Limnochemistry of Three Freshwater Springs of Kashmir Himalaya

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Abstract: The present investigation was carried out during 2005-06 on three limnocrene freshwater springs located in single groundwater area in Kokergund (Yaripora) of District Kulgam, Kashmir, India. A perusal of the data showed that these springs were hard water type with slightly lower values of dissolved oxygen (DO) (1.2-6.4mg/L). The ionic composition of the spring waters revealed the predominance of bicarbonate and calcium over the other ions with usual ionic progression as $HCO_3^- > Ca^{++} > Mg^{++} > Na^{+} > K^{+}$. None of the parameters studied floated the standards set by WHO for drinking water quality. However, relatively higher values of NO_3-N (2500-3900µg/L), but well within the permissible limits of WHO, were observed. 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. 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, are still in vogue and fulfill over 45% of the demand of rural inhabitants. The springs can be considered as representative of ground water (Magaritz, Brennen and Ronen 1990) and chemical composition of these water bodies varies with geological formation (Drever 1982:138-162).

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 they are deteriorating in water quality. Ecological and anthropogenic factors, however, induce some changes in their quality (Mahajan 1989). Moreover, our knowledge of spring ecosystems in Kashmir valley is very little. Only a few preliminary reports on spring ecology are available and it is against this backdrop, that a baseline study of water quality of three limnocrene 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 75° 01´E longitude. All three springs are of alluvial type, with a mean annual discharge of 0.401 L/s, 0.17 L/s and 0.299 L/s, respectively, falling in sixth order classification (Meinzer 1923) based on discharge (Table 1). The immediate catchments of these springs are settlements with a population of about 1100 people. 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 as a result of population increase.

Material and Methods

The three limnocrene freshwater springs were chosen for detailed study during 2005-2006. The parameters like pH and conductivity were measured with a digital pH meter and a conductivity meter, respectively, while DO was estimated by Winkler's titration method. The parameters Cl, alkalinity and hardness were measured by tittrimetry 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, Wetzel and Likens 2000). Geo-coordinates and elevation were determined with GPS. Statistical analysis was conducted using multivariate statistical package program (ver. 12).

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

	Parameter	NAGRAD	TUMBERNAG	KHUDANAG
1	Altitude m(a.s.l)	1,665m	1,667m	1,667m
2	Lat. & Long.	33°44´N;075°.01´E	33°44´N;075°.01´E	33°44´N;075°.01´E
3	Mean annual discharge L/s	0.401	0.172	0.299
4	Spring order	6	6	6
5	Spring type I.(Meinzer,1923) (a) Hydraulic characteristics	Gravity-Contact type	Gravity-Contact type	Gravity-Contact type
	(b)Topography	Pool type	Pool type	Pool type
	(c)Permanence	Perennial	Perennial	Perennial
	(d)Character of opening	Filtration type	Filtration type	Filtration type
	Spring type II. Thieneman (1924)	Limnocrene	Limnocrene	Limnocrene
6	Spring area(1-5)*	3	1	2
7	Naturalness(0-3)**	2	2	2
8	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=<5m^2, 2= 5-10m^2, 3= 10-20m^2, 4=20-40m^2 and 5= 40-100m^2

**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.

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
Orthophosphor-us(μg/L)	48	26	77	34	75	44	76	51	68	64	65	76	58.67	17.64
Total Phosph- orus(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

Results and Discussion

The data obtained for different hydrochemical parameters are presented in Tables 1-4. 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, Singh and Singh (1986) who reported the pH in the 24 springs of Imamganj (Uttar Pradesh, India) 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, Quentin and Schneider 1988:725-726).

The electrical conductivity of the springs exhibit a variation within the range of 411-556μs/cm.The electric conductivity values do 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, Rawat and Joshi (1996).

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	17.01	14.58	22.84	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
Orthophosphor-us(µg/L)	37	34	14	19	67	44	67	46	48	66	51	41	44.50	17.30
Total Phosph- orus(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
Orthophosphor-us(µg/L)	29	26	24	20	59	28	48	51	34	26	48	61	37.83	14.60
Total Phosph- orus(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 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 very pronounced, but a slightly low concentration of DO during August and September may be attributed to a slightly increase in water temperature. Similar observations have also been made in springs of Almora town by Kumar, Rawat and Joshi (1996).

