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Water Quality Monitoring of Some Freshwater Springs in Hazratbal Tehsil, Srinagar, Kashmir Himalaya

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ABSTRACT

Some springs in Hazratbal Tehsil were assessed to determine their quality for consumption and usage. As the springs present in that area are most important source of drinking water and is used for agricultural practices and the water is consumed in its natural state without any treatment. Thirty water samples were collected from thirty different springs and physico chemical parameters were analyzed using standard methods. The overall status of spring waters was found to be acidic to highly alkaline and hard water. The ionic composition of spring waters revealed predominance of bicarbonate and calcium over other ions and, consequently, the usual ionic progression was HCO_3^- > Ca^{2+} >Mg^{2+}. Cluster analysis categorized study areas into two main clusters (Cluster 1 and Cluster 2). From cluster analysis it was found that nitrate values was relatively similar between the two clusters, with slight variations within sub-clusters. While calculating the correlation ($p<0.05$) it was found that various parameters like water temperature, pH, DO, nitrate, ortho phosphorous, silicate and total phosphorus was negatively correlated with most of the water parameters. Box plot comparison test of different physico-chemical parameters along different sites was done. Results reveal the springs have good water quality conditions, which fall within the permissible limit prescribed by WHO and BIS. Water quality index results based on various physiochemical parameters showed almost all values were found within permissible and desirable water quality standards.

Key words: *Kashmir, Water chemistry, Cluster analysis, Correlation.*

INTRODUCTION

Springs are a rich source of freshwater for people all over the globe. Importance of these upwelling aquifers is understood in the fact that rural and urban populations depend on their water for a variety of purposes, making them indispensable to communities. Springs have been associated with mineral-rich water, low frequency of pathogenic organisms, less incidence of pollution, while in the same rhythm acting as a valuable reservoir for irrigation, drinking, aquaculture, and even religious purposes. USA has average water footprint per year per capita of 2842 cubic metres, which is enough to fill an Olympic swimming pool, i.e. an average of 7786 litres of water per person per day. Per person per day use is 2934 litres in China. However in India, the water availability per capita is 1720.29 cubic meter per year (Hameed, 2018). Springs are refuge for pollution-sensitive organisms thriving at locations where anthropogenic activities have debarred all other resources of their sheen because these constitute the last polluted natural resource in densely populated areas. In India, Himalayan communities are hugely dependent on spring water, securing water issues at '*groundwater*' level. As spring sustainable development has not given due importance so far. At the same time protective legislation of springs is insufficient leading to water abuse in their natural habitat (Cantonati *et al.*, 2012). The largest user of groundwater in the world is India. The nation uses an estimated 251 cubic kilometres of groundwater per year i.e. over a quarter of the global total. Dependency on groundwater is more than 85% of drinking water supplies and 60% of agriculture. This showcases the importance of groundwater resource in the country. However, the number of aquifers reaching unsustainable levels of exploitation is accelerating. If such a trend continues, in 20 years 60% of all aquifers in India will approach critical status (Engineer, 2018).

Since the early 1980s, people of Kashmir have started to face increasing shortages of water which was unheard of earlier due to modest requirements. The population, like other parts of India, is witnessing an enormous growth which in turn pressurizes the water resources they are hugely dependent upon. The population of Kashmir Valley, as per 2011 census, is 1,25,41,302 which represents 1.04% of the total population of the country. The population of Srinagar district is 12,36,829 (Census of India, 2011). The water requirements for the population of Srinagar city are directly drawn from surface water resources, such as river Jhelum and water bodies like Dal, Nigeen, etc. Hazratbal tehsil, being the area at the urban fringe is experiencing rapid urban growth and form potential area for future expansion of the city. And thus water shortages stem from unproductive use of freshwater, degradation of the available surface water resource by pollution and by non-utilization or under-utilization of groundwater from aquifers. This has resulted in less flow rate of springs; permanent springs turning seasonal, and seasonal springs drying up completely. Springs are disappearing at an alarming rate globally, and most of that loss goes unrecognized. Our valley is no exception, and the situation is more alarming than ever in light of climate change predictions for Himalayas (IPCC, 2007). While studying some ground-water resources it was shown that intense chemical weathering processes and ground-water flow pattern in the valley follows the local surface topography which not only modifies the hydrogeochemical facies but also controls distribution of spring waters (Jeelani *et al.*, 2014). To provide a better view of importance of springs in Kashmir Valley, a section of Srinagar district was undertaken for study. This section included Hazratbal Tehsil, and about 30 different springs of varying nature and types were taken into consideration for this study. To assess drinking water quality of represent-tative freshwater springs of Hazratbal Tehsil of Srinagar District.

