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HYDROGEOCHEMISTRY OF GROUNDWATER AND ITS SUITABILITY FOR DRINKING AND IRRIGATION PURPOSES FROM BARAMULLA DISTRICT, KASHMIR VALLEY, INDIA

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ABSTRACT

Groundwater investigations from Baramulla district, has been carried out to study its chemical quality. 83 Groundwater samples were collected from dug wells for physico-chemical analysis. The physico-chemical parameters of the study area showed remarkably wide range; pH: 6.0 to 8.5, Ca^{++}: 3.5 to 282.2 mg/L, Mg^{++}: 0.9 to 157.1 mg/L, Na^{+}: 3.5 to 282.2 mg/L, K^{+}: 0.5 to 300.9, Cl^{-}: 7.1 to 248.5 mg/L, HCO_3^{-}: 60 to 830 mg/L, SO_4^{--}: 0.8 to 344.7 mg/L. Attempted characterizations of groundwater on conventional Piper-trilinear (1944) diagram three water types were identified: Ca-Mg-HCO_3 type, Ca-Mg-SO_4-Cl type, Na-HCO_3 type. The conceptual model of Ca + Mg Vs HCO_3, Ca + Mg Vs HCO_3 + SO_4, Ca+ Mg TZ+ and Ca+ Mg Vs Na+K suggested chemistry of groundwater is mostly controlled by rock-water interaction and bear the imprints of lithological control however; the ground water at some places is obliterated by anthropogenic inputs. Comparing results with the drinking water standards W.H.O (1984) and plotting on U.S.A salinity diagram, most of the samples were within the permissible limit and were excellent for irrigation and drinking purposes.

Key words: Groundwater, Baramulla, rock-water interaction, lithological, anthropogenic, piper-trilinear diagram

INTRODUCTION

Ground water is that hidden treasure of water that seeps beneath the surface of the ground, collects in natural underground reservoirs known as aquifers, and is the source of water in spring and wells and is also important for the support of habitat. The quality of Groundwater is of vital concern to mankind, since it is directly linked with human welfare. Poor quality of water adversely affects human health and plant growth (Wilcox, 1948; Thorne and Peterson, 1954; WHO, 1984; Todd, 1980).The groundwater acquires its chemistry due to a number of factors which include composition of precipitation, mineralogy of the rock or soil matrix through which it flows, climate, topography and at some places from the anthropogenic inputs. Number of studies on geochemistry of groundwater with respect to drinking and irrigation purposes have been carried out in the different parts of the country (Durvey *et al.*, 1991; Subba Rao *et al.*, 1999; Majumdar and Gupta, 2000; Khurshid *et al.*, 2002; Sreedevi, 2004; Subba Rao and John

Devadas, 2005). However, the quality of groundwater in the Valley has received little attention hence an attempt was made to assess the ground water quality from valley.

STUDY AREA

Baramulla District, of Kashmir valley lies between 32° 58′ and 35° 50′ latitude, 73° 45′ and 75° 20′ longitude, covers an area of about 4,588 km² at an altitude of about 1581 meters above mean sea level (Fig:1). The phsiography of area consists of mountains towards the periphery, plain towards the town and marshy along the Jhelum river banks.

