Hydrochemical Assessment of Ground Water of Springs (Bowlis) of Udhampur District, J&K, India

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Abstract: ***The ground water quality of springs (bowlis) in Udhampur District, Jammu, J&K, India has been assessed to see the suitability of ground water for domestic applications. The various parameters analyzed were pH, Electrical conductivity (EC), Carbonate (CO_3^{2-}), Bicarbonate (HCO_3^-), Chloride (Cl^-), Sulphate (SO_4^{-2}), Nitrate (NO_3^-), Fluoride (F^-), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^+), Potassium (K^+), Iron (Fe) and Total hardness (TH). The water samples were collected from 17 different springs (Bowlis) during the pre-monsoon period (Mar. 2014 to May 2014). The results were compared with standard values of drinking water prescribed by IS:10500, BIS and WHO. To analyse the data with statistical point of view the statistical parameters like Mean, Range, Standard deviation, coefficient of variation, correlation coefficient, Kurtosis, Skewness were systematically calculated for each parameter. Also, Single factor Anova tables, Piper Diagram and Schoeller graph were prepared to signify the major results. Also, an account has been prepared to analyze the factors like Sum of Anions (meq/l), Sum of Cations (meq/l), calculated TDS (mg/l), Dissolved Minerals (mg/l) like Halite (NaCl), Sylvite (KCl), Carbonate ($CaCO_3$), Dolomite ($CaMg(CO_3)2$), Anhydrite ($CaSO_4$), permanent hardness, temporary hardness and alkalinity.***

Keywords: Springs, Bowli, Groundwater, Physico-chemical parameters, water quality standards, Statistical Analysis.

1. Introduction

Groundwater is the primary source of water for domestic, agricultural and industrial uses in many countries, and its contamination has been recognized as one of the most serious problems in India. A spring is a concentrated discharge of ground water appearing at the ground surface as a current of flowing water. Springs are formed where the ground surface intersects the water supply. Spring water is one of the important sources of fresh water used for the survival of life. However, due to anthropogenic activities these water bodies are under constant threat resulting in ecologically adverse alterations and the need of the time is their effective management. In the present study an attempt has been made to analyse the physico–chemical parameters of 17 different springs (Bowlis) during the pre-monsoon period (Mar. 2014 to May 2014). The results were compared with drinking water specifications of WHO and IS:10500, 1991(reaffirmed in 1993).

1.1 Statistics

To analyse the data with statistical point of view the statistical parameters like Mean, Range, Standard deviation, coefficient of variation, correlation coefficient, Kurtosis, Skewness were systematically calculated for each parameter. Also, Single factor Anova tables, Piper Diagram and Schoeller graph were prepared to signify the major results. Also, an account has been prepared to analyze the factors like Sum of Anions (meq/l), Sum of Cations (meq/l), calculated TDS (mg/l), Dissolved Minerals (mg/L) like Halite (NaCl), Sylvite (KCl), Carbonate ($CaCO_3$), Dolomite ($CaMg(CO_3)2$), Anhydrite ($CaSO_4$), permanent hardness, temporary hardness and alkalinity.

1.2 Study area (Map 1)

District Udhampur lies between 32 degree 34 minutes to 39 degree 30 minutes North Latitude and 74 degree 16 minutes to 75 degree 38 minutes East Longitude. The altitude of District Udhampur varies from 600 meter to 3,000 meter above sea level. The District is situated in the South-Eastern part of Jammu and Kashmir State and is bounded in the West by Rajouri District, in North-East by Doda District, in the South-East by Kathua District and in the South-West by Jammu District.

Total population of Udhampur town is 116727 souls as per the latest census of India and the area of Udhampur city is about 6 square km. Udhampur city abounds a number of natural springs locally known as Bowli. The water of these Bowlis is hot in winter and cold in summer. Maximum population of Udhampur in the wee hours goes to these Bowlis for having a refreshing bath and also takes water from these Bowlis for drinking purpose as it is said that the water of Bowli is good for digestion. Temples, shady trees, big rocks etc. are usual accomplices of these Bowlis, where Hindus pay their obeisance.

2. Materials and Methods

2.1Sample collection

The ground water samples were collected from springs (bowlis) from 17 chosen sites during the pre-monsoon period (Mar. 2014 to May 2014).

