

LIMNOCHEMISTRY OF THREE FRESHWATER SPRINGS OF KASHMIR HIMALAYA

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ABSTRACT

The present investigation was carried out during 2005-2006 on three limnocene freshwater springs located in single groundwater area in Kokergund (Yaripora) of District Kulgam, Kashmir. A perusal of the data showed that these springs were hard water type with slightly lower values of DO (1.2-6.4 mg/L). The ionic composition of the spring waters revealed the predominance of bicarbonate and calcium over the other ions with usual ionic progression as $\text{HCO}_3^- > \text{Ca}^{++} > \text{Mg}^{++} > \text{Na}^+ > \text{K}^+$. None of the parameters studied floated the standards set by W.H.O. for drinking water quality. However, relatively higher values of $\text{NO}_3\text{-N}$ (2500-3900 $\mu\text{g/L}$), but well within the permissible limits of W.H.O. were observed in the present study. The dissolved silica did not show any temporal variation between the different months but exhibited slight spatial variations (17.8-21mg/L).

Key words: Limnochemistry, water quality, groundwater, Kashmir Himalaya

INTRODUCTION

Traditionally, springs have been considered as old, uniform, isolated and fairly constant aquatic systems promoting speciation processes in a variety of taxonomic groups (Nielsen, 1950, 1951; Hubbs, 1961). From a physico-chemical point of view, Roca (1990) classified more than two hundred Pyrenean springs into several typological categories, showing the relation between spring features and underlying lithology, but also stressing the

individual characteristics that springs developed independently of the geology of the area. Water, one of the basic requirements for life, is scarcely available in the most of the towns located on hill tops. People in the valleys are facing acute shortage of drinking water and the rivers flowing in the deep valleys can provide water only through pumping which entails appreciable costs. Under these conditions, springs yield a cost-effective solution to the water problem. The importance of natural springs as a source of drinking water in high altitude regions of the Himalaya is well documented (Singh and Pande, 1989). In the past, natural springs were the only source of drinking water and even now the spring water is consumed by the surrounding population irrespective of its quality because the ever-increasing demand is hard to fulfill through public water supply schemes on account of the decreasing water discharge. Therefore, the water of springs, though under immense pressure, is still in use and fulfills over 45% of the demand of rural inhabitants. The springs can be considered as representative of ground water (Magaritz *et al.*, 1990) and chemical composition of these water bodies varies with geological formation (Drever, 1982).

The vale of Kashmir once known for its vast array of springs with sparkling waters is losing many of these not only in size and number but many are deteriorating in water quality. Ecological and anthropogenic factors, however, induce some changes in its quality (Mahajan, 1989). Moreover, our knowledge of spring ecosystems in Kashmir valley is very little and only few preliminary reports on spring ecology are available (Qadri and Yousuf, 1979; Rashid, 1982; Yousuf *et al.*, 1983; Bhat and Yousuf, 2002; Latief *et al.*, 2003; Pandit *et al.*, 2001, 2002, 2005a &b, 2007). It is in this backdrop, baseline data on water quality of three limnocene springs in Kashmir Himalaya was carried out.

STUDY AREA

The three springs namely Nagrad, Tumbernag and Khudanag in village Kokergund Yaripora fall within the geocoordinates 33°.44'N latitude and 075°.01' E longitude and are of alluvial type, with mean annual discharge of 0.401 L/s, 0.17 L/s and 0.299 L/s respectively falling in sixth order classification of Meinzer (1923) based on discharge (Table 1). The immediate catchments of these springs are settlements with

a population of about 1100 people in this village. The catchment outside the settlements is comprised of both agriculture and horticulture. Land utilization in the catchment has changed significantly over the years due to conversion of agriculture into horticulture because of droughts/ water shortages and also settlements as a result of population increase.

MATERIAL AND METHODS

Three limnocene freshwater springs namely Nagrad, Tumbernag and Khudanag were chosen for detailed study during 2005-2006. The parameters like pH, conductivity were measured with digital pH metre and conductivity metre respectively while DO was estimated by Winkler's titration method. The parameters Cl, alkalinity and hardness were measured by titrimetry methods while nitrogen, phosphorus, silica, sulphate and sodium and potassium were analyzed by spectrophotometric and flame photometric methods respectively (Golterman and Clymo, 1969; APHA, 1998; and Wetzel and Likens, 2000). Geocoordinates and elevation were determined with GPS. Statistical analysis was conducted using multivariate statistical package programme version no. 12.