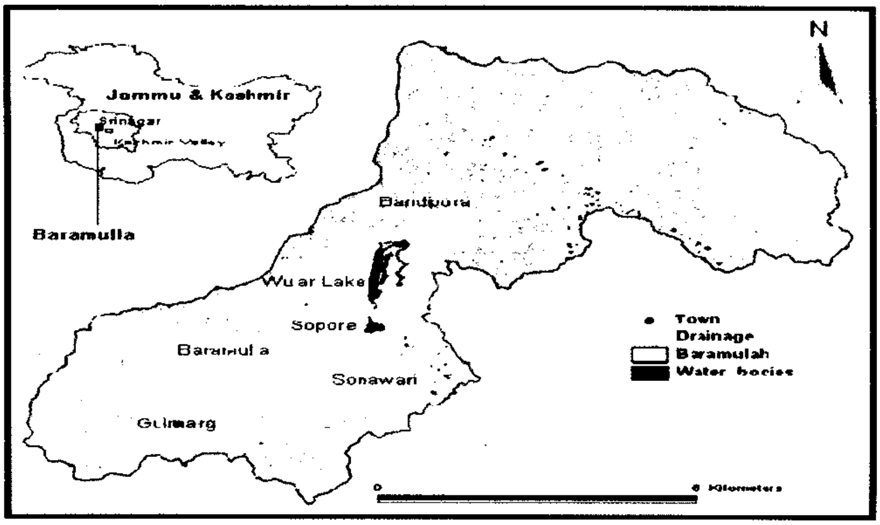


Fig. 1. Study area map

MATERIAL AND METHODS

Groundwater samples (n=82) were collected in high density polyethylene (HDPE) bottles from dug wells / hand pumps and springs across district Baramulla in September - October 2004. The temperature, pH and electrical conductivity (EC) were determined in the field with the help of digital water analysis kit. For major ion characterization the samples were filtered through <0.45 μm nucleopore filter paper and brought to the laboratory. The samples were analyzed for the major ions as per the standard methods (APHA, 1998). CO_3^- and HCO_3^- were determined by titrating with HCl. Total hardness as $CaCO_3$ and Ca^{++} were analysed titrimetrically, using standard EDTA. Magnesium (Mg^{++}) was calculated from the total hardness and Ca^{++}. Cl^- was determined by standard $AgNO_3$ titration. Flame emission photometry has been used for the determination of Na^+ and K^+. Sulphates and Nitrates were determined by spectrophotometry.

RESULTS AND DISCUSSION

Groundwater in Baramulla district (Table 1) is slightly acidic to alkaline (pH: 6.0 –

8.5) with low electrical conductivity (43-900 µS/cm) and total dissolved solids (TDS: 28 – 576 mg/l). The concentrations of cations, Ca^{++}, Mg^{++}, Na^{+} and K^{+} ranged from 3.5 to 282.2 mg/L, 0.9 to 157.1 mg/L, 3.5 to 282.2 mg/L and 0.5 to 300.9, respectively and the concentrations of anions, Cl^{-}, HCO_3^{-} and SO_4^{--} ranged from 7.1 to 248.5 mg/L, 60 to 830 mg/L and 0.8 to 344.7 mg/L.

Evolution of water and relationship between rock types and water composition can be evaluated by the Piper trilinear diagram (Piper, 1944), which is very useful in determining chemical relationships in groundwater in more definite terms than possible with other plotting methods (Walton, 1970). The piper diagram is an ingenious construction, which consists of two triangular diagrams at the lower left and lower right, describing the relative composition of cations and anions and an intervening diamond-shaped diagram that combines the composition of cations and anions. The plot of chemical data on trilinear diagram (Fig. 2), reveals three major chemical water types were present; Ca-Mg-HCO_3 type, Ca-Mg-SO_4 (Cl) type (hybrid type) and Na-HCO_3 type. Most of the groundwater samples (84%) were Ca-Mg-HCO_3 type (Bartarya, 1993; Datta and Tyagi, 1996) reflecting its young age and characterized by active groundwater flushing (Freeze and Cherry, 1979). This water type is normally evolved from the soil zone and the solubility of calcite and dolomite (Garrels and Mackenzie, 1971; Stumm, 1992). The groundwater samples (16%) belonged in other two water types reflects rock-water interaction at deeper level and/or anthropogenic activity. As groundwater samples were collected from shallow aquifer the major source of these water types may be anthropogenic.