2.2 Preparation of water samples

The samples were collected in pre-cleaned, sterilized polyethylene bottles of one litre capacity without any air bubbles as per standard procedure. Each sample bottle was clearly labelled and relevant details were recorded. The samples were kept in refrigerator maintained at 4°C and were analyzed within 12 to 24 hrs after collection.

2.3 Physico-chemical analysis

Physico-chemical analysis were carried out for various water quality parameters such as pH, Electrical conductivity (EC), Carbonate (CO_3^{2-}), Bicarbonate (HCO_3^-), Chloride (Cl^-), Sulphate (SO_4^{-2}), Nitrate (NO_3^-), Fluoride (F^-), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^+), Potassium (K^+), Iron (Fe) and Total hardness (TH) as per standard methods (APHA, 1989). High purity certified analytical grade reagents; double distilled de-ionized water and borosil glassware was used.

Table 1: Analytical methodology for various parameters analysed

Parameters	*Analytical methods*
pH	Electro-metric method (pH meter)
Conductivity (EC)	Electrical conductivity meter (EC meter)
Carbonate (CO_3^{2-}), Bicarbonate (HCO_3^-), Chloride (Cl)	Titrimetric method
Sulphate (SO_4)	Argenoto metric method
Nitrate (NO_3)	Turbidity method
Fluoride (F)	Ultraviolet spectrophotometric method
Total Hardness (TH)	SPADNS method
Calcium (Ca), Magnesium (Mg)	EDTA Titrimetric method
Sodium (Na)	By difference
Potassium (K)	Flame photometric method
Iron (Fe)	Digestion followed by Atomic Absorption Spectrophotometry (AAS)

3. Results and Discussion

The experimental values for all the physico-chemical parameters are tabulated in table 2 and were compared with standards as prescribed by different agencies (IS:10500, WHO). The interpretation of data has been made with the help of statistical tools.

pH

pH serves as an index to denote the extent of pollution by acidic and alkaline waste and represents hydrogen ion activity in water. It affects equilibrium between most chemical species in water. The permissible range for pH is 6.5-8.5 as per IS:10500 for potable drinking water. pH of the underground water tested is in the range of 7.1-7.9 which is within the permissible limit.

3.1 Electrical Conductivity (EC)

It is a measure of the ability of an aqueous solution to carry an electric current. It depends on the presence of ions, on their total concentration, mobility and temperature of measurement. Higher value of conductivity shows higher concentration of dissolved ions (Wightman *et al*., 2003). Conductivity of water sample was found in the range of 260-380 micromhos per cm^2, which is well within range as compared to the WHO standards (0-800). Electrical conductivity is considered to be a rapid and good measure of dissolved solids.

3.2 Carbonate (CO_3^{2-}) and Bicarbonate (HCO_3^-)

The stoichiometric or chemical equilibrium equation between bicarbonate and carbonate is $HCO^{3-} = CO3^{2-} + H^+$. Because bicarbonate and carbonate are on opposite sides of the equilibrium equation, they are not often detected in the same groundwater sample. However, they can occur simultaneously at defined temperatures, pressures, and hydrogen ion concentrations (pH). The carbonate concentration is zero throughout the area. Bicarbonate ranges from 190 to 450 mg/l. The acceptable limit of Carbonate (CO_3^{2-}) and Bicarbonate (HCO^{3-}) is 75 mg/l and 30 to 400 mg/l respectively. The presence of high concentrations of HCO^{3-} can cause nutritional disturbances, such as reducing the availability of calcium and the uptake of iron.

3.3 Chloride (Cl)

Chloride is an anion found in variable amount in groundwater. Chloride may be present naturally in groundwater and may also originate from diverse sources such as weathering, leaching of sedimentary rocks. The maximum permissible limit of chloride in potable water is 250 mg/l.

In the analyzed water samples, the concentration of chloride varied from 7.1 to 11 mg/l which is well within the permissible limit.

3.4 Sulphate (SO_4)

The acceptable limit of sulphate is 200 mg/l. The sulphate content in analyzed water samples varied from 0.63 to 24.5 mg/l.