Table1.General characteristics of three limnocene freshwater springs in Kokergund Yaripora, Kulgam

Parameter	NAGRAD	TUMBERNAG	KHUDANAG
Altitude m(a.s.l)	1,665m	1,667m	1,667m
Lat. & Long.	33°44'N;075°.01'E	33°44'N;075°.01'E	33°44'N;075°.01'E
Mean annual discharge L/s	0.401	0.172	0.299
Spring order (Meinzer, 1923)	6	6	6
Spring type I.(Meinzer,1923)	Gravity-Contact type	Gravity-Contact type	Gravity-Contact type
(a) Hydraulic characteristics	Pool type	Pool type	Pool type
(b)Topography			
(c)Permanence	Perennial	Perennial	Perennial
(d)Character of opening	Filtration type	Filtration type	Filtration type
Spring type II. Thieneman (1924)	Limnocene	Limnocene	Limnocene
Spring area(1-5)*	3	1	2
Naturalness(0-3)**	2	2	2
Substrate composition	pebble,gravel, Sand,and less organic matter	gravel with Less sand	gravel, sand, Mud, and organic matter

*Classes of spring area are: 1=<5m², 2= 5-10m², 3= 10-20m², 4=20-40m² and 5= 40-100m²

**Spring naturalness is:

1 = severe pressure/ damage from humans in spring or vicinity.

2 = minor pressure/ damage in or near the spring.

3 = almost or totally undisturbed spring in its surrounding.

RESULTS AND DISCUSSION

The data obtained for different hydrochemical parameters are presented in Tables1-4. The pH of the investigated springs varied between 7-7.16 throughout the sampling period. These

values of pH are in consonance with the findings of Afroz *et al.* (1986) who reported the pH in the 24 springs of Imamganj (U.P.) in the range of 7.3-8.0.No significant changes were observed in water pH during the different

seasons and it was found well within the desirable limits (6.0-8.0) for drinking water as specified in the guidelines of the World Health Organization (Fresenius *et al.*, 1988).

The electrical conductivity of the springs exhibit a variation within the range of 411-556µs/cm. The electric conductivity values does not show any significant variation during the seasons. The relatively higher values of conductivity in these springs, in general, may be due to contamination from domestic sewage

and inorganic fertilizer inputs. Similar results have been reported by Kumar *et al.* (1996).

The DO in the studied springs during the monitoring period revealed a variation within the range of 1.2 -6.4 mg/L. The seasonal trend is not much pronounced but slightly low concentration of DO during August and September may be attributed to slightly increase in water temperature. Similar observations have also been observed in springs of Almora town by Kumar *et al.* (1996).