Study area

The study area selected for this research work was Hazratbal tehsil. It is one of the 8 tehsils in district Srinagar. Streams, springs, lakes, and wetlands neighboring the world-famous Dal Lake are a part of its water resource. Thirty spring samples were collected from the Hazratbal area. Elevations varied between 1592m to 1935 m above sea level. A plethora of vegetation cover could be found varying in size, proportion and quantity from one spring site to another. Two of the spring samples were collected from Dachigam National Park with due permission from the park authorities. Some important characteristics including geographical co-ordinates and elevation of selected water springs are given in (Table 1; Fig.1).

Table 1. Hydrogeochemical characteristics of 30 freshwater springs of Hazratbal tehsil of district Srinagar

Site No.	Site Name	Latitude	Longitude	Elevation (m asl)	Mean Discharge (L/s)	Magni-tude	Dominant Vegetation
1	Kral Nag	34°09'54.8"	74°51'02.6"	1595	Stagnant	8	*Populus* sp., *Acacia* sp., *Salix alba*.
2	Wanihama Payeen	34°09'58.5"	74°51'07.6"	1597	Stagnant	8	*Populus* sp., *Malus pumila*
3	Palbagh Nag (Batpora)	34°09'36.1"	74°50'55.3"	1598	0.5	6	*Platanus orientalis*, *Populus* sp., *Acacia* sp.
4	Batpora High School	34°09'32.3"	74°50'42.0"	1603	Stagnant	8	*Platanus orientalis*, *Populus* sp., *Acacia* sp.
5	Azad Colony	34°09'42.1"	74°50'40.6"	1594	0.057	7	*Populus* sp., vegetable garden
6	Batpora Ballah	34°10'10.0"	74°50'33.6"	1612	1.25	5	*Platanus orientalis*, *Populus* sp., *Acacia* sp., and *Juglans regia*
7	Noubough	34°10'38.7"	74°49'58.4"	1625	Stagnant	8	*Populus* sp., *Acacia* sp., *Juglans regia*
8	Wanihama Ballah Masjid	34°10'52.4"	74°50'55.9"	1622	0.75	6	*Populus* sp., *Acacia* sp., *Platanus orientalis*, *Juglans regia*
9	Wanihama Ballah	34°10'57.2"	74°50'54.7"	1935	1.875	5	*Populus* sp., *Acacia* sp., *Juglans regia*
10	Vijnag	34°11'07.9"	74°51'04.8"	1654	0.35	6	*Populus sp.*, *Acacia* sp
11	Batpora Nag	34°11'11.4"	74°50'56.2"	1636	0.166	6	*Populus* sp., *Acacia* sp., *Juglans regia*
12	Chuientwean Nag	34°11'15.6"	74°51'05.9"	1658	0.833	6	*Populus* sp., *Acacia* sp., *Salix alba, Malus pumila*.

13	Gadbal (Bakura)	34°11'42.9"	74°50'29.6"	1723	0.765	6	*Platanus orientalis*, *Populus* sp., *Salix alba*, *Prosopis glandulosa*
14	Virwar Nag	34°11'11.1"	74°51'30.1"	1659	232.26	3	*Acacia* sp., *Salix alba*, *Prosopis glandulosa*
15	Reshipora Nag	34°11'21.5"	74°51'31.6"	1672	0.493	6	*Salix alba*, *Populus* sp., *Acacia sp.*, *Juglans regia*, *Platanus orientalis*
16	Kral Kund Nag	34°11'05.1"	74°51'04.96"	1654	3.5	5	*Pyrus pashia*, *Salix alba*, *Acacia* sp., *Prosopis glandulosa*
17	Chattarhama	34°10'59.4"	74°52'04.5"	1647	Stagnant	8	*Populus* sp., *Acacia* sp., *Platanus orientalis*
18	Bijirteng Nag (Danihama)	34°10'24.2"	74°56'07.0"	1664	1	5	*Populus* sp., *Acacia* sp., *Salix alba*
19	Boninar Nag (Danihama)	34°10'15.8"	74°53'15.5"	1656	0.333	6	*Acacia* sp., *Populus* sp., *Platanus orientalis*
20	Astan Nag (Mulfaq)	34°10'07.8"	74°52'48.4"	1626	0.1	6	*Acacia* sp., *Prosopis glandulosa*, *Morus serrata*
21	Draphama Nag (DNP)	34°10'07.7"	74°52'43.2"	1628	0.338	6	*Populus* sp., *Juglans regia*, *Aesculus indica*
22	Oak Patch Spring (DNP)	34°08'27.7"	74°55'57.5"	1753	Stagnant	8	*Morus serrata*, *Prunus armeniaca*, Ferns, *Rubus ellipticus*
23	Kaunsar Nag (DAULM)	34°09'36.8"	74°54'36.8"	1763	Stagnant	8	*Populus* sp., *Ulmus wallichiana*
24	Mal Nag (Harwan)	34°09'25.6"	74°53'47.8"	1650	Stagnant	8	*Juglans regia*, *Platanus orientalis*, *Salix alba*
25	Astan Nag (Harwan)	34°09'09.7"	74°53'26.4"	1634	0.214	6	Ferns, *Urtica dioica*, *Salix alba*, *Populus* sp., Thorns
26	Mustafa Colony (Chandpora)	34°09'29.3"	74°53'26.3"	1634	Stagnant	8	*Populus* sp. and *Salix alba*.
27	Meerakshah Nag (Shalimar)	34°08'44.2"	74°52'21.0"	1613	Stagnant	8	*Platanus orientalis*, *Populus* sp., *Salix alba*
28	Chakora Nag (Ishber)	34°08'05.2"	74°52'36.9"	1615	Stagnant	8	*Morus serrata*, and *Salix alba*
29	Deoun Nag	34°08'01.8"	74°52'53.2"	1614	0.652	6	*Juglnas regia*, and *Salix alba*
30	Meayt Nag	34°07'43.4"	74°52'51"	1592	Stagnant	8	*Pinus wallichiana, Malus pumila,Prunus armeniaca*

