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LIMNOLOGICAL INVESTIGATION OF THREE FRESHWATER SPRINGS OF PULWAMA DISTRICT- KASHMIR VALLEY

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Abstract
An assessment on quality and hygienic conditions of spring water was undertaken in Pulwama during 2009.The present investigation was carried out during January 2009 – June 2009 in three limnocrene freshwater springs located in single groundwater area in Pulwama district, Kashmir. A perusal of the data showed that these springs were hard water type with slightly lower values to higher values of DO (1.6-12mg/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^+. The water of all the three springs is used for multipurpose including drinking, irrigation, washing, bathing etc. None of the parameters studied floated the standards set by W.H.O. for drinking water quality.

Keywords: Limnological, Water quality, groundwater, Spring, Kashmir Valley

Introduction

One in three people worldwide live in water-scarce regions particularly in the Middle East and Africa where the water shortages may show prominent signs because of surging populations and climate change. The World Bank report has warned that water availability per person worldwide will drop to half by 2050. Many countries already face crises in meeting water demands, and water rationing, which in turn have long-term effects on economic growth, putting increasing pressure on public budgets. Such a situation is likely to cause poverty and exacerbate social tensions within and between communities. While water shortages are likely to affect Africa and the Middle East first and most seriously, the price of water has been increasing throughout the world. The World Bank has warned that India is on the brink of a severe water crisis (Briscoe, 2005). Nationally, groundwater accounts for about 50–80% of domestic water use and 45–50% of irrigation (Kumar *et al*., 2005; Mall *et al*., 2006). In India, water scarcity has prompted some farmers to profit by selling their water instead of farming. The water they formerly used to irrigate their crops is pumped from their wells and trucked to nearby cities and as such they harvest water rather than food thereby causing dangerously rapid decreases in underground water tables. Consequently, many farmers have given up farming to make more money by selling their water to the cities. On the average, nearly 40% of municipal suppliers worldwide do not charge enough for water to even meet their basic operating costs. In most countries, consumers don't pay the actual cost of water because governments subsidize the water supply. This has some obvious benefits, but under such arrangements, the people don't come to appreciate what they are receiving. Sometimes water is available for almost nothing and this leads to excessive waste; For instance, water revenues in the city of Delhi are less than 20% of what the city spends to provide water and the situation does not seems quite different in many other parts of the world.

Groundwater forms an important source of water supply in rural India. It is often the only source of water supply, particularly in remote villages, where surface water supplies cannot be relied upon for more than a couple of months. With increasingly growing demands on the stock of replenishable groundwater supplies, many areas of rural India have started facing acute water crises, including the drying up of wells and springs in many villages (Rodell, 2009). It is a common practice to tank water to such villages during dry periods for meeting basic drinking water needs. The overall increase in the demand for groundwater has resulted in its overexploitation (Macdonald et al., 1995; Balukraya, 2000). Natural springs are a common source of household water supply to suburban and rural Indian population. It is estimated that almost 50% of Indians are using ground water (especially spring water) for their drinking and domestic needs. 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