3.5 Nitrate (NO_3)

Natural nitrate levels in groundwater are generally very low (typically less than 10 mg/l NO_3), but nitrate concentrations grow due to human activities, such as agriculture, industry, domestic effluents and emissions from combustion engines. Nitrates generally move relatively slow in soil and groundwater: there is a lag time of approximately 20 years between the pollution activity and the detection of the pollutant in groundwater. For this reason, it is predicted that current polluting activities will continue to affect nitrate concentrations for several decades. However, if the pressure in the aquifer is high, transport can be very rapid within the saturation zone (Spalding and Exner, 1993). The nitrate content in the study area varied in the range 3 to 15 mg/l which is again within the prescribed limit of 45 mg/l at selected places.

3.6 Fluoride (F)

Small concentration of fluoride in drinking water has beneficial effect on human health for preventing dental caries. Higher concentration of fluoride than that of 1.5 mg/l carry an increased risk of dental fluorosis and even higher concentration could lead to skeletal fluorosis (Vyas and Sawant 2008). Fluoride content of groundwater samples of the study area ranges from 0.01 to 0.31 mg/l which is well within the permissible limit.

3.7 Total Hardness (TH)

When water passes through or over deposits such as limestone, the levels of Ca^{2+}, Mg^{2+}, and HCO^{3-} ions present in the water can greatly increase and cause the water to be classified as hard water. High levels of hard-water ions can cause scaly deposits in plumbing, appliances, and boilers. These two ions also combine chemically with soap molecules, resulting in decreased cleansing action. In the present study the total hardness values ranged from 82-170 mg/l. The hardness level is presented as below:

3.8 Total Hardness (mg/L as CaCO3)

- Soft: 0-30
- Moderately soft: 30-60
- Moderately hard: 60-120
- Hard: 120-180
- Very hard: >180

The high values of total hardness have an effect on the soil nature like lack of aeration and permeability of earth surface and it may indirectly affect the growth of plants and the general health of human society.

3.9 Calcium (Ca)

Calcium salts and calcium ions occur most commonly in nature. They may result from the leaching of soil and other natural sources or may come from man-made sources such as sewage and some industrial wastes. Calcium is usually one of the most important contributors to hardness. Human body requires approximately 0.7 to 2.0 grams of calcium per day as a food element; excessive amounts can lead to the formation of kidney or gallbladder stones. The desirable limit of calcium is 75 mg/l while in the present samples it ranged from 23 to 49 mg/l and it was found well within the desirable limit.

3.10 Magnesium (Mg)

The magnesium content in the study area varied in the range from 9.5 to 51 mg/l while the range prescribed by WHO is 30 mg/l (desirable limit) to 100 mg/l (permissible limit in the absence of alternate source). A major hypothesis that has emerged from studies in recent years is that magnesium, which together with calcium is the main determinant of water hardness, protects against death from ischemic heart disease (Rubenowitz, *et al.*, 1996). There are number of facts to support the hypothesis that magnesium deficiency can induce artery spasm, as has been shown in animal experiments (Altura *et al.*, 1981, 1984, Luthringer *et al.*, 1988, Turlapaty and Altura, 1980).

Epidemiologic studies in the United States (Schroeder, 1960), Canada (Anderson *et al*., 1971, Allen, 1972), South Africa (Leary *et al*., 1983), Finland (Punsar and Karvonen, 1979, Luoma *et al*., 1983), and Sweden (Rylander *et al*., 1991) have shown an inverse correlation between magnesium in drinking water and mortality from ischemic heart disease.

It has been suggested that it is mainly the incidence of sudden death from ischemic heart disease that is higher when water magnesium levels are lower, owing to an increased tendency to vasoconstriction (Turlapaty and Altura, 1980, Altura et al., 1981) or arrhythmias (SjOgren et al., 1989, Allen, 1972, Seelig & Heggtveit, 1974, Anderson, 1977).

3.11 Sodium (Na)

The sodium content of groundwater samples of the study area ranges from 3.2 to 9.2 mg/l while the permissible limit is 50 mg/l as prescribed by BIS. At room temperature, the average permissible limit of sodium is about 200 mg/l according to WHO.

