04±0.001	0.03-0.07	0.05±0.02	0.04-0.07	0.06±0.01	0.042-0.081	0.06±0.02
		2	0.37-0.72	0.53±0.10	0.02-0.04	0.03±0.01	0.06-0.73	0.40±0.33	0.04-0.08	0.06±0.01	0.06-0.09	0.08±0.01
		3	0.08-0.17	0.14±0.03	0.03-0.10	0.07±0.04	0.06-0.15	0.11±0.05	0.04-0.07	0.06±0.01	0.05-0.08	0.06±0.01
		4	0.12-0.23	0.19±0.03	0.047-0.057	0.052±0.01	0.03-0.06	0.05±0.01	0.02-0.08	0.04±0.02	0.06-0.07	0.07±0.003
15	Nitrite (mg/l)	1	0.01-0.02	0.01±0.001	0.019-0.021	0.02±0.001	0.003-0.005	0.005±0.001	0.002-0.04	0.02±0.02	0.008-0.057	0.03±0.02
		2	0.001-0.006	0.004±0.001	0.006-0.009	0.01±0.002	0.002-0.007	0.004±0.003	0.006-0.051	0.02±0.02	0.003-0.006	0.01±0.001
		3	0.01-0.06	0.03±0.02	0.01-0.03	0.02±0.01	0.02-0.03	0.03±0.005	0.01-0.05	0.04±0.01	0.027-0.028	0.02±0.001
		4	0.05-0.10	0.09±0.02	0.03-0.06	0.048±0.01	0.02-0.05	0.04±0.01	0.02-0.04	0.03±0.01	0.03-0.05	0.04±0.001

*Sampling stations: 1= Dug well, Village Doghou , 2= Dugwell, Village Katli, 3= Borewell, Chichi Mata 4= Bore well, Village Chak Manga.

Table 2. WHO and BIS standards for drinking water

S.No.	Parameter	WHO 1997	BIS 2012 (Desirable-Permissible limits)
1	pH	8.0-8.5	6.5-8.5
2	Conductivity (µS/cm)	-	-
4	TDS (mg/L)	500	500-2000
5	Turbidity (NTU)	5	5
6	Total Alkalinity (mg/L)	200	200-600
8	Total Hardness (mg/L)	-	200-600
9	Calcium (mg/L)	75	75-200
11	Magnesium (mg/L)	50	30 - No relaxation
12	Sodium (mg/L)	-	-
13	Potassium (mg/L)	-	-
14	Chloride (mg/L)	250	250-1000
15	Fluoride (mg/L)	1	1
16	Sulphate (mg/L)	200	200-400
17	Phosphate (mg/L)	-	-
18	Nitrite (mg/L)	-	-

potash fertilizer (Singh et al. 2013). It is also more abundant in sedimentary rocks and usually present in feldspar, mica and other clay minerals (Kolahchi and Jalali 2006). Besides, the cation-exchange process, agricultural and industrial activities are also responsible for the high content of sodium and potassium.

Chloride (Cl^-)

Chloride generally, occurs naturally in all type of waters. Chloride released in groundwater system through various physicochemical reactions like ion exchange. There is no bad impact on human health due to high concentration of chloride in the groundwater. Even chloride is not harmful to humans at low concentration but it could alter the taste of water at concentration above 250 mg/L (Hauser 2001). In the present study chloride concentrations varied from 14.75 to 41.25 mg/L, which are within permissible standard limits (Table 2).

Sulphate (SO_4^{2-})

Almost all natural waters contain sulphate ions. Sulphate in groundwater is generally present as calcium, magnesium and sodium soluble salts. Wastewater from urban settlement and industrial area cause sulphate pollution in the ground water. Sulphate content studied varied from 15.65 to 113.60 mg/L which were within permissible limit (Table 1, 2).

Phosphate (PO_4^{3-})

Occurrence of phosphorus-bearing minerals in particular areas causes the presence of phosphate in groundwater. It is found in nature as soluble phosphates and organic phosphates. Its concentration was found varying from 0.02 to 0.53 mg/L (Table 1).

Fluoride

Fluoride is present in nature because of amphiboles, apatite, fluorite and mica. Ground water contamination with fluoride is because of geological processes such as weathering of minerals, rock dissolution and decomposition. Besides, an anthropogenic factor such as industrial process liberates higher concentration of fluoride into atmosphere (Arya et al. 2011). Fluoride rich water causes development changes in teeth and bones (dental and skeletal fluorosis). Low concentration (less than 0.5 mg/L) of fluoride in drinking water causes dental caries. It may also lead to depression, nausea, low heamoglobin levels, deformities in RBCs, skin rashes, muscle fiber degeneration, gastrointestinal problems, abdominal pain, reduced immunity, urinary tract malfunctioning male sterility etc. (Sushila and Kaushik 2013). Fluoride in the groundwater samples ranged from 0.02 to 0.16 mg/L (Table 1).

CONCLUSION

The values of parameters of groundwater collected from various sources of study area were within the permissible limits as laid down by the WHO and BIS. However, turbidity values were observed to be higher than maximum desirable limit during monsoon.

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