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 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 243mg/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, 2.43-25.51mg/L for magnesium, 3-22mg/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: $HCO_3^- > Ca^{++} > Mg^{++} > Na^{++} > K^+$ 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, Mathur and Mathur (1999).

The NO_3-N and NH_3-N varied between 2500-3900µg/L and 10-580 µg/L, respectively, throughout the study period. NO_3-N is an important drinking water standard and its higher concentration is fatal for infants (Steel and McGhee ,1984). The WHO standards prescribe 10ppm as maximum permissible nitrate concentration for potable water (Fresenius, Quentin and Schneider 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, Suzuki, Katsuno and Yamaura 1992; 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, whereas 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 NO_3-N is considered to be highest oxidized form of nitrogen in water and wastewater (Metcalf & Eddy and Tchobanoglous 1979).

The ortho-phosphate phosphorus concentration fluctuated between 20 and 77µg/L, highest being recorded in summer and lowest during autumn. However, the total phosphorus ranged between 150 and 580 µg/L, with highest in autumn and lowest in summer. Among the three springs, Nagrad spring exhibited peak levels of total phosphorus (580 µg/L) during autumn season. The mean values of orthophosphorus and total phosphorus for the spring were in the range of 37.83-58.67 µg/L and 420.58-440.83 µg/L, respectively, which are higher than the values (OPP; 7-44 µg/L; TP; 45-107 µg/L) recorded in Irish Karst springs by Kilroy and Coxon (2005). Total phosphorus upto 1,814 µg/L due to local pollution (silage clamp) located up gradient of these springs has also been reported. Phosphorus has been overlooked primarily because the maximum admissible concentration (5000 µg/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 µg/L may trigger eutrophication in some lakes (Champ 1998).The OECD model suggests threshold of 35 µg/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 µg/L for karistic springs in the Çekirge-Bursa area of Turkey, while Elhatip (1997) reported concentration of phosphate ranging from 70-90 µg/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 2.58mg/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 1.1-62.5mg/L, being reported by Jeelani (2004) and (29.7-57.5mg/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 $CaSO_4$, 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, 45-8.40 mg/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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Introduction of Institutions

Water and Land Management Institute (WALMI)

Water and Land Management Institute (WALMI) was established by the Government of Maharashtra with an aim to create awareness in the minds of water manager about integrated approach towards water & land management with reference to irrigated crops under irrigation project. WALMI, Aurangabad is an autonomous registered society under Irrigation Department. The main objectives of the institute are to provide in-service training of interdisciplinary nature to staff engaged in irrigation water management and land development in irrigation and agriculture departments, Action and adaptive research pertaining to irrigation project commands, providing consultancy services, production of training materials (in print and electronic media), conducting seminars/workshops and organizing farmer's training programs.

It is located in Aurangabad, Maharastra, India. It is widely known as the first and foremost training Institute in Water and land management all over the India. The rich and varied experience possessed by the Institute, well trained and highly qualified faculty members of all disciplines related to irrigation water management, beautiful and well developed infrastructure, well equipped computer center, library and laboratories and above all the dedication and commitment of faculty and other staff of WALMI are some of the distinguishing characteristics.

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IN-SHP
International Network on Small Hydro Power

INTERNATIONAL NETWORK ON SMALL HYDROPOWER (IN-SHP):

The International Network on Small Hydro Power (IN-SHP) was founded in December 1994 and co-sponsored by UNDP, UNDIO and China's government. As one of the Network's founders, The Ministry of Water Resources of China, wanted IN-SHP to serve as a "Window", through which the outside world could understand the state of development of medium and small hydro power in China and promote international cooperation in this field. With the backing of the government of China, IN-SHP acts as the agency for the introduction of foreign investment by: providing technical and economic evaluations of medium and small hydro power projects, introducing those medium and small hydro projects seeking foreign investment to potential investors outside of China, serving as the intermediary between domestic and foreign project partners and in some cases, serving as the domestic executive unit of a project.

The success of IN-SHP has created a unique form of international "triangular" cooperation among developing countries, developed countries and international organizations. The IN-SHP has developed a spirit among its members and staff, which is characterized by high enthusiasm, hard work and commitment, irrespective of the obstacles ahead. It is a splendid result of all the Chinese people's participation in SHP building, inspired by the Chinese government, under the leadership/advocacy of late Mr. Deng Xiaoping. This also signals a new landmark for the SHP development worldwide. For eight years, people around the world, experiencing difficulties, have devoted themselves to their beloved SHP career.

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