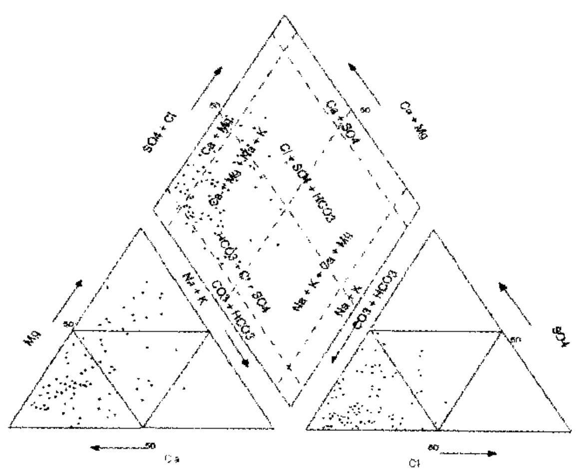


Fig. 2. Piper trilinear diagram showing broad water types

Table1. Chemical analysis of groundwater samples from District Baramulla

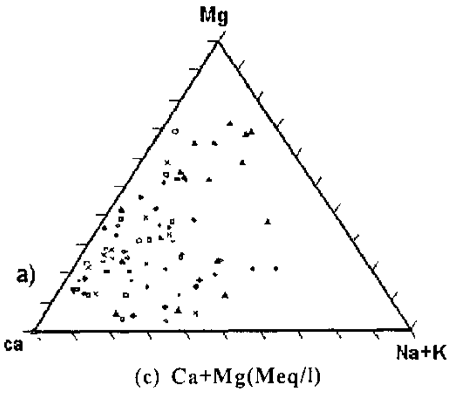
S.No	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Cl mg/l	So4 mg/l	Hco3 mg/l
(1)	282 2	66 7	115	66	248.5	248.2	830
(2)	68.9	1.9	39	8.6	19.8	19.8	260
(3)	221 2	99.1	60	8.6	204.4	204.4	575
(4)	129.8	42.8	74	17	99.4	53.5	650
(5)	136 3	14 6	22.5	-	24.14	64.8	440
(6)	28 8	10 7	2.5	-	7.1	9.2	155
(7)	125.1	16.1	80.5	17.9	9.94	195.9	380
(8)	86.7	11.8	5	-	7.1	36.7	275
(9)	104.2	27.7	22	-	7.1	64.8	360
(10)	229.5	54.1	39	80.5	142	340.6	365
(11)	101.8	79.5	28	-	18.46	283.6	355
(12)	229.5	36.76	75	107.9	116.4	344.6	485
(13)	363.9	86.8	5	-	142	283.6	965
(14)	160.3	43.8	106	68.7	142	344.6	440
(15)	173.4	68.3	53	-	21.3	216.3	805
(16)	218.3	98.7	102	-	117.8	344.6	830
(17)	102.6	25.3	24.5	-	15.6	25.5	400
(18)	51.3	11.7	3.2	1.5	12.2	43.6	145
(19)	68.9	26.3	74	-	7.1	31.2	380
(20)	27 3	157.1	103	-	150.5	191.6	630
(21)	32.1	121.9	51 4	3.2	66.7	43.1	660
(22)	16.8	79 5	27	20.2	21.3	89.7	455
(23)	38.5	44 9	100	-	38.3	32.7	465
(24)	27 3	56 1	15.5	10 2	9.9	36.2	375
(25)	98.6	22.4	31 5	-	12.7	59.6	330
(26)	80.2	30.2	13.5	-	12.7	35.9	395
(27)	36.2	58.1	1.35	-	22.7	20.6	370
(28)	17 6	42.7	18.4	32.2	12.7	4.3	365
(29)	3.5	36 1	23.5	8.6	22.7	82.6	217
(30)	60.1	59.9	32.5	-	28.7	15.7	480
(31)	63.3	63 4	7.5	-	29.8	21.2	505
(32)	44.9	1.9	5.5	4.6	14.2	8.88	140
(33)	61.7	28 7	4	-	14.2	19.9	295
(34)	113.1	7.7	45	37	49.7	32.8	425
(35)	84.9	14.6	65	63	56.8	149.8	325
(36)	92.9	9.7	5.5	-	17.1	-	330
(37)	137.1	13.1	8	-	25.6	43.1	350
(38)	29 6	1 1	10	-	11.4	7.2	95
(39)	20 1	6.3	8	8.6	19.8	1.4	110
(40)	31.3	5.8	2	-	17.1	3.1	125
(41)	28.1	2.9	1.5	-	11.36	-	90
(42)	49.7	8.8	3	8.6	14.2	2.2	175
(43)	24.1	8.3	6	-	19.8	3 4	110
(44)	31 5	6 8	3 2	-	19.8	5.6	125
(45)	36 1	6 8	5 5	8 5	25 6	-	115