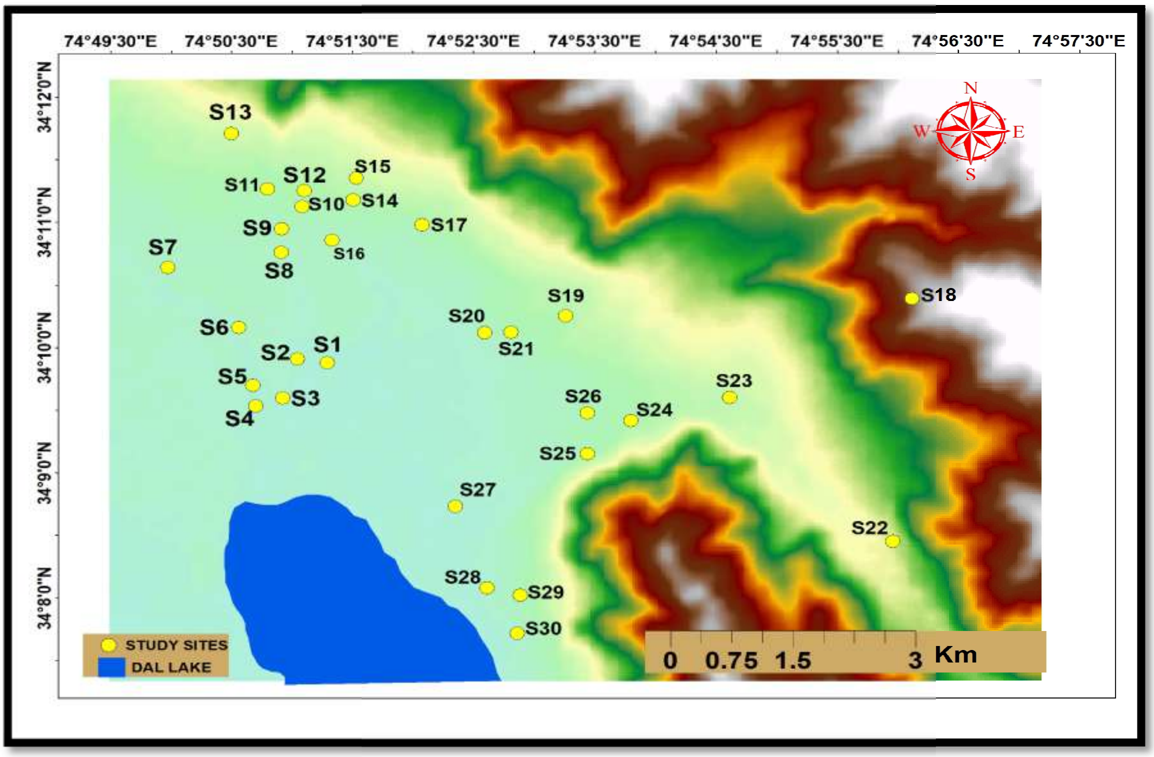


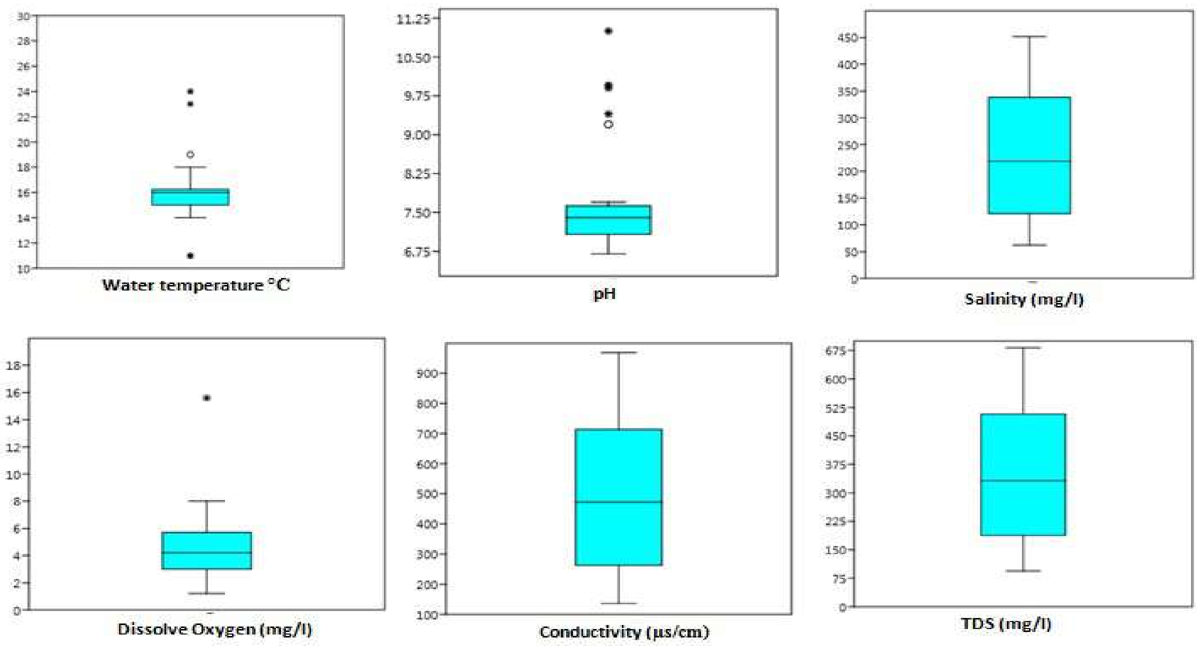
Fig. 1. Map showing location of study area and study sites across Hazratbal tehsil

MATERIAL AND METHODS

The main aim of study was to collect a portion of material (water) small enough in volume to be transported handily and handled in the laboratory while still accurately representing the material that is being sampled (APHA, 2005). Samples have to be taken care of in such a way that no significant change in composition occurs before the analysis is carried out. For the present study, thirty sites were selected and water samples were collected and stored in 1 litre capacity unsoiled plastic bottles. Before the collection of samples, the bottles were carefully washed with distilled water. Each sample was analyzed for different physico-chemical parameters such as temperature, pH, conductivity, chloride, alkalinity, total hardness, calcium hardness, total dissolved solids, ammonia, nitrite, nitrate, ortho-phosphorous, total phosphorus, iron and sulphate. Results obtained were verified by careful calibration and blank measurements (APHA, 2005; Wetzel and Likens, 2000). All statistical calculation was done through Microsoft office EXCEL 2007 and PAST (v.1.93) software applications were also employed for statistical analysis.