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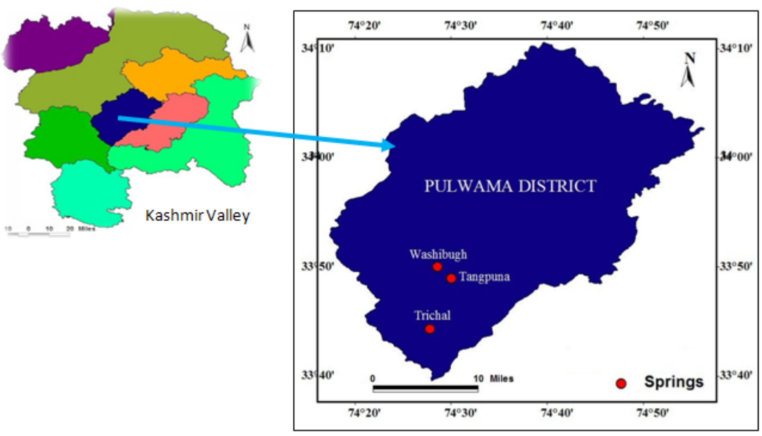
demand is hard to fulfill through public water supply schemes on account of the decreasing water discharge. Therefore, the water springs, though under immense pressure, are still in vogue and fulfill over 45% of the demand of rural inhabitants. The springs can be considered as representative of ground water (Magaritz 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 but also number, and are deteriorating in water quality as witnessed elsewhere in India due to ecological and anthropogenic factors (Mahajan, 1989). The water related health issues remain a major public health problem and the lack of a sufficient quality and quantity of safe drinking water is a risk factor for infectious diseases. Recent assessment of the water quality of the springs by different researchers have found that most of the springs are in good hygienic conditions and are usually fit for drinking water purposes (Qadri and Yousuf, 1979; Rashid, 1982; Yousuf *et al*., 1983; Bhat and Yousuf, 2002; Latief *et al*., 2003; Jeelani, 2004; Pandit *et al*., 2001, 2002, 2005a &b, 2007;Bhat and Pandit, 2010). Moreover, our knowledge of spring ecosystems in Kashmir valley is patchy and only few preliminary reports on spring water and ecology are available. This study on the quality and hygienic conditions of spring water was undertaken to assess the quality and hygienic conditions of spring waters in suburban and urban areas with the aim of generating base line data which will serve as an important tool in the management of these springs for policy makers and is likely to cultivate awareness among the community on safe water use (Salunkhe and Rasal, 1996).

Study area

The three springs namely Tangpana, Washibugh and Trichal in pulwama district fall within the geocoordinates 33°.44´N latitude and 075°.01´ E longitude. All the three springs are of alluvial type falling in eighth order classification based on discharge (Meinzer, 1923) with very low mean annual discharge of 0.008 L/s, 0.001 L/s and 0.002 L/s respectively (Table 1).The immediate catchment of these springs are settlements of urban and suburban areas. The catchment outside the settlements is comprised of both agriculture and horticulture. Land utilization in the catchment has changed significantly which in turn can have an effect on water quality of these springs.Over the years due to conversion of agriculture into horticulture because of droughts/ water shortages and settlements because of population increase.

Fig. 1: Spatial and locational characteristics of the study area



Material and Methods

Three limnocrene freshwater sprizngs namely Tangpana, Washibugh and Trichal were chosen for study during 2009. The parameters like water temperature, pH and conductivity (APHA, 1998) were measured with digital thermometer, pH metre and conductivity metre respectively while dissolved oxygen (APHA, 1998; Wetzel and Likens, 2000) was estimated by Winkler's titration method. The parameters like chloride (Argentimeteric), alkalinity (Titrimetric) and hardness (EDTA titrimetrc method) were measured by tittrimetry methods while ammonical nitrogen (Phenate method),nitrate (Sodium salicylate), phosphorus (Ascorbic acid), dissolved silica (Molybdate blue), sulphate (Turbidimetric method) and sodium and potassium were analysed by spectrophotometric and flame photometric methods respectively (APHA, 1998; Wetzel and Likens, 2000). Geo-coordinates and elevation were determined with GPS.

Table1. General characteristics of three freshwater springs in Pulwama-Kashmir

	Parameter	Tangpana	Washibugh	Trichal
1	Altitude	1665m	1667m	1667m
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	0.008	0.001	0.002
4	Spring order	8	8	8
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 (1922)	Limnocrene	Limnocrene	Limnocrene
6	Spring area(1-5)*	3	4	3
7	Naturalness(0-3)**	2	2	2

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

Results and Discussion

Following the Theineman (1922) classification of springs, all the three springs under study fall under limnocrene category while as on the basis of magnitude of discharge employing the Meinzer (1923) classification of springs, all the three springs happen to fall under spring order 8 because of their low discharge (Table 1). Based on the hydraulic characteristics and character of opening, the springs under study proved to be artesian and fracture type. The springs displayed the mean water temperatures always less than their mean air temperatures (Tables 2-4) and as such are categorized into cold water springs as per the classification of Meinzer (1923), Waring et al. (1965), Reed (1983) and Nathenson et al. (2003).