(46)	24.8	21 9	10	-	25 6	7 7	150
(47)	19 2	6 8	2	8 6	19 8	6.4	75
(48)	16 1	8.3	3	8.6	34 1	4 1	60
(49)	72.9	19 1	3	8 6	25.6	5.5	290
(50)	22.4	20.1	6	-	25 6	3.6	110
(51)	22.4	2.4	2	8.6	28 4	1 1	70
(52)	41.7	10.7	4	-	17.1	6 5	165
(53)	16.1	24.8	4.5	-	25.6	4.4	125
(54)	52.1	4.8	1.5	8.6	22.7	-	145
(55)	54.5	21.9	5.5	-	25.6	21.6	200
(56)	76 2	13.6	38	42.9	56	6.26	375
(57)	200.4	19.4	20	-	99.4	139.7	385
(58)	108.2	44.8	105	93.7	210.1	151.1	475
(59)	128.5	5.2	40	17.9	48 2	11 5	475
(60)	163 5	23.8	57	17.2	59.6	21.1	685
(61)	121.8	9 7	71	-	48.2	92.1	453
(62)	55.3	11.7	37	17.2	59.6	15.2	243
(63)	90.6	47.3	54	82.8	48 2	112.8	725
(64)	63.3	6 3	10.3	-	51.1	5 1	227
(65)	98.6	38 5	47	92.6	136 3	44 1	605
(66)	118.6	65.3	35	-	25.5	170.1	355
(67)	185.2	26.7	14	-	105.5	35.1	650
(68)	118.6	62.3	53	42.9	99.4	191 1	425
(69)	52.9	26.8	7	-	22.7	35.1	210
(70)	75.4	42.9	10	-	176	150.8	225
71)	44.1	41 9	12	17.2	31.2	77.8	215
(72)	115.4	69.3	53	51.6	241.4	116.7	375
(73)	157.1	68.3	73	8.6	195.9	91.1	560
(74)	18.4	4.4	2	8.6	11.4	4.1	76
(75)	33.5	34.6	8	-	12 7	75.9	151
(76)	40.8	9.3	6.5	-	8.5	3.1	196
(77)	23.6	6 8	3	-	8 5	15.5	106
(78)	44.8	11.6	9.1	-	8.5	1.1	196
(79)	26.5	4 8	1	-	9.9	5.8	91
(80)	23 2	1.5	19	-	8.5	2.6	140
(81)	28.1	6.8	4	-	11.3	12 9	125
(82)	64.1	17 1	8	-	7 1	17 9	260
(83)	36 1	17.1	9	-	12.7	1 8	170

To study the relative importance of different weathering regimes, binary plots are plotted, (Ca + Mg) is plotted against HCO_3 (Fig. 3a). In this plot most of the samples fall on the 1:1 equiline Indicating carbonate lithology as the main contributor of major ions (Jeelani and Shah, 2006; Sarin *et al.*, 1989; Sarin and Krishnaswami, 1984). However, some points that do not fall on the equiline suggest that Ca and Mg occur as sulphates too (Fig 3b). The abundance of various ions can be modelled in terms of weathering of various rock forming minerals (Singh and Hasnain, 1999).