Table 2. Limnochemistry of Nagrad freshwater spring 2005-2006

Month	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Mean	SD
pH	7.09	7	7.16	7.16	7.02	7	7.08	7.06	7.14	7.13	7.09	7.1	7.09	0.06
Conductivity (µs/cm)	551	517	494	561	519	476	488	520	527	540	556	508	521.42	27.22
DO (mg/L)	4.8	6.4	6.4	3.2	5.6	5.6	4.8	6.4	6.4	5.6	6.4	6.4	5.67	0.99
Cl(mg/L)	14	30	38	24	30	27	23	21	22	20	23	21	24.42	6.14
Alkalinity(mg/L)	130	160	144	140	128	132	128	126	134	124	130	128	133.67	10.08
T.H(mg/L)	280	240	244	320	220	260	240	220	200	260	220	220	243.67	32.83
C.H(mg/L)	254	230	231	287	200	214	210	168	178	220	174	189	212.92	34.83
Mg .H(mg/L)	26	10	13	33	20	46	30	52	22	40	46	31	30.75	13.38
Ca++(mg/L)	101	92	92.4	114	100	85.6	84	67.2	71.2	87.99	70.4	75.6	86.78	14.16
Mg++(mg/L)	6.31	2.43	3.15	8.01	4.86	11.2	7.29	12.6	5.34	9.72	11.17	7.53	7.47	3.25
Sodium(mg/L)	7.5	4	5	3	10	12.6	8.5	10.5	11	8.2	12.5	10.5	8.61	3.21
Potassium(mg/L)	5	1	2	0	1.25	2.7	1.5	3	2.5	2.5	4	3.5	2.41	1.38
Nitrate-N (µg/L)	2800	3900	3810	3660	3640	3110	3270	3800	3900	3800	3580	3720	3582.50	345.02
Ammonia(µg/L)	43	356	250	480	285	10	120	135	100	60	125	28	166.00	146.09
Orthophosphorus(µg/L)	48	26	77	34	75	44	76	51	68	64	65	76	58.67	17.64
Total Phosphorus(µg/L)	180	180	300	450	580	560	440	545	475	490	415	440	421.25	134.86
Sulfate(mg/L)	1.8	5.6	5.6	9.8	12	11.3	7.8	7	6.6	9.5	9.9	7.8	7.89	2.84
Silicate(mg/L)	21	16.2	15.6	17.3	16	15.2	16.5	17	16.8	16.2	15.8	17.5	16.76	1.50

Table 3. Limnochemistry of Tumbernag freshwater spring 2005-2006

Month	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Mean	SD
pH	7.08	7.1	7.12	7.16	7.1	7.09	7.1	7.08	7.09	7.1	7.12	7.144	7.11	0.02
Conductivity (µs/cm)	449	445	430	444	460	435	460	470	438	444	485	465	452.08	16.14
DO (mg/L)	4.8	4.2	3.6	3.4	1.2	3.8	3.8	4	4.2	3.8	3.8	3.6	3.68	0.86
Cl(mg/L)	19	20	22	23	24	18	18	19	18	19	20	21	20.08	2.02
Alkalinity(mg/L)	240	320	360	240	320	280	300	260	240	260	280	300	283.33	37.98
T.H(mg/L)	220	240	220	240	260	240	220	200	240	220	210	230	228.33	16.42
C.H(mg/L)	168	210	189	207	210	168	168	130	210	150	150	136	174.67	29.90
Mg .H(mg/L)	52	30	31	33	50	72	52	70	30	70	60	94	53.67	20.49
Ca++(mg/L)	67.2	84	75.6	82.8	84	67.2	67.2	52	84	60	60	54.4	69.87	11.96
Mg++(mg/L)	12.6	7.29	7.53	8.01	12.15	17.5	12.63	17	7.29	17.0	14.5	22.8	13.04	4.98
Sodium(mg/L)	6	5	8	5	14	12	10	9	8	10	6	6	8.25	2.86
Potassium(mg/L)	2	1	3	0	1	4	2	1	3	1	0.8	0.5	1.61	1.20
Nitrate-N (µg/L)	3610	2500	3690	3660	3270	3610	3310	3655	3665	3620	3200	3220	3417.50	347.36
Ammonia(µg/L)	576	200	420	300	183	330	285	580	187	170	332	168	310.92	147.86
Orthophosphorus(µg/L)	37	34	14	19	67	44	67	46	48	66	51	41	44.50	17.30
Total Phosphorus(µg/L)	460	412	490	475	150	450	450	440	435	435	455	395	420.58	88.93
Sulfate(mg/L)	2.6	3.8	1.6	3	1	1.8	1.6	3.2	1.7	5.2	2.8	2.7	2.58	1.16
Silicate(mg/L)	15.8	16.6	15.9	15.6	15.5	16.5	16	16.8	17.8	16.3	17	18.1	16.49	0.83