RESULTS AND DISCUSSION

To locate the significant differences between various water parameters, they were subjected to tukeys box plot analysis. The results showed that some parameters have significant as well as non-significant variation. The parameters such as water temperature, pH, DO, conductivity, silicate, iron, ammonical-nitrogen, alkalinity, ortho phosphorous and total phosphorous showed significant differences as the values vary at certain sites. The outliers present in the graphs showed the extreme values at certain during the study period among various study sites (Fig.2). Majority of springs recorded temperature in the range of 15–20°C. Some of the springs recorded temperature of <15°C whereas some springs recorded temperature above 20°C, qualifying as warm springs. This indicates that water has been somehow stagnant for longer period of time or hydrothermal activity has been ongoing beneath the surface. The water was found to have slightly acidic to highly alkaline pH (6.7-11). The highly alkaline character of springs may be due to limestone rich lithology of the valley, liberating Ca^{2+} and Mg^{2+} ions into the water. Electrical conductivity was found in the range 136-968 µS/cm, indicating high mineral content. Significant variations and relatively higher values of conductivity in some springs are likely attributed to contamination from fertilizer inputs from the catchment area (Kumar *et al*., 1996). All values of TDS were found to be in proportion with electrical conductivity. Salinity at the study sites ranged from 62 mg/L – 452 mg/L. Groundwater salinity depends on aquifer geology and its chemical characteristics (Al-Naeem, 2015). Thus, variations in these features, in and around the study areas, affected the spring salinity. The values of DO ranged from 1.2 mg/L – 9 mg/L. The fluctuation in DO values may be due to difference in water temperature and algal growth (Singh *et al*., 2014). The presence of relatively high oxygen at some sites seems to be a function of good periphytic algal populations liberating oxygen. As hardness is measured in terms of Ca^{2+} and Mg^{2+} ions, concentration of these indicates water quality. Total hardness values ranged from 48 mg/L – 274 mg/L, thereby indicating hard water character of the springs. The major source of Ca^{2+} and Mg^{2+} ions may be attributed to limestone, gypsum and dolomite rocks in the valley. Majority of springs fall in hard and very hard water category. The difference in alkalinity values may be due to the prevailing land use type and recharge zones and also due to the presence of bicarbonates released from rocks. In general, ionic composition of spring waters revealed predominance of bicarbonate and calcium over other ions and, therefore, the usual ionic progression was $HCO_3^- > Ca^{2+} > Mg^{2+}$same trend was seen in springs from Pulwama district of Kashmir valley (Bhat *et al*., 2010). The quantity of nitrate and ammonia present in water in the form of nitrogen are of great interest because of their nutrient values. Nitrate concentration varied from 214 µg/L – 3844 µg/L. Higher concentration of nitrate at some sites could be contributed by nitrogenous fertilizers, human and animal wastes, and even decomposition of living matter. Presence of ammonia in water indicates ammonification. Ammonia values ranged from 5µg/L – 302 µg/L. The main source of ammonical-nitrogen in these springs could be due to decomposition of organic matter and of sewage near springs. The concentration of ortho and total phosphorous fluctuated between 16µg/L –188 µg/L and 57µg/L –769µg/L respectively. The possible source of phosphates can be artificial or anthropogenic which depends on activities that occur in the area under study. The presence of phosphates in higher concentrations is directly influenced by agriculture and horticulture activities undertaken in the catchment of these springs (Kipngetich *et al*., 2013). Phosphates, as nutrients, have the potential for growth of macrophytes and other algal masses. The concentration of sulphate varied from 6 mg/L – 53 mg/L. High concentration of sulphate at some sites is linked to dissolution of gypsum, which underlies the springs (Obiefuna and Sheriff, 2011). Values of specific parameters were compared with permissible and desired limit standards provided by WHO and BIS. All values were found within permissible and desirable water quality standards (Table 2).