3.12 Potassium (K)

Potassium, an important fertilizer, is strongly held by clay particles in soil. Therefore, leaching of potassium through the soil profile and into ground water is important only on coarse-textured soils. Potassium is common in many rocks. Many of these rocks are relatively soluble and potassium concentrations in ground water increase with time (GW MAP, 1999). Potassium is weakly hazardous in water, but it does spread pretty rapidly, because of its relatively high mobility and low transformation potential. Vital functions of potassium include its role in nerve stimulus, muscle contractions, blood pressure regulation and protein dissolution. It protects the heart and arteries, and may even prevent cardiovascular disease. The intake of a number of potassium compounds may be particularly harmful at high doses (IOM, 2004). In the present samples the range of potassium varied in between 0.7 to 5.5 mg/l.

3.13 Iron (Fe)

Iron in rural groundwater supplies is a common problem: its concentration level ranges from 0 to 50 mg/l, while WHO recommended level is < 0.3 mg/l. Iron and manganese occur naturally in water, especially groundwater. Neither of the elements causes adverse health effects; they are, in fact, essential to the human diet. In the present samples the concentration ranges from 0.01 to 0.8 mg/l which is within the desirable limit.

4. Statistical Analysis

The standard formulae were used in the calculation for statistical analysis as follows:

Mean $\mu = \frac{\Sigma x}{N}$

Where x= Value of observation
N= No. of observations

Standard deviation $\sigma = \sqrt{\frac{\Sigma(\bar{X} - X)^2}{n-1}}$

Where x= Value of parameter
n= No. of observations

Coefficient of variation $cv = \frac{\sigma}{\mu}$

Correlation coefficient

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2]\,[n\Sigma y^2 - (\Sigma y)^2]}}$$

Where
x,y = values of array 1 and array 2 respectively
n= No. of observations

The statistical results mean, standard deviation and coefficient of variation are given in table 3, Anova tests are depicted in table 4 and Correlation coefficient is shown in table 5.

Also, an account has been prepared (Table 6) to analyze the factors like Sum of Anions (meq/l), Sum of Cations (meq/l) and ion balance. Since most natural waters are electro-neutral, the sum of cations (positive ions) should equal the sum of anions (negative ions) when the concentrations are calculated in milliequivalents per liter, meq/L. This means that existing water quality data for major ions may be independently checked for accuracy using the formula given below:

1. Sum of anions, Σ_{anions} in meq/L

$\Sigma_{anions} = [OH^-] + [CO_3^{2-}] + [HCO_3^-] + [SO_4^{2-}] + [Cl^-]$, meq/L

2. Sum of cations, $\Sigma_{cations}$ in meq/L

$\Sigma_{cations} = [Ca^{2+}] + [Mg^{2+}] + [Na^+] + [K^+]$, meq/L

3. Ion balance percent:

Ion Balance Percent = $\{(\Sigma_{cations} - \Sigma_{anions}) \div (\Sigma_{cations} + \Sigma_{anions})\} \times 100$

TDS (mg/l) was calculated from sum of major ions, $\Sigma(ions)$ in mg/L, using analysis results:

$TDS_c = \Sigma(ions)$

$= [OH^-] + [CO_3^{2-}] + [HCO_3^-] + [SO_4^{2-}] + [Cl^-] + [Ca^{2+}] + [Mg^{2+}] + [Na^+] + [K^+]$

Dissolved Minerals (mg/L) like Halite (NaCl), Sylvite (KCl), Carbonate ($CaCO_3$), Dolomite ($CaMg(CO_3)2$), Anhydrite ($CaSO_4$) for the present water samples was calculated using the software. Permanent hardness and temporary hardness were measured using the EDTA method and alkalinity was determined using standard procedure.

Also, the major ionic species obtained from the physico-chemical analysis are projected graphically on the modified Trilinear Piper diagram (Graph 1). This shows the percentage composition of different ions. By grouping Na^+ and K^+ together, the major cations were displayed on the trilinear diagram. Likewise, CO_3^{-2} and HCO_3^- are grouped resulting in three groups of the major anions. The cations and anions were plotted in left and right triangles as a single point. These points have been projected into the central diamond-shaped area parallel to the upper edges of the central area. All these points in the diamond-shaped area represent the total ionic distribution. For each water sample, a single point was obtained in the diamond-shaped area, which represents the total ionic distribution. The water-types interpreted from Trilinear Piper diagrams are summarized in Table 2.