In the plot of Ca + Mg vs TZ+ plot (Fig. 3c) samples lie below the trend line depicting some contributions from alkalies to the major ions supplied by silicate weathering (Zhang *et. al.*, 1995). The Ca + Mg vs Na + K plot (Fig. 3d) suggest carbonate lithology as the dominant source of major ions (Jeelani, 2005). The dominance of carbonate rocks, volcanics and unconsolidated fluvio-lacustrine sedimentary deposits in the study area also favor intake of Ca and Mg by Groundwater (Jeelani, 2005). The excess Na in some samples suggests that the ions result from the silicate weathering, dissolution of soil salts (Stallard and Edmond, 1983; Sarin *et. al.*, 1989) and or anthropogenic activity.

In the triangular plot of cations (Fig 4a) most of the data falls towards Ca-Mg side, reflecting carbonate lithology as the dominant source of ctions. It is interesting to note that the samples with high concentration of Na also show an increase in Cl concentration reflecting the anthropogenic inputs; the field survey also favors the anthropogenic inputs at these sites. The dominance of HCO_3 in the anion is evident from the ternary plot (Fig, 4b) Bicarbonate is mainly supplied by the soil zone and the solubility of calcite and or dolomite (Singh and Hassnain, 1998) reflecting carbonate weathering; Cl next in abundance to HCO_3 followed by SO_4.

(a) Ca+Mg(Meq/l) (b) Ca+Mg(Meq/l)



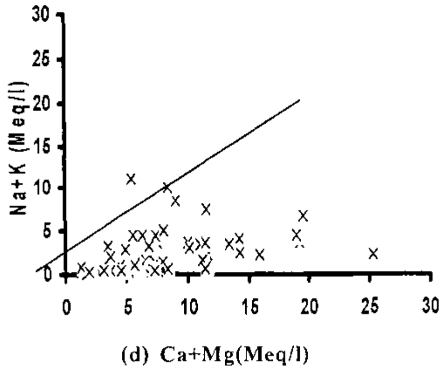
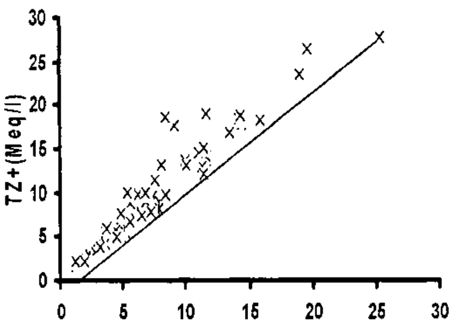


Fig. 3. Scatter diagrams between (a) Ca+Mg vs HCO3; (b) Ca+Mg vs HCO_3+SO_4; (c) Ca+Mg vs TZ⁺; (d) Ca+Mg vs Na+K showing possible liganding of the major ions



