



## Research Paper

### Assessing Groundwater Quality in a part of Reasi District, Jammu and Kashmir, India

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Received: 06/04/2019

Revised: 21/04/2019

Accepted: 28/04/2019

**Abstract:** Water has played very important role in the growth and development of human civilization. It has a significant role in sustenance of plant, animal and human beings. The quality of water gets affected either by geogenic that is from the aquifer through which it flows or by anthropogenic contaminants which includes disposal of waste. By these contaminants not only the surface water is polluted but also the groundwater gets contaminated. Therefore, monitoring of quality of water being used for drinking as well as irrigation is a major concern.

In this paper an attempt has been made for the first time to assess the suitability of ground water of a part of Reasi District for drinking purpose, based on the water samples analysed for all the major cations and anions. The statistical assessment, analysis of variance, Pearson's correlation analysis, dominance of elements and Hill Piper Plot were the other methods used to understand the hydro-geo-chemistry, dominance and correlation among the major elements. Comparison of the concentration of chemical constituents with the standards of Bureau of Indian Standards (BIS) 1991 and their statistical

assessment shows that the water quality of the study area is fit for drinking and other domestic uses.

**Keywords:** Groundwater, quality, BIS.

#### INTRODUCTION:

Water is an essential commodity to mankind and the largest available source of fresh water lies under ground. (Sajil et al, 2011). The haphazard development, industrialization, urbanization and population growth is having irreversible damage to this vital resource. Water being an important component of the ecosystem, any imbalance either in quantity or quality affects the whole ecosystem negatively (Aminu and Amadi, 2014).

Comparatively, groundwater contamination is not as common as surface water but once contaminated, treatment is often difficult and time consuming (Agbaire and Oyibo, 2009). The improper disposal of domestic, industrial or chemical waste is the main environmental issue. These sources of contamination may influence important biological, physical

and chemical variables of groundwater (Sappa et al. 2013). The need of surveillance on the quality of ground water is more than its quantity.

Acquiring the relationship between various physico-chemical parameters helps in reducing the uncertainties associated with decision making and also, it helps in promoting the advancement in research (Devi and Premkumar, 2012). In Reasi District, hilly and hard rocks that have experienced multiple tectonic events resulting in its complex geomorphic setup and lack of abundant surface water sources, the groundwater occurring in the dugwells and springs are considered to be the only source for water. An attempt has been done for the first time to assess the chemical quality of ground water in a part of Reasi District. The chemical parameters were determined and compared with the permissible/desirable values prescribed by the Bureau of Indian Standards (BIS) to ensure its suitability for drinking and allied uses. The relationship between the elements present in the ground water of the study area was determined by the statistical analysis and Pearson's Correlation matrix.

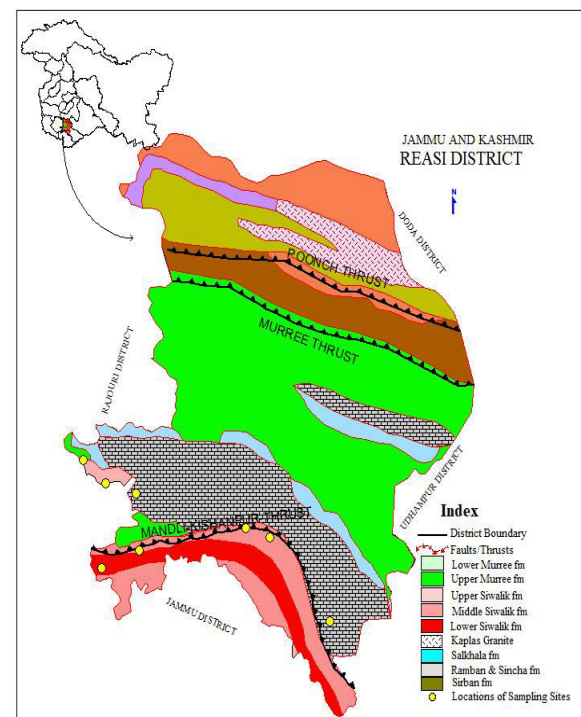
### Introduction of Study Area

Reasi District lies between longitude  $33^{\circ}05'$  N and latitude  $74^{\circ}50'$  E, at a distance of 64 km from Jammu and is well connected by metalled road, to Jammu-Srinagar National Highway. The district is bounded by Tehsil Sunderbani and Kalakote of District Rajouri in the west, Udhampur in the east, Tehsils Jammu and Akhnoor of District Jammu on the south and Tehsil Gool-Gulabgarh in the north. The study area that lies on the south

western part of the district lies between  $32^{\circ}55'5''$  and  $33^{\circ}11'54''$  North latitude to  $74^{\circ}31'12''$  and  $75^{\circ}2'34''$  East longitude.

