Water Quality Assessment of Springs in the Srinagar Valley, Garhwal Himalaya, India

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Abstract: ***Spring water in the Himalayas is often considered holy and assumed to be always fit for drinking. However, a scientific analysis of drinking water quality is essential for vital springs that feed thousands. In this work, we assess the drinking water quality of 11 springs in Alaknanda valley at Srinagar, Garhwal Himalaya. The water quality index (WQI) is estimated based on 11 physical parameters that are compared with the World Health Organization (WHO) and the Bureau of Indian Standard (BIS). An average pH of 7.22 is estimated at all the springs while other parameter averages, such as TDS (403), Chloride (1.87), Total hardness (237), Calcium (77), Magnesium (11.24), Total alkalinity (203), Nitrate (1.24), Sulphates (26), Fluoride (0.19) and Iron (0.18), are within desirable limits. The WQI indicates that out of the 11 only 2 springs are of very good quality, 7 are good quality and 2 are moderately good quality. The results also show that the excellent WQI is assessed in those springs which headwater zone is non - residential areas where as WQI is moderately good near urban residential zones as compared to non - residential areas. Prominent springs among them are Srikot, Bhaktiyana, Kamleswar, and Hanuman temples. These four springs are just below the residential area. The natural drainage is suspended by the local people by constructing residential houses and around springs' land is encroached and mismanaged by the local people. Underground percolation of sewerage water of each residential house is also one of the causes of the deteriorating of spring water and needs proper purification before use. This insight points to increased contamination because of anthropogenic activities.***

Keywords: Spring; water quality; parameter; assessment; anthropogenic activities

1. Introduction

Water is very essential for all aspects of our livelihood. Mountain provides up to 60 and 80 percent of the world's freshwater. Mountain water resources are indispensable for drinking, irrigation, energy production, industrial development, municipal water supply, management of resources, conservation of environment and source of streams and rivers. In the Himalayan Mountain, region water has religious values and important source of freshwater for the local people. Glaciers, springs and seepage (locally known as Dhara, Naula, Kund, Paniyar and Tal) water are the major sources of mountain streams and rivers which are locally known as *Gad*, *Gadheras* and Nadi/Ganga. Springs are the major source of drinking and irrigation water in the rural areas of Lesser Himalaya. The lakes and spring of Uttarakhand Himalayas are phenomenal and have attracted a lot of scholarly attention (Valdiya et al, 1996) [1]. Each and every village and its hamlets are located near the springs which are the major source of drinking water. But since the last few decades, it is noticed that people face an acute shortage of water during summer. They are sometimes compelled to reduce water consumption and face social conflicts (Negi and Joshi, 1996) [2]. The spring are drying or becoming seasonal and reducing their water discharge due to the low intensity of regional rainfall. Besides this, some of the springs in the Lesser Himalayan region are silted by road construction debris and infrastructural development. With the rapid expansion of urbanization and recreational activities in the mountain, the spring's water is being polluted and unhygienic. In Srinagar, Pauri, Gopeswar, etc towns, the spring space land is encroached by near urban dwellers. At present management and conservation of the springs is a matter of vigorous worrying in the inhabited area of the mountains. Another facet of the problem is a landslide, flash flood, soil erosion, instability of hillslope and associated catastrophic losses in the adjoining area caused by instance rainfall during the rainy season (Negi and Joshi, 1996) [2]. The previous studies indicate that deforestation, land - use changes, a decline of rainfall, etc are the major causes of diminishing discharge of the springs in the mountain. Despite these facts spring tapping for drinking water to villages in the headwater zone of the catchments is one of the reasons for diminishing discharge of springs to downward headwater zone. Earlier free flow springs were recharged the downward springs and seepage water but after tapping subsurface and surface water reduced the recharged. In addition to these factors geological and Geomorphological factors are responsible in the mountains. Thrust, faults, fractures, lineaments, and joints of the rocks are playing a significant role in the mountain geo - hydrological system (Bartarya 1989[3]; Bartarya and Valdiya 1989[4]). Viviroli D. et al (2011) [5] present overviews of climatic change and mountain water resources.