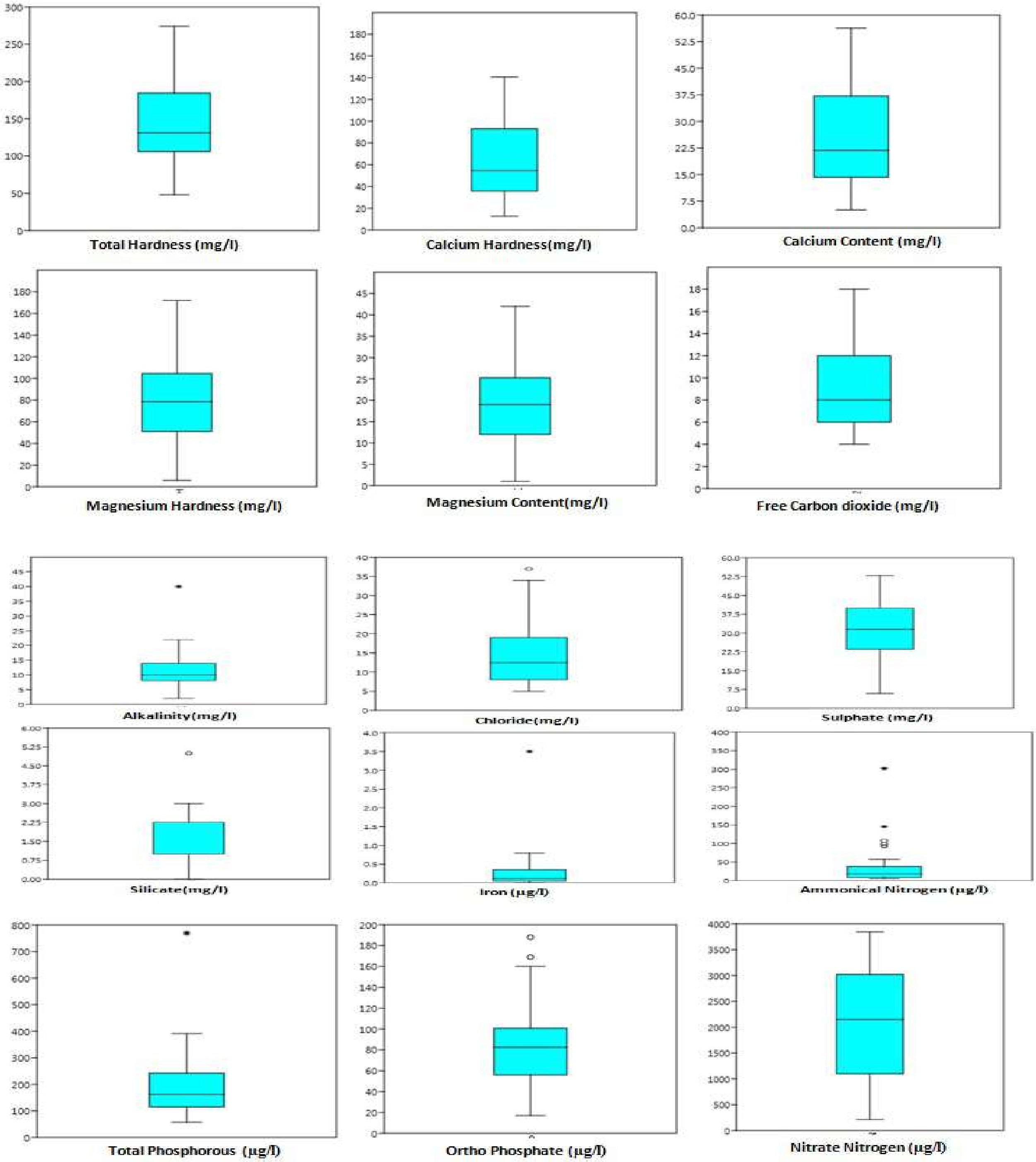


Fig. 2. Box plot comparison test of different physico-chemical parameters

Table 2. Range in values of various physico-chemical parameters of spring waters

Parameters	Observed range of samples	WHO & Indian Standards	
		Desirable	Permissible
pH	6.7 – 11	6.5-8.5	6.0-9.0
Conductivity (µS/cm)	136 – 968	750	1400
Salinity (mg/L)	62 – 452	--	--
Total dissolved solids (mg/L)	94 – 682	600	600
Total alkalinity (mg/L)	39 – 156	300	600
Chloride (mg/L)	5 – 37	250	1000
Total hardness (mg/L)	48 – 274	300	600
Calcium (mg/L)	5 – 56	75	200
Magnesium (mg/L)	1 – 42	30	100
Sulphate (mg/L)	6 – 53	200	400
Iron (µg/L)	0.008 – 3.503	300	1000
Nitrate (µg/L)	214 – 3844	45000	100000
Nitrite (µg/L)	9 – 337	--	--
Ammonia (µg/L)	5 – 302	--	--
Ortho-phosphorous (µg/L)	16 – 188	--	--
Total phosphorous (µg/L)	57 – 769	--	--