Graph 2 represents the groundwater types in the Schoeller diagram. The Schoeller (1965) diagram is used to study the comparative changes in the concentrations and ratios of water quality parameters for different samples. The different water quality parameters are plotted along with their concentrations (meq L-1). Results specify that lines of similar slope connecting concentrations of different parameters are indicative of water from a similar source.
Graph 3 represents the variation in different parameters at 17 stations.

5. Conclusion

In the sub-urban and rural areas of Udhampur, springs are a major source of water for domestic use. Though spring water is considered to be aesthetically acceptable for domestic use and the water of the bowlis/springs under consideration was observed to be fit for drinking purposes, yet, it is thought that the anthropogenic pressure, poor solid waste management in the area as well as poor and inadequate spring protection, may lead to contamination of spring water with pathogenic bacteria.

The presence of nitrates and chlorides in spring water is associated with faecal contamination derived from wastewater (Lewis *et al.*, 1980; Langennegger, 1981). An increase of these parameters in drinking water indicates contamination with wastewater. In the present study, both these parameters were found to be well within the permissible range. However, this could also be due to high dilution of faecal matter by rainwater and surface runoff or selective removal of nitrates and chlorides during transport in the soil.

6. Future Scope

Therefore, sanitary inspection of the bowlis for pathogenic bacteria is suggested for further assessment of contamination of spring water. It shall identify the risk of future contamination as well as an overall assessment of operation and maintenance of water supplies.

7. Acknowledgement

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Figure Legends

Table 1: Analytical methodology for various parameters analysed
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Table 3: Statistical evaluation of different parameters in the groundwater samples
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Graph 1: Piper trilinear diagram for anion and cation composition of water samples
Graph 2: Schoeller graph showing the groundwater types.
Graph 3: Line Graph showing variation in different parameters at 17 stations

Author Profile

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Table 2: Result of Physico-chemical analysis of samples of Ground water from some Springs (Bowlis) of dist. Udhampur, J&K, India

S. No.	Location	Lat	Long	pH	EC	CO_3	HCO_3	Cl	SO_4	NO_3	F	Ca	Mg	Na	K	Fe	TH	TYPE OF WATER
						mg/L												
1.	Sakan Bawli	32.9262	75.1542	7.2	295	0	375	7.1	0.63	15	0.02	49	37	3.5	1.1	0.09	170	Mg-Ca-HCO3
2.	Billan Bawli	32.9115	75.1360	7.8	340	0	410	8.9	8.52	11	0.04	24	11	5.5	2.4	0.02	123	Ca-HCO3
3.	Sukki Karlai Bawli	32.9114	75.1323	7.6	310	0	390	7.5	10.48	10	0.31	31	43	9.2	1.3	0.01	90	Mg-Ca-HCO3
4.	Sonarain di Bawli	32.9150	75.1266	7.1	290	0	190	8.2	24.5	14	0.04	40	51	4.8	1.6	0.11	93	Mg-Ca-HCO3
5.	Baddi Bawli	32.9345	75.1505	7.9	310	0	326	7.1	0.93	3	0.01	27	26	6.8	0.7	0.3	108	Mg-Ca-HCO3
6.	Rani Bawli	32.9255	75.1379	7.5	365	0	226	11	17.03	11	0.06	43	24	3.6	2.8	0.01	85	Ca-Mg-HCO3
7.	Bhlata 1	32.8190	75.1636	7.6	380	0	396	7.1	12.9	8.6	0.01	37	15	6.5	4.8	0.06	113	Ca-Mg-HCO3
8.	Bhlata 2	32.8181	75.1625	7.4	340	0	317	11	7.5	9.2	0.3	35	27	5.6	5.5	0.01	110	Mg-Ca-HCO3
9.	Devika Complex 1	32.9303	75.1282	7.2	280	0	323	8.1	0.82	5.5	0.01	23	11	3.2	1.2	0.02	93	Ca-Mg-HCO3
10.	Devika Complex 2	32.9131	75.1282	7.2	260	0	344	8.1	1.9	7.2	0.02	29	9.5	3.9	1.6	0.02	85	Ca-HCO3
11.	Kallar Bawli	32.9209	75.1372	7.3	340	0	290	8.2	9.2	9.1	0.01	36	23	4.5	2.6	0.08	82	Mg-Ca-HCO3
12.	Khartairi Bawli 1	32.9241	75.1501	7.8	310	0	310	9.1	8.56	12	0.3	45	34	6.5	2.5	0.06	89	Mg-Ca-HCO3
13.	Khartairi Bawli 2	32.9344	75.1500	7.6	280	0	380	9.5	11.45	8.7	0.21	29	28	3.5	2.8	0.3	98	Mg-Ca-HCO3
14.	Mian Bagh Bawli	32.9007	75.1568	7.9	260	0	290	8.6	3.89	6.8	0.11	34	39	6.4	3.2	0.04	102	Mg-Ca-HCO3
15.	Ratairi Bawli	32.9262	75.1542	7.5	370	0	340	7.8	9.7	7.2	0.21	28	27	3.6	5.4	0.01	110	Mg-Ca-HCO3
16.	Sansu Bawli	33.0646	75.1457	7.2	310	0	450	7.2	8.4	11.0	0.05	36	32	4.8	4.8	0.8	120	Mg-Ca-HCO3
17.	Mangu di Bawli	32.5530	75.1752	7.8	290	0	360	9.1	7.8	10.6	0.03	29	45	5.4	3.9	0.04	98	Mg-Ca-HCO3