The hydrochemistry of the springs is depending upon the lithological structure, rock weathering, slope, topography of the spring catchment area, climatic changes, and anthropogenic activities in addition to precipitation. The assessment of spring water quality is very necessary from the human health and ecological point of view (Boyd 2015) [6]. The WHO report indicates that about 80 percent of diseases in the human population are caused by drinking water (Sharma et al, 2014) [7]. Although the spring water is freshwater causes of water quality declination are several pollutants that come from the leaching of rocks, sewage and human waste nearby springs and agricultural waste (Pathak B. et al, 2021) [8]. Due to the fast growth of the urban population, the process of urbanization, construction of the hydroelectric project and ecological changes around Srinagar valley of Garhwal Himalaya, it is observed that the springs of Srinagar valley are disappearing. Increasing anthropogenic pressure around springs is a big contribution to pollution. Joshi et al (2006) [9] define the contents of toxic elements of the Nainital lake water by EDXRF. The water quality of the reservoir of Lambagar and Supana Dams (Srinagar) in Alaknanda valley was carried out by Rawat et al, (2019) [10]. Recently Nainital lake water quality measurement and analysis was also assessed by Pathak et al (2021) [8] which shows that lake water is highly polluted and is not suitable for drinking without purification.

2. Study Area

Tectonically formed Srinagar valley is located in the lower Alaknanda basin of Garhwal Himalaya 30°12* to 30°15* N latitude and 78°45* to 78°50* E longitude at the average height of 600m. The Srinagar Town is situated at the left bank of the river. River water and natural springs are the major source of water for the 5lake resident in addition to large numbers of pilgrimages and tourists. It is 8.5km long and 2.5km wide extended from Supana village to Kirtinagar. The valley is well demarcated by the Badiyargarh - silkakhal - kirtingar ridge in the north and Sumari - Khola - Ganga Darshan ridge in the south covering an area of 36 Km^2 and The Alaknanda River flows in the center in a bow - shaped meander. The valley is drained by the Alaknanda river which rises from the Satopant Glacier and numerous tributary streams both the side of the master stream.

Geologically the valley falls in the Lesser Himalaya of Garhwal which consists of Chandpur phyllite, quartzite of Garhwal group, Marora limestone, and Kilkileswar - Chamdhar metabasic rocks (Rawat et al, 2019) [10]. Out of that North Almora Thrust, Kirtinagar fault and numerous longitudinal and transverse faults and lineaments are found in the Srinagar valley through which different small order drainage streams rise (Sati et al, 2005, 2007) [11].