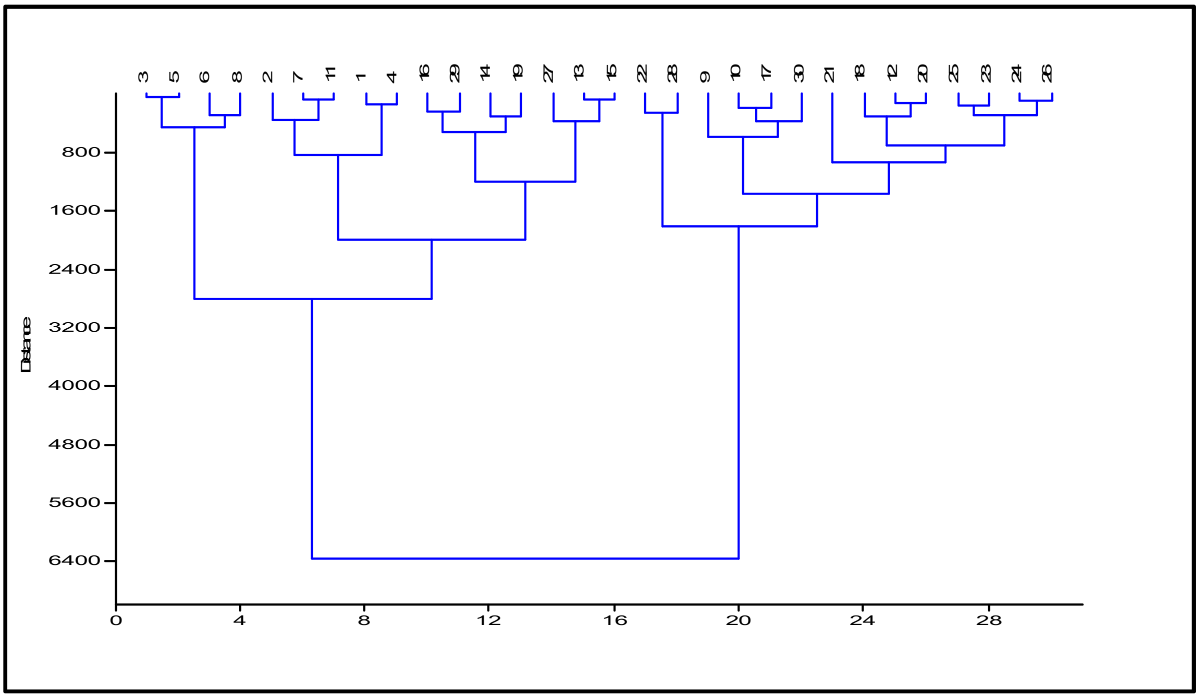


Fig. 3. Dendrogram showing clustering of respective sites

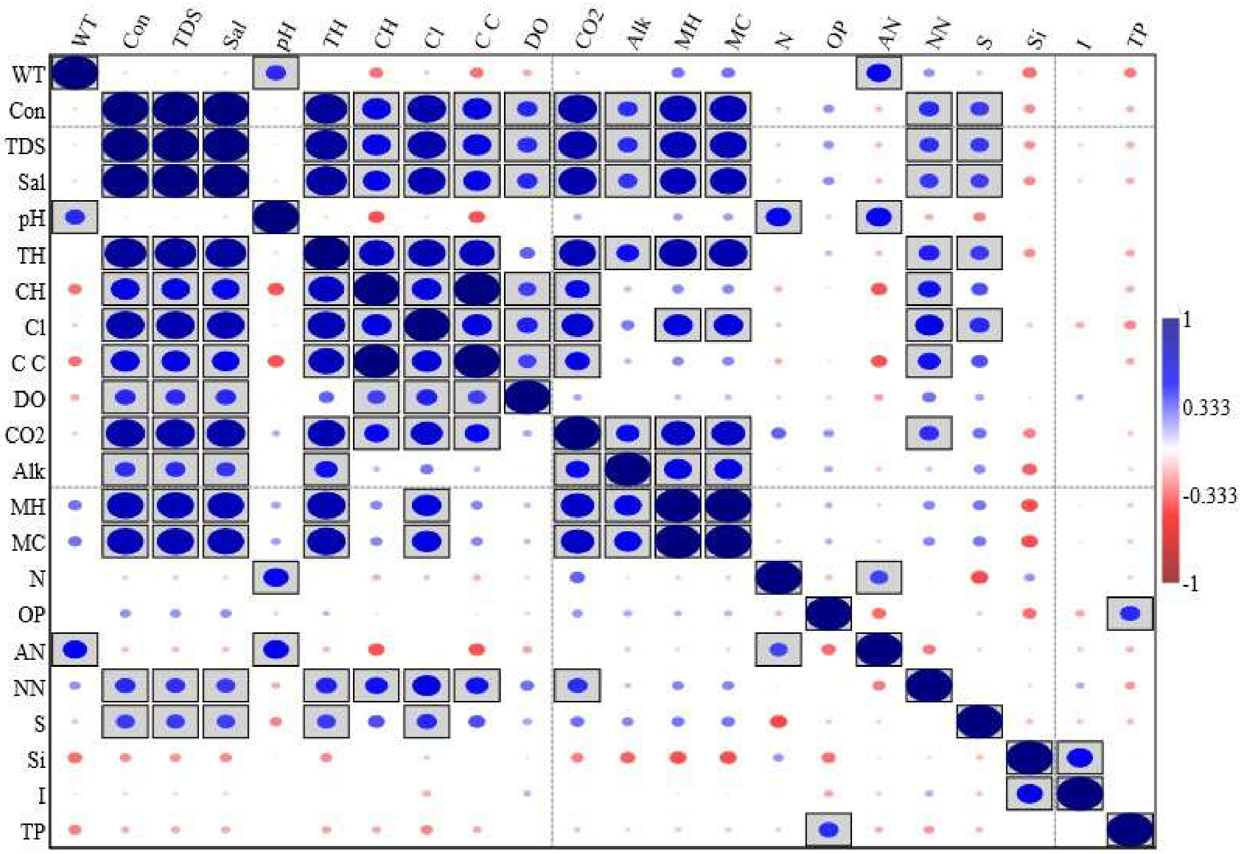


Fig. 4. Correlation of various physico chemical parameters (boxed p<0.05)