Table 4. Limnochemistry of Khudanag freshwater spring 2005-2006

Month	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Mean	SD
pH	7.14	7.06	7.07	7.13	7.04	7.1	7.15	7.12	7.13	7.16	7.08	7.1	7.11	0.04
Conductivity (µs/cm)	439	426	411	496	465	426	470	480	486	478	465	455	458.08	26.94
DO (mg/L)	4	4.2	4	4	3.2	3.8	3.8	3.6	4	4.2	4	3.8	3.88	0.28
Cl(mg/L)	24	26	39	29	27	21	23	22	21	26	24	23	25.42	4.93
Alkalinity(mg/L)	140	140	144	124	120	140	144	136	150	138	174	138	140.67	13.36
T.H(mg/L)	240	260	244	270	220	240	240	230	270	230	250	230	243.67	16.11
C.H(mg/L)	210	231	231	231	210	199	185	145	165	195	190	149	195.08	30.14
Mg .H(mg/L)	30	29	13	39	10	51	65	85	105	35	60	81	50.25	29.68
Ca++(mg/L)	84	92.4	92.4	92.4	84	75.6	74	58	66	78	76	59.6	77.70	12.07
Mg++(mg/L)	7.29	7.04	3.15	9.47	2.43	12.4	15.79	20.7	25.5	8.5	14.58	19.68	12.21	7.21
Sodium(mg/L)	8	12	22	2	16	12	8	10	15	9	8	12	11.17	5.02
Potassium(mg/L)	2	2	4	1	0.5	2	2	3	4	1	1	2	2.04	1.14
Nitrate-N (µg/L)	3720	3790	3750	3300	3780	3660	3760	3690	3300	3675	3810	3830	3672.08	181.65
Ammonia(µg/L)	188	300	340	175	255	317	177	120	175	200	285	305	236.42	71.97
Orthophosphorus(µg/L)	29	26	24	20	59	28	48	51	34	26	48	61	37.83	14.60
Total Phosphorus(µg/L)	475	450	270	425	440	430	470	435	460	460	480	495	440.83	57.91
Sulfate(mg/L)	1.7	1.8	1	3	1	1.8	1.2	1	1	2.9	2.8	1.7	1.74	0.77
Silicate(mg/L)	15.9	15.6	15.3	16.2	15.3	15.9	15.8	15.2	15.3	15.8	16	15.9	15.68	0.33

The chloride concentration of spring water showed a fluctuation of 14 mg/L to 39mg/L

throughout the sampling period. The mean annual values for chloride concentration in three

springs varied between 20.08 and 25.42 mg/L. This small variation in the chloride indicates the same recharge zone and source of impurities that add the chlorides to the groundwater. Seasonal variation in chloride is slightly significant as higher values of chloride was found in July because of more domestic and cultural activities in the immediate catchment during the summer.

The bicarbonate alkalinity for the three springs ranged between 120 and 360 mg/L while the mean annual values fluctuated from 133.67 to 283.33 mg/L. The alkalinity does not show any specific seasonal trend. However, the assimilation of carbon dioxide from rain water and the lacustrine origin of the valley may be the probable cause of increasing HCO_3^- concentration (Wadia, 1961).

The hardness values fluctuated between 200 and 320 mg/L, thereby indicating hard water nature of the springs (Moyle, 1945). The mean annual values ranged between 228 and 243 mg/L, being highest in Nagrad and Khudanag and lowest in Tumbernag (Tables 1-3). The hardness directly seems related to the source of Ca^{++} and Mg^{++} which owes its origin to the lacustrine deposits in the valley (Wadia, 1961).

Calcium and magnesium accounted for most of the hardness. The spring water depicted the ranges of 52-114 mg/L for calcium, 2.43-25.51 mg/L for magnesium, 3-22 mg/L sodium,

and 0.5-4 mg/L potassium. In general, the ionic composition of the spring waters revealed the predominance of bicarbonate and calcium over the other ions and, therefore, the usual ionic progression was: $\text{HCO}_3^- > \text{Ca}^{++} > \text{Mg}^{++} > \text{Na}^{++} > \text{K}^+$ which brings it close to the well known sequence for global freshwaters (Rhode, 1969). However, relatively higher values of sodium were found in these springs, which may be attributed to domestic sewage, being discharged directly into the immediate catchment of these springs, a fact also revealed by Sharma *et al.*, (1999).