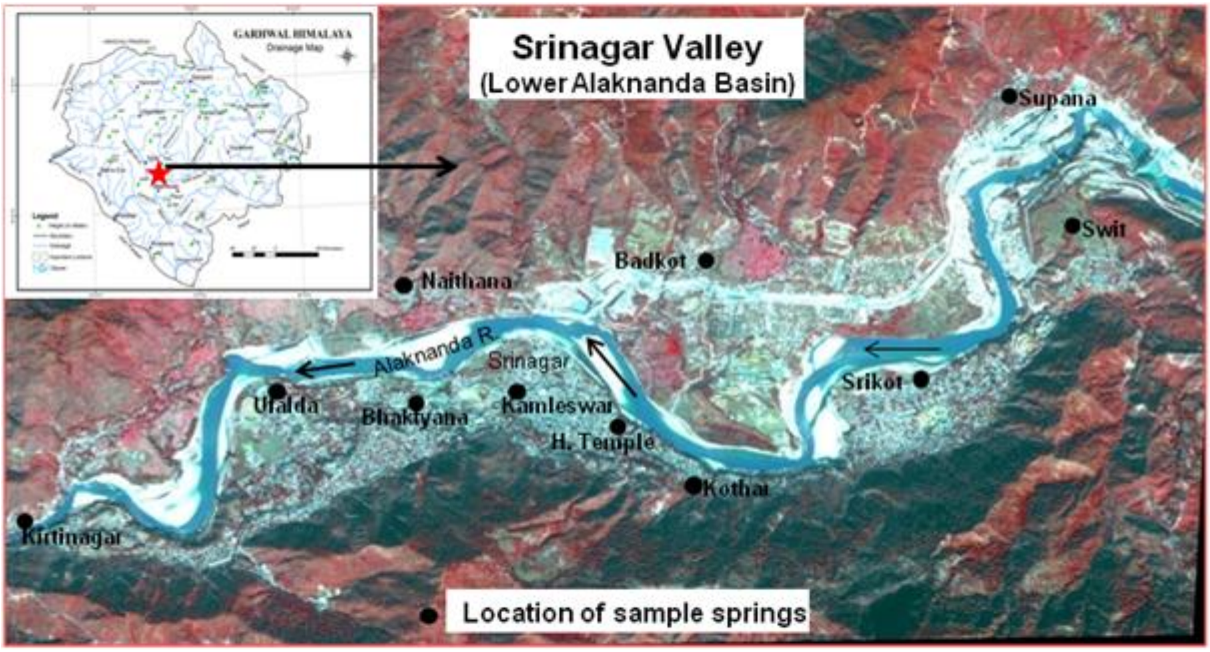

Figure 1: Satellite image of Sringar valley in Garhwal Himalaya (Uttarakhand) and location of sample springs

Objectives

The study focuses on the water quality of eleven springs located in different lithology, land use and ecological conditions. The authors made an attempt to understand the hydro - chemical characteristics of springs in Srinagar valley which are frequently used for drinking water.

3. Research Methodology

Out of the total 25 perennial springs in the valley, 11 springs of different locations and lithological units are selected for water samples.7 springs are selected in right side and 4 are in the left side of the Alaknanda River. All are shown on the map (Fig.1). Water samples of springs are collected in the month of November in polypropylene bottles. The water samples are analysed for 15 chemical and 2 biological parameters (Table 1). The physical - chemical characteristics of the samples are tested and measured in the Jal Nigam Laboratory of Srinagar Garhwal.

Determination of Water Quality Index

The water quality index has been calculated on the basis of Pathak et al (2021) [8], Anuradha et al (2021) [12], Rawat et al (2019) [10], and Sharma et al (2014) [7]. A total 11 parameters are considered and each parameter is given a definite assigned weightage according to its relative importance (Table 2). The relative importance assigned from 1 to 5 on overall quality of water. The higher numbers (5) are given to those parameters which are more affective to quality of water while lower numbers are given to those which are least affective. The relative weight calculated as the following method -

Wr = Wa ∑ Ni=1Wi

Where,

Wr = Relative weight

Wa = Weight of each parameter

N = Number of parameters

Here Wa represents the assigned waitage, N is number of parameter and Wr is relative weight for each parameter which is calculated as per formula (Table 1). After calculated relative weight of the all parameters, Quality Rating Scale (Qi) is calculated dividing the concentration of selected parameters (Ci) divided by its standard value (Si) as suggested by WHO and BIS as per formula -

Qi = Ci/Si*100

Where,

Qi = Quality rating scale

Ci = Concentration of each chemical parameter in water sample in mg/L

Si = Indian drinking water standard for each chemical parameter in mg/L

The Q value of pH parameter is calculated differently by using formula given by Pathak et al (2021) [8]. The ideal value (Vi) of pH is 7 guided by WHO and BIS has been used for the calculation of Q.

Q = Ci - Vi/Si - Vi*100

After calculating of the selected parameters, the Sub - Indices (Si) are calculated as a product of relative weight (Wr) and Quality Rating Scale (Qi). In the end the Water Quality Index is sum of all indices (Pathak et al 2021[8], Rawat et al 2019, Ramakrishanaih et al 2009[13], Yadav et al 2010[14]). Finally WQI has been calculated by the following formula -