In our study, cluster analysis categorized study areas into two main clusters. The first two clusters comprised of sites in the following order: Cluster 1 contained sites 3, 5, 6, 8, 2, 7, 11, 1, 4, 6, 29, 14, 19, 27, 13, and 15, whereas Cluster 2 contained sites 22, 28, 9, 10, 17, 30, 21, 18, 12, 20, 25, 23, 24, and 26. This reveals that Cluster 1 sites have similar hydro-chemical characteristics, which are different from Cluster 2 sites. Cluster 1 is sub-divided into two sub-clusters while Cluster 2 sub-divides into two as well, showing further classification of sites as being similar in water quality parameters Talking about major parameters affecting the physico-chemical nature of drinking water, it was found that Cluster 2 sites were more alkaline than Cluster 1 sites. Cluster 2 sites had lesser conductivity, chloride content, total hardness, calcium content, and magnesium content than Cluster 1. Nitrate values were relatively similar between the two clusters, with slight variations within sub-clusters (Fig. 3).

Correlation matrix of different water parameters was calculated at p<0.05 significance level, some important correlations has been observed which revealed parameters like water temperature, pH, DO, nitrate, ortho phosphorous, silicate and total phosphorus was negatively correlated with most of the water parameters. Temperature being important parameter causing many direct and indirect effects, here directly affecting the solubility of gases which clearly depicts that increase in temperature can lead to decrease in DO. Whereas total phosphorous was found to be in strong positive correlation with ortho phosphorus which showed increase in concentration of total phosphorous could lead to increase in concentration of ortho phosphorous. Similarly conductivity, TDS, salinity, hardness, alkalinity was found to be in strong positive correlation with other water parameters. Alkalinity helps in regulating pH of water thus was found to be significant (Fig.4).

Table 3. Water quality index of various sites as per WHO standards

WQI	**0-50**	**50-100**	**100-200**	**200-300**	**>300**
Water quality	**Excellent**	**Very good**	**Poor**	**Very Poor**	**Unsuitable for drinking**
1	-	62.09	-	-	-
2	-	53.47	-	-	-
3	-	63.24	-	-	-
4	-	57.96	-	-	-
5	-	64.65	-	-	-
6	-	65.16	-	-	-
7	-	51.61	-	-	-
8	-	54.91	-	-	-
9	47.43	-	-	-	-
10	43.82	-	-	-	-
11	-	52.22	-	-	-
12	40.87	-	-	-	-
13	37.86	-	-	-	-
14	42.83	-	-	-	-
15	36.84	-	-	-	-
16	40.95	-	-	-	-
17	-	50.21	-	-	-
18	-	52.11	-	-	-
19	47.23	-	-	-	-
20	39.06	-	-	-	-

21	33.93	-	-	-	-
22	36.57	-	-	-	-
23	36.16	-	-	-	-
24	31.66	-	-	-	-
25	37.22	-	-	-	-
26	30.11	-	-	-	-
27	-	50.87	-	-	-
28	45.95	-	-	-	-
29	34.68	-	-	-	-
30	-	50.76	-	-	-

Mathematical calculations determined WQI for thirty sampled sites which helped assemble these into groups demarcated by the WHO. Out of 30 sites, 17 sites qualified as being in the excellent water quality while 13 sites were eligible for very good water quality. Thus, from the following observations it was found that the sites present in Cluster 2 presented excellent water quality than Cluster 1. No study site was grouped under poor or very poor WQI category (Table 3). This signifies that water, from the springs under study, is safe for consumption. Hence, the local population can safely utilize water from these springs for carrying out daily life activities, such as drinking, irrigation, and cattle rearing. During the course of sampling, it was also observed that the neighbouring population was dependent on freshwater springs in their area. The dependence was particularly evident in regions where the springs fell within residential environs or near agricultural fields. Such springs were properly maintained as well, such as springs present at site 24, 26 and 29. But springs that were located near roadsides were neglected and poorly managed, resulting in massive formations of algae, and eutrophication. This deteriorates the spring water quality which in turn affects water usage requirements of the surrounding populace.

CONCLUSION

The findings revealed that the studied springs have excellent to very good water quality conditions, which fall within the permissible limit prescribed by WHO and BIS. Thus population can safely utilize water from these springs but should implement some hygienic and proper management practices for carrying out daily life activities, such as drinking, irrigation, and cattle rearing. This conclusion is supplemented by results obtained from WQI. But many of these springs aren't handled well and need attention as they have the potential to fulfill water demands of the nearby population. These need to be taken care of with proper management techniques, and by prompting stakeholders to share the responsibility of spring water protection.

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