The data obtained for different hydrochemical parameters is presented in Tables 2-4. The pH of the three investigated springs varied between 6.01-7.22 throughout the sampling period and such a slightly acidic character may be attributed to carbon dioxide and other organic acids. These values of pH are in contradiction to 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 months 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*., 1998). The specific conductance of the springs exhibited a variation within the range of 204-380 µS/cm. The specific conductance values does not show much significant variation during the different months however, relatively higher values of conductivity in these springs in general may be due to contamination from domestic sewage and inorganic fertilizer inputs (Kumar *et al*., 1996).

Table 2. Limnochemistry of Tangpana freshwater spring during 2009.

Month/parameter	Jan.	Feb.	Mar.	Apr.	May	June	Mean	SD
Depth (cm)	100	100	97	98	99	98	98.7	1.2
Air temp (°C)	6	9	14	18	18	16	13.5	5
Water temp.(°C)	8	10	12	12	10	11	10.5	1.5
pH	6.5	6.71	6.84	6.82	6.55	6.88	6.72	0.2
Conductivity (µS/cm)	380	247	236	228	240	248	263	58
Free CO_2 (mg/L)	20	16	18	16	10	18	16	3.4
DO (mg/L)	1.6	2	3.2	4	3.5	3.1	2.9	0.9
Cl(mg/L)	17	30	25	19	26	29	24.3	5.3
Alkalinity(mg/L)	46	42	50	46	48	50	47	3
T.H(mg/L)	48	90	360	182	310	260	208	124
Ca^{++}(mg/L)	33.6	28.56	33.6	35.28	36.96	38.64	34.4	3.5
Mg^{++}(mg/L)	3.4	14.92	79.31	35.65	66.34	53.7	42.2	29.6
Nitrate-N (µg/L)	175	182	189	190	220	280	206	39.4
Ammonia(µg/L)	150	130	120	140	135	122	133	11
Orthophosphorus(µg/L)	8	10	12	14	12	10	11	2
Total Phosphorus(µg/L)	32	35	40	46	48	48	42	7

Table 3. Limnochemistry of Washibugh freshwater spring during 2009

Month/parameter	Jan.	Feb.	Mar.	Apr.	May	June	Mean	SD
Depth (cm)	55.00	55.00	55.00	54.00	53.00	54.00	54.33	0.82
Air temp. (°C)	7	12	11	15	19	17	13.50	4.37
Water temp.(°C)	11	8	9	11	8	10	9.50	1.38
pH	6.67	6.5	6.6	6.54	7.01	7.22	6.76	0.29
Conductivity (µS/cm)	285	286	274	278	283	288	282.33	5.32
Free CO_2 (mg/L)	18	20	16	20	18	16	18.00	1.79
DO (mg/L)	4.4	3.6	3.6	2.8	3.5	3.8	3.62	0.52
Cl(mg/L)	15.98	20.97	39.96	50.94	36.96	42.12	34.49	13.34
Alkalinity(mg/L)	62	66	80	66	68	64	67.67	6.38
T.H(mg/L)	90	160	320	204	260	180	202.33	80.10
Ca^{++}(mg/L)	52.92	24.36	63	36.12	56.28	57.12	48.30	14.83
Mg^{++}(mg/L)	9.01	32.96	62.45	40.79	49.5	9.5	34.04	21.55
Nitrate-N (µg/L)	220	216	238	250	240	260	237.33	16.95
Ammonia (µg/L)	8	12	14	20	18	16	14.67	4.32
Orthophosphorus(µg/L)	2.5	2	4.5	5	8	6	4.67	2.23
Total Phosphorus(µg/L)	22	20	28	34	38	40	30.33	8.33