SIi = Wr*Qi

WQI = ∑ SIi - N

Where,

SIi= Sub - index of ith parameter

Wi= Relative weight of ith parameter

Qi= Rating based on the concentration of ith parameter

N = number of chemical parameters

Table 1: Weightage and relative weightage of each parameter

S. No	Parameter	WHO Standard (Desirable Limit)	Bureau Indian Standard (Desirable Limit)	Weight (Wa)	Relative Weight (Wr)
1	pH	6.5 - 8.5	6.5 - 8.5	4	0.1290322581
2	TDS	500 - 1000	500	4	0.1290322581
3	Chloride	250	250	3	0.0967741935
4	T. Hardness	500	300	2	0.064516129
5	Calcium	100	75	2	0.064516129
6	Magnesium	50	30	2	0.064516129
7	Alkalinity	200	200	2	0.064516129
8	Nitrate	50	45	1	0.0322580645
9	Sulphate	250	200	4	0.1290322581
10	Fluoride	-	1	2	0.064516129
11	Iron	0.3	0.3	5	0.1612903226
			Total	31	

and 8.5. pH water samples are collected from the 11 springs in Srinagar valley range from 6.61 to 7.59. The maximum value of pH is recorded from the Barkot spring (7.569) while the minimum pH value of 6.61 is observed in the spring water sample of Hanuman Temple in Srinagar. The rest of the spring's water samples are fall in the same range of acceptable limit. It shows that all the springs' water is useful for all purposes.

TDS:

The permissible limit of TDS is less than 500mg/L as per guidelines of BIS while as per the WHO guideline it ranges between 500 to 1000 mg/L. Here the authors have followed the guideline of BIS. Thus all 11 spring's water samples of TDS falls range from 314 to 502. The maximum value of TDS is found in Ufhlda (502) and the minimum in Barkot (314) springs. It is observed that the TDS values are maximum (414 to 502) in those springs which are situated in the densely populated zones. Kamleswar, Bhaktiyana and Ufhlda are prominent among them.

Chloride:

The BIS guidelines promote water with 250mg/L for drinking purposes. Chloride is usually not harmful to people. Chloride may get into surface water from sources including rock containing chloride and agricultural runoff. In general, the chloride in the water samples varies from 7 to 48 mg/L. The highest amount of chloride is observed in the water samples of Kamleswar (48mg/L) while least is observed at Supana spring (Table 2).

T. Hardness:

Hardness is primarily caused by the dissolved mineral compound with water. The main compound of hardness is calcium and magnesium which actually benefit people. Hardness is measured and expressed in milligrams per litter. Magnesium is a very important nutrient for a human being. As per the BIS guidelines, the total hardness is permissible as 300mg/L. Our water samples show hardness ranging from 180 to 296. The highest value of hardness was obtained from the spring sample of Ufhlda while the lowest value was obtained in Supana.

Calcium:

Calcium is a nutrient that all human beings need. Calcium is crucial for bone health and is found abundantly in the human body. About 99 percent of bones and teeth of the human body are built by calcium. As per the BIS guidelines, the desirable limit of calcium is 75mg/L and 100 mg/L by WHO. The calcium in the collected water samples varies from 36.8 to 99.4 (Table 2). The mostly maximum amount of calcium (>90) is observed in those spring samples which source is rock fractures such as Ufhlda, Srikot, Kamleswar. The calcium is also higher in those springs which source catchment is limestone rocks.

Magnesium:

Magnesium is a chemical element that plays many crucial roles in the human body, such as energy production, nerve systems, and supporting muscle. The magnesium in the water samples varies from 7.78 to 13.69. As per BIS guidelines, the magnesium of normal water has 30 and all the spring water samples fall under the BIS range. The maximum amount of magnesium (13.64) was found in the water samples of Kothar and Srikot while minimum magnesium was in Supana i. e.7.8.

Alkalinity:
The alkalinity refers to the capability of the water to neutralize the acid. It measures the bicarbonate, carbon dioxide, hydroxide ion, and carbonates present in the water. When it is mixed with drinking water it helps protect the health. According to WHO and BIS, the desirable limit of alkalinity is about 200 ppm (Table 1). The alkalinity of the 11 spring water sample varies from 148 to 260 ppm. It shows that maximum alkalinity is found in the samples of Ufhlda (260) followed by Kamleswar and Bhaktiyana (256). Minimum alkalinity is measured in the water samples of Supana (106) and Hanuman Temple. The average value of alkalinity in all the samples is 203.