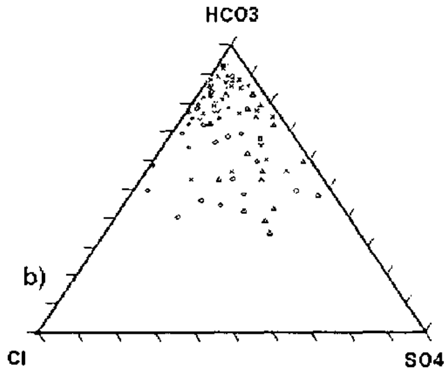


Fig. 4. (a) Ternary cation plot (b) Ternary anion plot

Drinking Quality

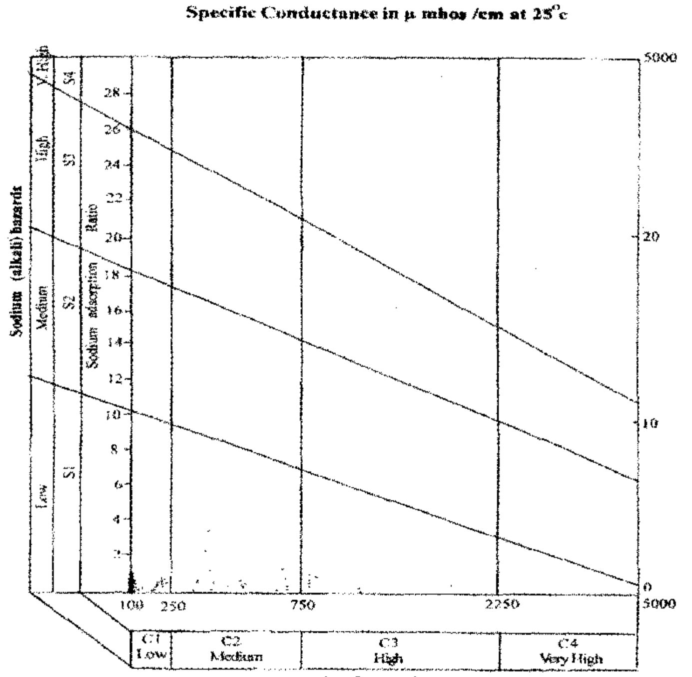
Water for drinking and domestic purposes should be colorless odorless and free from turbidity. The ground water of the study area is odorless and free from visible impurities/ turbidity. Chemical analysis suggests that most of the constituents fall within the permissible limit (Table 2) set by W.H.O, 1984 except Ca, mg and K which are attributed to sewage and dissolution of soil and rock especially limestone, Dolomite and gypsum. Ca and Mg cause hardness and most of the scale-forming properties of water; usually have no effects on suitability of water for irrigation or stock water. Higher concentrations of K give a salty taste when combined with chloride. For most purposes moderate levels have little effect on the use of water.

Table 2. Range of chemical constituents in ground water samples and their comparison with W.H.O (1984) drinking water standards

Constituents	Minimum	Maximum	Average	Permissible limit W.H.O (1984)
pH	6.0	8.5	7.25	6.5-8.5 mg/l
Ca mg/l	3.5	282.2	142.9	200 mg/l
Mg mg/l	0.9	157.1	79	50 mg/l
Na mg/l	3.5	28.2	15.9	200 mg/l
K mg/l	0.5	300.9	150.7	12 mg/l
Cl mg/l	7.1	248.5	127.8	250 mg/l
HCO3 mg/l	60	830	445	
SO4 mg/l	0.8	344.7	172.8	400 mg/l
Ec µmhos/cm	43	900	471.5	1400 µmhos/cm
T.D.S mg/l	320	576	448	1000 mg/l

Irrigation Quality

In order to study the suitability of water for irrigation use E.C and Sodium absorption ratio (SAR) were plotted against each other on U.S salinity laboratory hazard diagram (1954) (Fig. 5), most of points fall in C1S1 faces (low), few in C2S1 faces (medium) and C3S1 faces (high), indicating low, medium to high salinity. Most of the groundwater from the area is good for irrigation except few sample locations where the water shows high saline and high sodium content.



Salinity Hazards

Fig. 5. USA Salinity Hazard Diagram

CONCLUSIONS

From the geochemical investigation of groundwaters from Baramulla District, following conclusions were drawn.

(a) The groundwater from the district is slightly acidic to alkaline, low electrical conductivity and low dissolved solids.

(b) Varied lithology and anthropogenic activities showed impact on groundwater

(c) Most of the groundwater samples were where within the permissible limit of drinking water standards (W.H.O, 1984)

(d) Most of the ground water was found to be excellent for irrigation

Thus, the analytical data from the study area confirm; ground water present in the area is suitable for domestic and irrigation purposes with few exceptions, however the waters must be analyzed for Bacteriological counts prior to its use.

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