Table 3: Statistical evaluation of different parameters in the groundwater samples

	pH	EC	CO_3	HCO_3	Cl	SO_4	NO_3	F	Ca	Mg	Na	K	Fe	TH
MIN.	7.1	260.0	0.0	190.0	7.1	0.63	3.0	0.01	23.0	9.5	3.2	0.7	0.01	82.0
MAX.	7.9	380.0	0.0	450.0	11.0	24.5	15.0	0.31	49.0	51.0	9.2	5.5	0.8	170.0
MEAN	7.505	313.52	0.0	336.29	8.44	8.482	9.40	0.102	34.7	28.38	5.13	2.83	0.11	104.0
RANGE	0.8	120.0	0.0	260.0	3.9	23.87	12.0	0.3	26.0	41.5	6.0	4.8	0.79	88.0
ST. DEV.	0.272	36.944	0.0	65.217	1.222	6.16	2.985	0.114	7.935	12.32	1.60	1.55	0.198	21.045
Coefficient of Variation	0.036	0.117	None	0.193	0.144	0.726	0.317	1.118	0.228	0.434	0.311	0.548	1.70	0.202
SKEWNESS	0.031	0.32	None	-0.535	0.867	0.856	-0.142	0.924	0.207	0.049	0.841	0.434	2.675	1.83
KURTOSIS	-1.377	-0.937	None	0.0825	-0.027	0.894	-0.073	-0.823	-1.117	-0.853	0.359	-1.044	6.544	3.679

Table 4:
ANOVA TABLE
Single Factor Anova:
Between subjects

1. Each group has a normal distribution of observations.
2. The variances of each observation are equal across groups (homogeneity of variance).
3. The observations are statistically independent.

	SS	Df	MS	F	p-value
Factor	2921437.66	13	224725.974	497.061	0.0
Error	101272.446	224	452.109		
Total	3022710.112	237			

Within subjects

	SS	Df	MS	F	p-value
Factor	2921437.66	13	224725.974	502.180	0.0
Within	101272.446	224	452.109		
Error	93080.178	208	447.501		
Total	3022710.112	445			

Table 5:

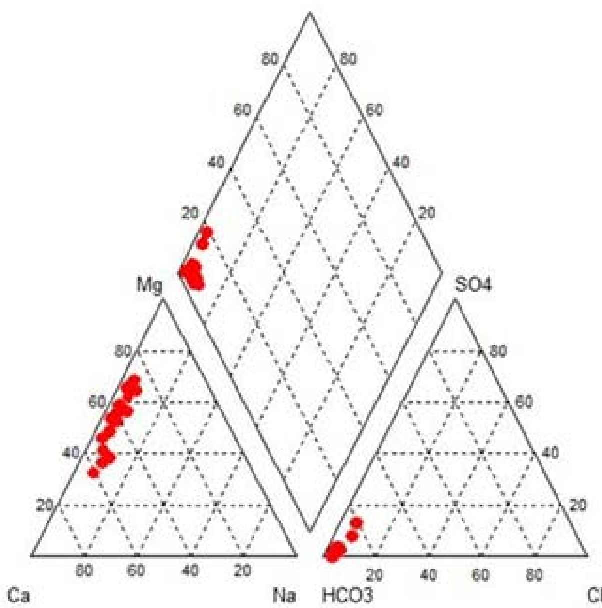
Correlation coefficient (Concentrations in mg/l)