Nitrate:
Nitrates are a set of compounds that are soluble in water salt - containing ions. Excess Nitrate in water is a source of fertilizer for aquatic plants and algae. According to BIS the desirable limit of nitrate in water is 45. Table 2 reveals that the maximum amount of nitrate is found 4.5in the water sample of Hanuman Temple followed by Srikot (2.1) while the minimum nitrate was observed in Barkot (0.2) and Kirtinagar (0.1). The nitrate is completely absent in the Ufhlda spring water sample. A low amount of nitrate in all the samples indicates the continuous flow of water.

Sulphate:
Sulphate is basically a chemical compound that is composed of sulphur and oxygen atoms. Sulphate minerals tend to be delicate and are found near the Earth's surface on different kinds of sedimentary rocks. Many kinds of bacteria which thrive near oxygen and water are found on these mineral sites. Infect a large community of bacteria even live without oxygen by reducing sulphate to sulfide. As per the BIS guidelines, the desirable limit of sulphate is 200mg/L and 250 mg/L by WHO. (Table 1).

All the water samples are under the desirable limit. The range of sulphate is from 8 (Barkot) to 47 (Ufhlda). The average of all the samples is 28.

Fluoride:
Fluoride is a chemical substance that can be found in water. It stands for the anion of fluorine that has a - 1 electrical charge. Any compound, whether it is organic or inorganic, contains fluoride. Fluoride of water samples ranges from 0.03 to 0.86. The maximum fluoride was recorded from the samples of Bhaktiyana (0.86) followed by Ufhlda (0.59) and the minimum Magnesium Fluoride of 0.03 was observed in the spring water sample of Kamleswar. As per BIS guidelines, the Fluoride is permissible 01. All the water samples are less than the desirable limit. The average value of all the water samples is 0.35.

Iron:
In most water samples iron exists in the oxidized form due to the presence of oxygen. Iron is a mineral that is very helpful for body growth and development. The iron of the collected water samples varies from 0.04 to 4. The highest iron is observed at Srikot and Supana and the least iron is observed in Kothar followed by Bhaktiyana. The table shows that all the iron samples are near the desirable limit (0.3).

Table 2: Results of Physical parameter of the studied samples

S. NO.	Spring	Parameter											
		PH	Turbidity	TDS	Chloride	T. Hardness	Calcium	Mg.	Alkalinity	Nitrate	Sulphate	Florida	Iron
1	Sweet	7.15	0.65	338	14	192	57.72	11.7	160	1.2	18	0.22	0.12
2	Srikot	7.51	1.55	540	14	280	92.0	12.15	254	2.1	24	0.42	0.4
3	Kothar	7.27	0.52	349	14	192	54.51	13.6	152	1.2	18	0.36	0.04
4	Hanuman T.	6.61	0.81	414	28	208	60.92	13.6	148	4.5	44	0.31	0.18
5	Kamleswar	6.74	0.95	480	48	280	97.79	8.77	256	1.2	46	0.03	0.15
6	Bhaktiyana	6.91	1.21	460	36	284	96.19	10.7	256	1.4	43	0.86	0.12
7	Ufhlda	7.13	1.36	502	20	296	99.4	11.7	260	0	47	0.59	0.14
8	Supana	7.65	0.96	236	7	124	36.8	7.78	106	1.2	11	0.25	0.4
9	Barkot	7.59	1.72	314	16	260	91.38	10.7	228	0.2	8	0.37	0.08
10	Naithana	7.71	1.12	378	11	196	60 - 0	11.18	172	1.6	16	0.37	0.3
11	Kirtinagar	7.23	1.46	426	32	280	97.79	11.7	244	0.1	31	`0.13	0.14

Table 3: Water quality index (WQI) and status of water quality (Ramakrishanaiah et al 2009, Yadav et al 201)

Ramakrishanaiah et al (2009)	Water Quality Scale	Yadav et al (2010)
Level of WQI	Status of water quality	Level of WQI
< 50	Excellent quality	0 – 25
50 - 100	Good quality	26 – 50
100 – 200	Poor quality	51 – 75
200 – 300	Very poor	76 - 100
>300	Unsuitable for drinking	>100