According to the 2011 census, Reasi district has a population of 314,714, and population density of 184 inhabitants per square kilometer. Climatically the study area experiences temperate climate viz. warm summers and cold winter.

Geologically, the sampling locations falls in the Siwalik country consist of sandstone with shale, siltstone and conglomerate and very thin alluvial thickness in this area. Hydro-geologically also the area is not so potential as the porosity and permeability of rock formations in this area is very low.



**Fig. 1 Location of Sampling Sites in the Study Area**

### MATERIALS AND METHODS:

During May 2012 (pre-monsoon) eight ground water samples were collected from

open dugwells of the study area. These samples were analyzed as per the guidelines of Bureau of Indian standards (BIS) using AR grade chemicals. Standard APHA methods (1998) were used to measure various water quality parameters in the analysis of ground water samples. The results of analysis for all the analysed parameters is shown in the Table 1.

Water quality parameters viz. carbonate  $\text{CO}_3^{2-}$ , Bi-carbonate  $\text{HCO}_3^-$ , Magnesium ( $\text{Mg}^{2+}$ ), Calcium ( $\text{Ca}^{2+}$ ), Sodium ( $\text{Na}^{2+}$ ), Potassium ( $\text{K}^+$ ), Fluoride ( $\text{F}^-$ ), Chloride ( $\text{Cl}^-$ ), Nitrate ( $\text{NO}_3^-$ ), Sulphate ( $\text{SO}_4^{2-}$ ), Iron (Fe), pH, and electrical conductivity (EC) were estimated by standard methods viz.  $\text{CO}_3^{2-}$ ,  $\text{HCO}_3^-$ , Chloride ( $\text{Cl}^-$ ) by Titrimetric method,  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  by EDTA Titrimetric method  $\text{K}^+$  by Flame photometric method,  $\text{F}^-$  by Ultraviolet spectrophotometric method,  $\text{SO}_4^{2-}$  by Argentometric method,  $\text{NO}_3^-$  by Turbidity method and Fe by Digestion followed by Atomic Absorption Spectrophotometry.

To test the distribution normality for each parameter univariate statistical analysis was done. Descriptive statistics, correlation analysis and one-way analysis of variance (ANOVA) were some of the analyses carried out in this study. In order to quantitatively analyse and confirm the relationship among major element contents in groundwater samples, Pearson's correlation analysis was applied to the data. Correlations among various metal contents, major elements and pH in groundwater samples are calculated.

## RESULTS:

The groundwater samples collected from the dugwells were analysed in the laboratory to determine the

physicochemical parameters and results along with their statistical analysis are presented in table 1.

### Major Cation Chemistry

The pH is the measurement of Hydrogen ion concentration and for drinking water its limit as per BIS is 6.50 to 8.5. In the dugwell samples the pH ranges between 6.9 and 8.24. The electrical conductivity ranges between 390 and 1030  $\mu\text{S}/\text{cm}$  at 25°C. The concentration of Calcium and Magnesium varies from 22 mg/l to 98 mg/l and 13 mg/l to 60 mg/l respectively and the average values are 39.01 mg/l and 30.37 mg/l. The concentration of sodium ranges from 6.1 to 84 mg/l with an average of 25.41 mg/l and potassium value ranges from 0.7 to 115 mg/l with an average of 3.22 mg/l.

### Major Anion Chemistry

The concentration of bicarbonate ion ranges between 232 and 549 mg/l with an average of 302.62 mg/l. The carbonate ions were absent in all the samples. The chloride concentration varies from 7.1 to 146 mg/l with an average of 34.13 mg/l. The concentration of sulphate ranges between 0 and 40 mg/l with an average of 13.75 mg/l. The nitrate concentration ranges from 4.2 to 26 mg/l with an average of 13.6 mg/l. The fluoride concentration values range between 0 and 0.41 mg/l with an average of 0.195 mg/l. All the samples were found well within the permissible limits of BIS (2012) standards of drinking water.

### Preferential order of Cations and Anions

The dominance of cations and anions is in the order of  $\text{Ca} > \text{Mg} > \text{Na} > \text{K}$  and  $\text{HCO}_3^- > \text{Cl}^- > \text{SO}_4^{2-} > \text{NO}_3^-$  respectively.