	pH	CO_3	HCO_3	Cl	SO_4	NO_3	F	Ca	Mg	Na	K	Fe
pH	1.0	0.0	0.141	0.151	-0.145	-0.319	0.248	-0.239	7.8E-2	0.559	7.2E-2	-0.165
CO_3		1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HCO_3			1.0	-0.411	-0.433	-6.0E-2	4.6E-2	-0.307	-0.253	0.178	0.223	0.418
Cl				1.0	0.285	0.132	0.367	8.8E-2	-2.6E-2	-0.192	0.272	-0.318
SO_4					1.0	0.476	0.13	0.295	0.36	3.4E-2	0.219	-2.3E-2
NO_3						1.0	7.6E-2	0.699	0.475	-9.1E-2	8.6E-3	8.9E-3
F							1.0	7.9E-2	0.294	0.385	0.272	-0.152
Ca								1.0	0.414	-3.5E-2	1.1E-2	2.8E-2
Mg									1.0	0.325	-2.0E-2	0.116
Na										1.0	-5.4E-2	-6.1E-2
K											1.0	0.149
Fe												1.0

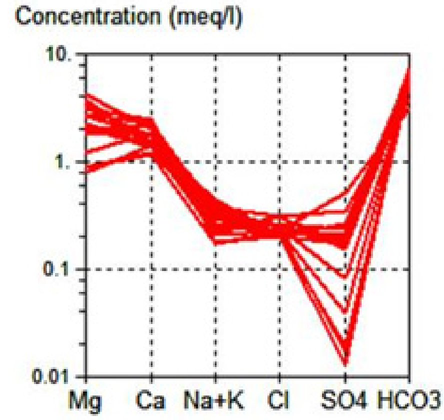
Table 6: Analysis of Physico-chemical parameters of samples of Ground water from some Springs (Bowlis) of dist. Udhampur, J&K, India

S. No.	Location	Sum of Anions (meq/l)	Sum of Cations (meq/l)	Balance	Cal. TDS (mg/l)	Dissolved Minerals (mg/L)					Permanent Hardness (mg/l $CaCO_3$)	Temporary Hardness (mg/l $CaCO_3$)	Alkalinity (mg/l $CaCO_3$)
						Halite (NaCl)	Sylvite (KCl)	Carbonate ($CaCO_3$)	Dolomite ($CaMg(CO_3 2)$)	Anhydrite ($CaSO4$)			
1.	Sakan Bawli	6.6031	5.6727	-7.58%	277.7	8.906	2.097	-	223.865	0.893	0.0	274.5	307.3
2.	Billan Bawli	7.3284	2.4039	-50.60%	129.1	11.095	4.576	5.767	83.303	12.081	0.0	105.1	336.0
3.	Sukki Karlai Bawli	6.9999	5.5183	-11.84%	258.8	10.431	2.479	-	122.307	14.86	0.0	254.2	319.6
4.	Sonarain di Bawli	4.0836	6.4455	22.43%	334.2	11.137	3.051	-	136.776	34.739	153.9	155.7	155.7
5.	Baddi Bawli	5.6121	3.8108	-19.12%	175.8	10.668	1.335	-	122.237	1.319	0.0	174.3	267.2