Table 4: Water Quality Index and status of water quality (Ramakrishanaiah et al 2009; Yadav et al 2010; Pathak et al 2021)

S. N.	Sample Spring	WQI	By Authors	Ramakrishanaaiah et al (2009)	Yadav et al (2010) Y
1	Sweet	39.01	V. Good Q	Excellent quality	Good quality
2	Srikot	78.29	Moderately Good	Good quality	Very poor quality
3	Kothar	38.86	V. Good Q	Excellent quality	Good quality
4	Hanuman T	54.04	Good Q.	Good quality	Poor quality
5	Kamleswar	56.79	Good Q.	Good quality	Poor quality
6	Bhaktiyana	55.38	Good Q.	Good quality	Poor quality
7	Ufhlda	57.25	Good Q.	Good quality	Poor quality
8	Supana	57.94	Good Q.	Good quality	Poor quality
9	Barkot	57.26	Good Q.	Good quality	Poor quality
10	Naithana	65.49	Moderately Good	Good quality	Poor quality
11	Kirtinagar	53.42	Good Q.	Good quality	Poor quality
	Average	55.78	-	-	-

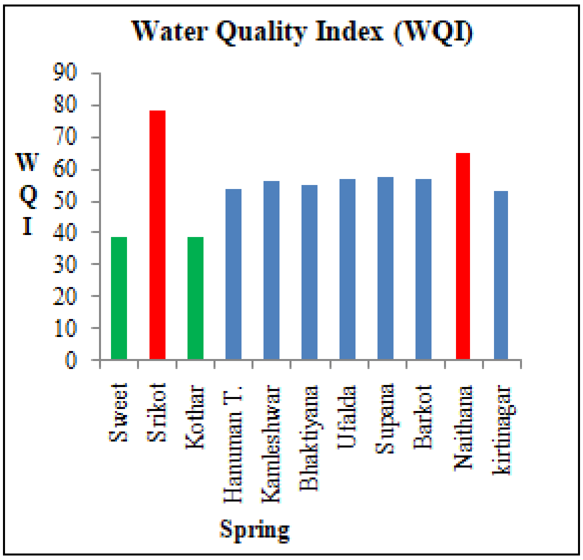

Figure 2: Water quality index of 11 springs in Srinagar valley. Two bars (green) are showing very good quality of water, 7 bars (blue) are showing good quality and 2 bars are showing moderate or poor quality of water.

Obtained WQI of springs have been matched with Ramakrishanaiah et al (2009) and Yadav et al (2010) [14] scale (Table 4). According to Ramakrishanaiah et al (2009) [13] scale, two springs are of excellent quality, and the rest of the nine springs are of good quality Ramakrishanaiah et al (2009) [13] while according to Yadav et al (2010) [14] scale, 2 springs are in good quality, 8 are poor quality and 1 is very poor quality. Because of the higher range of WQI, sharp results are not coming up. Therefore, the authors have suggested their own WQI scale for the springs of the mountain region. According to this scale, all the springs fall from good quality to excellent quality (Table 4 and 5). Generally, all the spring water in the mountains is used for drinking purposes.