**Table 1: Statistics of the hydro-chemical variables for the data in the study area**

Parameters	Units	BIS Standards		Dug wells						
		DL	PL	Min	Max	Mean	SD	CV	Skewness	Kurtosis
pH		6.5-8.5	No relaxation	6.9	8.24	7.56	0.476	0.0629	0.1661	-1.2939
EC $\mu$ mhos/cm at 25°C		500	2000	390	1030	610	248.710	0.4077	0.8644	-0.8836
Ca <sup>2+</sup>	(mg/l)	75	200	22	98.0	56.37	27.265	0.4836	0.2597	-0.9950
Mg <sup>2+</sup>	(mg/l)	30	100	13	60	30.375	15.315	0.5042	0.7092	-0.2010
Na <sup>+</sup>	(mg/l)	-	-	6.1	84.0	25.412	25.189	0.9912	1.7664	1.2468
K <sup>+</sup>	(mg/l)	-	-	0.7	11	3.225	3.912	1.2131	1.2468	-0.0912
HCO <sub>3</sub> <sup>-</sup>	(mg/l)	-	-	232	549	302.62	104.375	0.3449	1.8847	2.1498
Cl <sup>-</sup>	(mg/l)	250	1000	7.1	146	34.137	45.771	1.3408	2.1578	2.8610
NO <sub>3</sub> <sup>-</sup>	(mg/l)	45	100	4.2	26	13.6	7.956	0.585	0.4104	-1.3361
F <sup>-</sup>	(mg/l)	1.0	1.5	0	0.41	0.195	0.137	0.7026	-0.2608	-0.6573
SO <sub>4</sub> <sup>2-</sup>	(mg/l)	200	400	0	40	13.75	16.713	1.2155	0.7840	-1.0483
Fe	(mg/l)	0.3	1.0	0	1.6	0.588	0.603	1.0252	0.7207	-0.9339
TH	as CaCO <sub>3</sub> (mg/l)	300	600	190	490	265.62	100.229	0.3773	1.5864	1.2325

DL: Desirable Limit, PL: Permissible limit, SD: Standard Deviation, CV: Coefficient of Variation

Distribution normality of each parameter was tested by carrying out Univariate statistical analysis. Mean and standard deviation values of 13 physico-chemical parameters were calculated along with the

Skewness and Kurtosis to find the symmetry and the heaviness of the tails for a distribution. The correlation matrix among the 11 physico-chemical variables of the groundwater is presented in table 2.

**Table 2: Correlation coefficient (r): (Concentrations in mg/l) among water quality parameters**

	pH	HCO <sub>3</sub>	Cl	SO <sub>4</sub>	NO <sub>3</sub>	F	Ca	Mg	Na	K	Fe
pH	1.00	0.215	-0.282	-0.265	0.229	-0.024	-0.232	0.686	-0.272	0.530	0.268
CO <sub>3</sub>		1.000	-0.370	-0.231	0.697	-0.191	0.285	0.137	-0.308	0.394	-0.009
Cl			1.000	-0.190	0.071	0.414	-0.307	-0.104	0.986	-0.186	-0.334
SO <sub>4</sub>				1.000	-0.670	0.692	0.824	0.320	-0.177	-0.370	-0.434
NO <sub>3</sub>					1.000	-0.497	0.150	0.566	-0.004	0.439	-0.118
F						1.000	0.629	0.322	0.433	-0.349	-0.607
Ca							1.000	0.380	-0.272	-0.089	-0.504
Mg								1.000	-0.140	0.612	0.353
Na									1.000	-0.176	-0.364
K										1.000	0.054
Fe											1.000

ANOVA was used to define if there is statistically significant correlation between dependent variables within subjects and between subjects and is given in table 3.

**Table 3: ANOVA TABLE**

**Single Factor Anova:**

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.

**(Within the subjects)**

	SS	Df	MS	F	p-value
<b>Factor</b>	3262414.338	13	250954.949	48.568	0.0
<b>Within</b>	608044.512	98	6204.536		
<b>Error</b>	470202.798	91	5167.064		
<b>Total</b>	3870458.850	202			

**(Between the subjects)**

	SS	Df	MS	F	p-value
<b>Factor</b>	3262414.338	13	250954.949	40.447	0.0
<b>Error</b>	608044.512	98	6204.536		
<b>Total</b>	3870458.850	111			

**Hydro-geochemical Facies**

The hydro-geochemical facies can be inferred by Piper-Hill diagram. The Piper Hill plot includes two triangles and a diamond-shaped field, one triangle for plotting cations (lower left) and the other (lower right) for plotting anions. The diamond-shaped field shows the combination of cations and anion fields in a single point from which inference is drawn on the basis of hydro-geochemical facies concept. These tri-linear diagrams help to bring out the chemical relationships among groundwater samples in more definite terms. Chemical data of representative samples collected from the study area are presented by plotting them on a Piper-tri-linear diagram. These diagrams help to reveal the dissimilarities, the analogies and types of waters in the study area. Figure 2 reveals that the dominant cations in the study area are  $Ca^{2+}$  and  $Mg^{2+}$  whereas dominating anions include  $CO_3^{2-}$  and  $HCO_3^-$  in the study area. Hence, hydrochemistry of study area has

dominance of alkaline earth metals ( $Ca^{2+}$ - $Mg^{2+}$ ) and weak acids ( $CO_3^{2-}$  -  $HCO_3^-$ ).

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