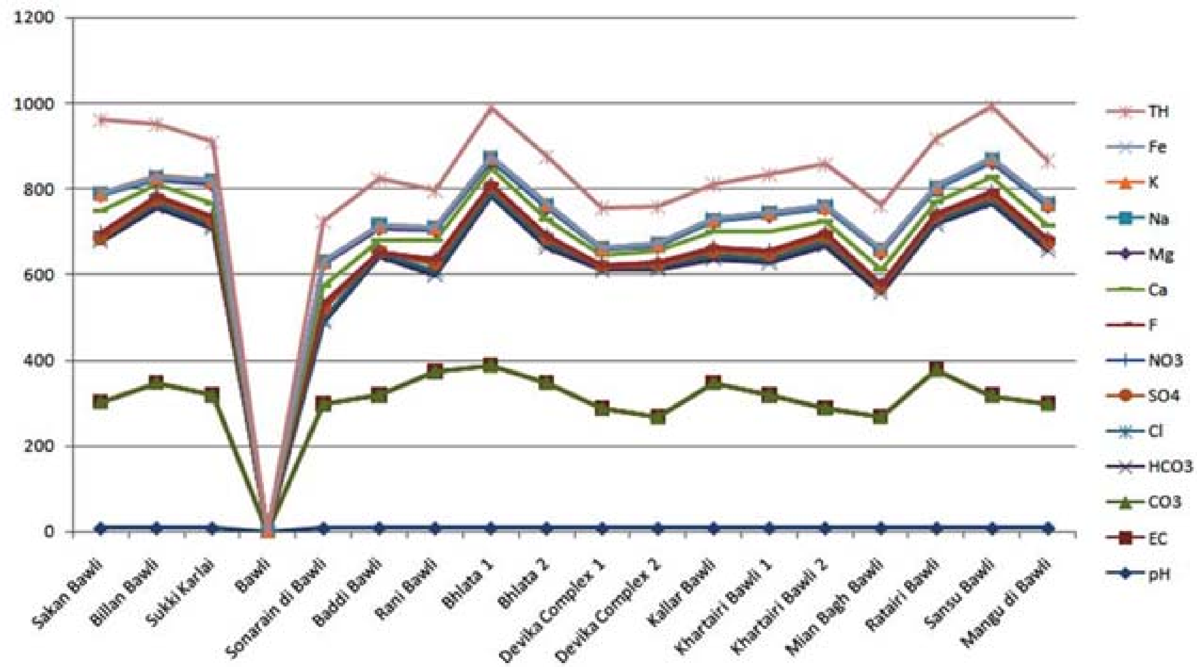
6.	Rani Bawli	4.5498	4.3488	-2.26%	338.5	9.161	5.339	-	164.873	24.147	20.8	185.2	185.2
7.	Bhlata 1	7.0990	3.4880	- 34.11%	176.3	4.534	9.152	17.2	113.595	18.291	0.0	154.0	324.5
8.	Bhlata 2	5.8266	4.3524	- 14.48%	215.5	9.922	10.487	-	146.392	10.634	0.0	198.4	259.8
9.	Devika Complex 1	5.6292	2.2233	- 43.37%	113.9	8.143	2.288	11.294	83.303	1.163	0.0	102.6	264.7
10.	Devika Complex 2	6.0238	2.4400	- 42.34%	126.9	9.924	3.051	31.33	71.944	2.694	0.0	111.4	281.9
11.	Kallar Bawli	5.3236	3.9537	- 14.77%	197.6	9.641	4.957	-	147.727	13.045	0.0	184.4	237.7
12.	Khartairi Bawli 1	5.7255	5.3915	-3.00%	264.0	11.275	4.767	-	190.293	12.137	0.0	252.1	254.1
13.	Khartairi Bawli 2	6.8864	3.9853	- 26.69%	198.8	8.906	5.339	-	111.261	16.235	0.0	187.5	311.4
14.	Mian Bagh Bawli	5.1925	5.2668	0.71%	392.0	9.403	6.101	-	148.717	5.516	7.6	237.7	237.7
15.	Ratairi Bawli	6.1222	3.9136	- 22.01%	191.4	4.791	10.296	-	110.022	13.754	0.0	180.9	278.7
16.	Sansu Bawli	7.9341	4.7893	- 24.72%	232.7	4.699	9.152	-	149.26	11.911	0.0	221.5	368.8
17.	Mangu di Bawli	6.4925	5.4853	-8.41%	260.5	9.181	7.436	-	118.257	11.06	0.0	257.5	295.0



Graph 1: Piper trilinear diagram for anion and cation composition of water samples



Graph 2: Schoeller graph showing the groundwater types.



Graph 3: Line Graph showing variation in different parameters at 17 stations