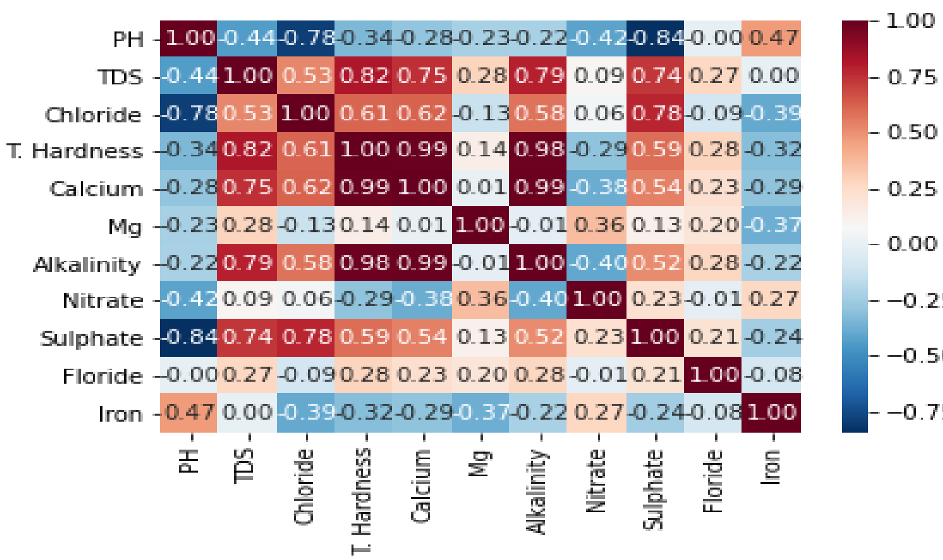

Figure 3: Pearson correlation matrix of different parameters and water quality.

A correlation heat map is a graphical representation of a correlation matrix is representing the correlation between different variables (Fig.3: The value of the correlation coefficient can take any values from - 1 to 1. A relationship between two variables, X and Y, in which the change in the value of one variable is exactly proportional to the change in the value of the other. That is know the value of one variable exactly predicts the value of the other variable (i. e. r x y=1.0). Heat map reveals that there is a highly perfect positive correlation between Calcium and Total Hardness, Alkalinity, and Calcium and Total Hardness and Alkalinity. A high positive correlation is observed between total hardness and TDS, Alkalinity and TDS and sulphate and chloride whereas a high negative correlation is found between Sulphate and pH and pH and chloride. The rest have the parameters have a moderate and low positive /negative or negligible correlation ship.

4. Discussion

The results of water quality index of against 11 springs were obtaining 11 water quality parameters in the study area. The work of Chatterji and Raziuddin (2002) [15]; Ramakrishnaiah et al., (2009) [13]; Varol & Davzaz (2015); Shah et al., (2018); has evaluated the water quality index for suitability of drinking water in the past. Table 4 and Figure 2 show that the higher the index value poorer the water quality and lower the index good to excellent the water quality. Obtained water index indicates that the overall WQI of all the spring samples ranges from 38.86 at Kothar to 78.29 at Srikot which falls into excellent to good quality (based on scale Ramakrishanaiah et al 2009) [13]. According to rating scale of Yadav et al (2010) [14], WQI ranges from very poor quality to good quality index (Table 4). Most of the spring's water samples are good quality. The lowest value of water quality index is observed in Kothar (38.86) followed by Sweet (38.01) while the highest value is found in Srikot (78.29) followed by Naithana (65.49). The average water quality index of all the 11 springs is 55.79. Out of which 4 springs are below average under good quality to excellent quality water index whereas rest of the 7 spring's index values are more than average which water is good to poor quality. Fig.2 also shows that WQI bar of Kothar and Sweet, are excellent (Ramakrishanaiah et al 2009) [13] or good quality (Yadav et al 2010) [14]. WQI of Srikot is highest (78.29) which indicates very poor quality of water as per the rating of Yadav et at (2010) [14].

Based on the methodology given by the previous workers, the authors also classified the water quality index of the Srinagar valley's springs in to 6 categories (Table 3). Thus all springs of the Srinagar valley are form poor quality to very good quality (Table 5) and all springs are suitable for drinking except two. These two index value is also very nearer to the good quality index. The overall results show that water quality of all the springs is almost suitable for drinking water (Table 5).

Table 5: Water Quality Index and status of water quality in Srinagar Valley

WQI Class	No	WQI	Spring
<20	-	Excellent	-
21 - 40	2	Very good	Kothar, Sweet
41 - 60	7	Good	Hanuman T, Bhktiyana, Ufhlda, Barkot, Kamleswar, Naithana, Srikot
61 - 80	2	Mod. Good	Srikot, Naithana
81 - 100	-	Poor	-
>101	-	V. Poor	-

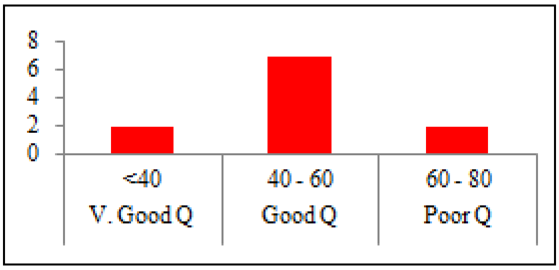

Figure 4: Bars are showing the numbers in each category of WQI

The moderate quality of water at Srikot spring is probably because of the more presence of TDS (540), Calcium (92) and Alkalinity (254) as compare to BIS desirable limit. The other anthropogenic factor of poor quality is that Srikot spring is just under the settlement zone.