Table 4. Limnochemistry of Trichal freshwater spring during 2009

Month/parameter	Jan.	Feb.	Mar.	Apr.	May	June	Mean	SD
Depth (cm)	51.00	51.00	51.00	51.00	50.00	50.00	50.67	0.52
Air temp. (°C)	10	5	8	18	17	12	11.67	5.09
Water temp.(°C)	8	9	12	12	10	10	10.17	1.60
Ph	6.01	6.3	6.2	6.53	6.88	6.72	6.44	0.33
Conductivity (µS/cm)	204	320	318	223	330	336	288.50	58.77
Free CO_2 (mg/L)	48	44	40	38	42	46	43.00	3.74
DO (mg/L)	12	8	10	8.5	7	10	9.25	1.78
Cl(mg/L)	10.98	18.98	26.97	36.96	17.98	23.24	22.52	8.89
Alkalinity(mg/L)	48	44	40	38	42	46	43.00	3.74
T.H(mg/L)	186	110	180	100	120	160	142.67	37.35
Ca^{++}(mg/L)	72.24	19.32	47.04	39.48	26.88	29.4	39.06	18.95
Mg^{++}(mg/L)	26.73	22.03	32.4	14.7	17.7	31.7	24.21	7.31
Nitrate-N (µg/L)	120	150	180	190	200	190	171.67	30.61
Ammonia(µg/L)	20	40	70	60	50	45	47.50	17.25
Orthophosphorus(µg/L)	3	5	8	7	4	9	6.00	2.37
Total Phosphorus(µg/L)	19	16	14	15	20	18	17.00	2.37

The DO in the studied springs during the monitoring period reveal a variation range of 1.6 -12 mg/L. The monthly 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 been observed from springs of Almora town by Kumar *et al*. (1996).The chloride concentration of spring water shows a fluctuation of 10.98 mg/L to 50.94 mg/L throughout the sampling period. The mean values for chloride concentration in three springs varied between 22.52±8.89 -34.49±13.34 mg/L. This small variation in the chloride indicates the same recharge zone and source of impurities that add the chlorides to the groundwater. The variation in chloride in 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 38 and 80 mg/L. while the mean values fluctuated from 43±3.74 to 67.67±6.38 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 probable cause of increasing HCO_3^- Concentration. (Wadia, 1961).

The hardness values fluctuated between 48 and 360 mg/L thereby indicating hard water to very hard water nature of the springs (Moyle, 1945).The mean annual values ranged between 142.67 and 208.33mg/L being highest in Tangpana and lowest in Trichal (Tables 2-4).The hardness directly seems related to the source of $Ca^{++}$and Mg^{++} which owes the 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 19.32-72.24 mg/L for calcium, 9.01-79.31mg/L for magnesium. 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^{++} which brings it close to the well known sequence for global freshwaters except Tangpana spring where possibility of calcium leaching occurrs (Rhode, 1969).

The NO_3-N and NH_3-N varied between 120-280µg/L and 8-150 µg/L respectively throughout the study period. Nitrates constitute an important drinking water standard and its higher concentration is fatal for infants (Steel and Mc Ghee,1984).The WHO standards prescribe 10ppm 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; 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 NO_3-N is considered to be highest oxidized form of nitrogen in water and wastewater (Metcalf and Eddy, 1979).

The ortho-phosphate concentration fluctuated between 2 and 14µg/L, highest being recorded at Trichal and lowest at Wasibugh spring. However, the total phosphorus ranged between 14 and 48 µg/L with highest in May and June and lowest in March. The springs usually contain only a minimal phosphorus levels because of the low solubility of native phosphate minerals and the well known ability of the soils to retain phosphate. The relatively lower concentrations of phosphorus in spring waters is attributed to the strong bond formation of phosphate with clay minerals and metal hydroxide as well as its involvement in biological cycle (Mathess 1982)..

Conclusions

The study revealed that these springs were hard water type with slightly lower values to higher values of DO (1.6-12mg/L). The ionic composition of the spring waters revealed the predominance of bicarbonate and calcium over the other ions (except Tangpana) with usual ionic progression as HCO_3^- $>Ca^{++}$ $>Mg^{++}$ $>Na^+$ $>K^+$. The water of all the three springs is used for multipurpose including drinking, irrigation, washing, bathing etc. None of the parameters studied floated the standards set by W.H.O. for drinking water quality or for irrigation purposes. Further, the authors are of the view that such case studies will pave the way of community based efforts in managing groundwater resources which holds the key for sustainable utilization of groundwater. However, these efforts are more of social movements than systematic, scientifically based attempts but will definitely help in community based groundwater management in rural Kashmir.

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