The $\text{NO}_3\text{-N}$ and $\text{NH}_3\text{-N}$ varied between 2500-3900 $\mu\text{g/L}$ and 10-580 $\mu\text{g/L}$ respectively throughout the study period. $\text{NO}_3\text{-N}$ is an important drinking water standard and its higher concentration is fatal for infants (Steel and McGhee, 1984). The WHO standards prescribe 10 ppm as maximum permissible nitrate concentration for potable water (Fresinius *et al.*, 1988). However, the spring waters studied fall within permissible limit. Relatively the higher concentration of nitrogen compounds may be due to domestic sewage (Voznaya, 1981; Suzukie *et al.*, 1992; and Chhathawal *et al.*, 1989) which enter into groundwater through leaching from soil. The nitrate values indicate the influence of agriculture activities due to the application of urea as a major inorganic fertilizer. Presence of ammonia in water indicates pollution of recent

origin as a result of ammonification where as nitrates in water suggests that some time has already elapsed during which nitrification has taken place and the water has got purified itself to some extent. The $\text{NO}_3\text{-N}$ is considered to be highest oxidized form of nitrogen in water and wastewater (Metcalf and Eddy, 1979).

The ortho-phosphate phosphorus concentration fluctuated between 20 and 77 $\mu\text{g/L}$, highest being recorded in summer and lowest during autumn. However, the total phosphorus ranged between 150 and 580 $\mu\text{g/L}$ with highest in autumn and lowest in summer. Among the three springs Nagrad spring exhibited peak levels of total phosphorus (580 $\mu\text{g/L}$) during autumn season. The mean values of orthophosphorus and total phosphorus for the spring were in the range of 37.83-58.67 $\mu\text{g/L}$ and 420.58-440.83 $\mu\text{g/L}$ respectively which are higher than the values (OPP; 7-44 $\mu\text{g/L}$; TP; 45-107 $\mu\text{g/L}$) recorded in Irish Karst springs by Kilroy and Coxon (2005). Total phosphorus upto 1,814 $\mu\text{g/L}$ due to local pollution (silage clamp) located upgradient of these springs has also been reported. Phosphorus has been overlooked primarily because the maximum admissible concentration (5000 $\mu\text{g/L}$ P_2O_5) for drinking waters under the directive on water intended for human consumption (CEC, 1980) is rarely approached except in areas of gross localized contamination. The revised directive on water

intended for human consumption according to CEC (1998) does not contain any limit for phosphorus. However, in surface waters the concern with phosphorus is at much lower concentration. Annual mean total phosphorus concentration in excess of only 20 $\mu\text{g/L}$ may trigger eutrophication in some lakes (Champ, 1998). The OECD model suggests threshold of 35 $\mu\text{g/L}$ for eutrophic lakes (OECD, 1982). However, our results are well in consonance with Imbach (1993) who reported concentration of phosphate ranging from 190-880 $\mu\text{g/L}$ for karstic springs in the Çekirge-Bursa area of Turkey while Elhatip (1997) reported concentration of phosphate ranging from 70-90 $\mu\text{g/L}$ for the Pamukkale thermal karst springs in Turkey. All the springs display the presence of sulfates in waters. The concentration varies from 1.0-9.9 mg/L. The values obtained for these three springs revealed significant differences. Lower concentrations were observed in Khudanag and Tumbernag (1.74 mg/L and 2.58 mg/L) against Nagrad (7.89 mg/L). The relatively higher concentration of sulfate in Nagrad may be correlated to the sewage, a source of sulfur in water (Metcalf and Eddy 1979). The ranges of sulfate in the springs were lower when compared to 1.1-62.5 mg/L, being reported by Jeelani (2004) and (29.7-57.5 mg/L) as obtained by Smith and Wood, (2002). The reason for low sulphate values in these springs may be

attributed to rock formation impregnated with low concentration of CaSO₄ which is reflected in the water chemistry especially when the water is issuing from underground sources (Cole, 1979).

The dissolved silica did not fluctuate much and showed a little constancy, exhibiting values between 17.8 and 21mg/ which are higher than the values reported by Crowe and Sharp (1997;11-12mg/L) and; Pandit *et al.* (2002; 45-8.40mg/L) and lower than reported by Jeelani (2004; 29-39mg/L) and Yousuf and Shah (1988; 8.3-18 mg/L).

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