The data of springs obtained by testing shows that the concentration of pH value of Srikot, Hanuman temple, Kamleswar, and Bhktiyana is below ideal value 7 and concentration of alkalinity value is also higher in those springs which are located just down slope of residential area. The natural drainage is suspended by the local people by constructing houses and land has been encroached around springs. The basic reason for high alkalinity values is probably because of underground percolation of sewerage water which flows towards the spring's discharge zone. The high calcium value in water is also because of the presence of limestone and dolomite dominating in situ rocks in the spring's catchment zone. Srinagar Base Hospital and densely populated settlements are located at the headwater zone of the Srikot spring. Sewerage water that has been percolated underground into a natural body of water and domestic wastewater also flows downward towards the spring recharge zone. Similar conditions are also observed at Bhktiyana, Kamleswar and Hnuman temple springs. Their head water zones dense urban settlements are constructed. Their observation and monitoring is essential in the perspective of utilization of water for drinking purpose by local residence without purification.

However, the water quality is very good or good in those springs of which headwater zone has no residential houses and limited human activities. Among them Sweet and Kothar, are prominent. Ufhlda and Kirtinagar spring's water quality is also moderately good because their headwater zone is partially inhabited. Comparison of data with the

WHO and BIS standard for drinking water indicates that most of the spring's water is suitable for drinking purposes.

5. Recommendation

Most population concentration in the catchment area together with the mismanagement approach to springs is responsible for water quality degradation. Steps should be taken to treat the flow of polluted drain water and encroachment free space of springs about more than 30m. There should be a proper sewerage line constructed in the catchment zone rather than construction of percolation pits/tanks in each residential and commercial houses. Springs are an important precious freshwater resource to local people so that their conservation and management are very valuable in such a densely populated valley. The process of urbanization and tourism activities are rapidly increasing in the mountains and its pressure on water resources is losing its original characteristics. Several springs in the Srinagar valley have desiccated which existed a few decades back. Athana village, Garhwal University, and Khola village springs are example of them. Therefore, inventory of springs in the Srinagar Valley, continuous monitoring of water discharge and measurement of quality of water is required and must be taken into consideration by planners, administrators, and hydrologists. The involvement of local people is very essential for the management of springs. It is the liability of every citizen to keep free pollution less of their water resources which is our only source of fresh water in the Lesser Himalayan region.

6. Conclusion

In the present study, spring water quality was analyzed by considering various physico - chemical parameters. Water samples collected from S1 and S2 were found satisfactory for drinking purposes and present within desirable limits according to the Indian and WHO standards except for EC and iron which exceeded the permissible limit. The overall water quality index revealed that S1 is having "excellent" water quality and S2 is having "good" water quality. The higher value of WQI at S2 was due to the elevated value of iron. Based upon the results of the current study, concentration of the studied physico - chemical parameters have no detectable negative.

Water quality results can be identified between the springs located in the residential area and non - residential area. It shows that the water quality of residential springs are good to very good quality for drinking while very good water quality is in non - residential area springs. Most of the water quality parameters are also more or less, WHO and BIS standards in residential springs. A spring at Srikot which is located at the base of dense residential area of Srikot Township has a low quality of drinking water. The water quality degradation trend is continuously increasing in the residential zone. It can be concluded that anthropogenic activities are responsible for deteriorating the quality of water in Srinagar valley near the residential zone. Pollution, encroachment, sewerage pits, and human activities around springs are responsible deteriorating factors. Attention should be given by the administrators, planners, local natives as well as scientists and environmental researchers.

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