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Full Length Research Paper

Spring Water Quality Assessment using Water Quality Index in Lansi village of Udhampur, Jammu and Kashmir (India)

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ABSTRACT

The present investigation is aimed to assess the drinking water quality of some of the springs of Lansi village of Udhampur district (Jammu and Kashmir), India by applying Water Quality Index (WQI) and comparing various physical and chemical parameters by Indian and WHO drinking water standards. Two springs (S1 and S2) of Lansi village, used for drinking water purposes were selected for the period of study. Water samples from springs were collected and analysed for various physico-chemical parameters viz. pH, total dissolved solids (TDS), total hardness, alkalinity, electrical conductivity (EC), bicarbonate (HCO_3^-), calcium (Ca^{2+}), potassium (K^+), magnesium (Mg^{2+}), sodium (Na^+), sulphate (SO_4^{2-}), nitrate (NO_3^-), iron (Fe), fluoride (F^-), and chloride (Cl^-). All the studied parameters were under permissible limit values except for EC for both the springs (421 µS/cm at S1 and 500 µS/cm at S2) and iron for the S2 (1.6 mg/L). The WQI value for S1 was 35.99 which falls under the "excellent" water quality category and for the S2, WQI was 88.19 which comes under good water quality. In general, water from both springs was found to be suitable for drinking purposes.

Introduction

Water is the most essential thing for the survival of humans and the ecosystem, therefore sustainable management of water resources is a very important need of the day (Kumar & Sen, 2018). Water plays a major role in the development of different economic sectors which includes cattle feed production, agriculture, forest management, fisheries, electricity generation for industries, and many other innovational activities (Ameen, 2019). Excessive depletion of groundwater and contamination of surface water by the growing human population leads to an increase in demand for water which threatens the sustainability of the freshwater supply (Poudel & Duex, 2017). As a result of this many nations are facing acute water paucity and substandard water quality. Therefore, details about water resources and their suitability for drinking are essentially required for managing these resources. This becomes more relevant in arid and semi-arid areas where water sources are few and average precipitation is also reducing (Mishra & Singh, 2010; Barakat et al., 2018).

Spring water provides a cost-effective option of potable water throughout the Indian Himalayan Region (IHR). Quality of spring water altered from spring to spring which results in different uses of springs by the users, such as recreational, domestic, industrial, and agricultural usages. Spring water quality depends on several factors such as the interaction of the water with the geology of the area, composition of minerals present in an aquifer, rock-water interactions, products of weathering, the topography of the surrounding area, climatic conditions as well as anthropogenic activities (Ghanem et al., 2021). Though the Indian Himalayan Range is a region of numerous perennial rivers but people living on mountains depend to a great extent on spring water for their sustenance as rivers flow in deep valleys and glaciers are very far away, and hence acquiring water from these resources is not feasible (Tambe et al., 2012). This issue emphasizes the importance of spring water in maintaining the life of residents in these regions. Also, springs sustain many rivers, especially in the lean season. Nearly 200 million Indians throughout the nation are dependent on spring water for accomplishing their daily water needs (NITI Aayog, 2017). Due to growing population and unplanned development, springs have been adversely affected which leads to depletion of this major water resource in the whole Himalayan region. In addition, rising air temperature, a decline in winter rainfall, and other climatic changes also affect the spring water resources (Tambe et al., 2012). The primary sources of water in the rural areas of Jammu and Kashmir are streams, rivers, and springs. Through the sub-surface and surface, water flows emerged largely from the unconfined aquifers. Due to the mountainous topography of the state, springs are the only viable source in the state mainly in the village area. Unfortunately, unlike streams and rivers, no agency regulates the monitoring of these springs. Also, the introduction of the piped water supply has shifted the focus of local people from conservation of this natural resource. Over the many years, springs are drying up in the state, as a result of which there is a drastic shortage of potable water in the villages. In the Lansi region of Udhampur, spring water is mostly used for drinking purposes; hence it should be tested and compared with national and WHO standards to ensure safe drinking water for the local population. The water quality index had been used worldwide to know the overall water quality in a particular area (Abdulwahid, 2013).

In view of the above, the present study evaluates the drinking water quality by analyzing physico-chemical parameters and using Water Quality Index as a feasible instrument for monitoring spring water quality in the Lansi village, Udhampur, Jammu and Kashmir (India).

Materials and methods

Study area

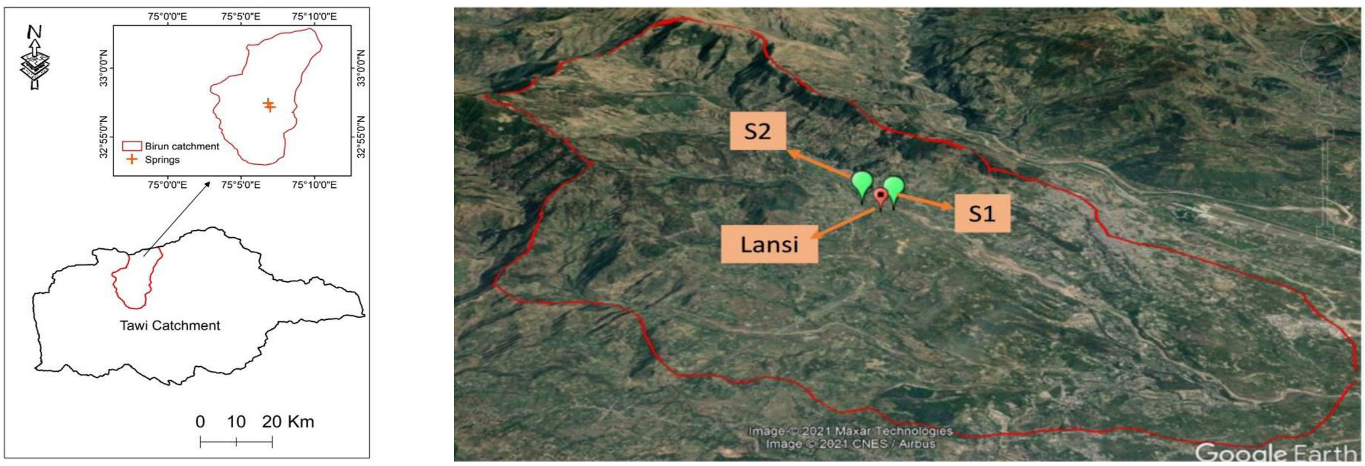

Fig. 1: Map of Birun catchment with a google earth image illustrating the sampling sites present in Lansi village.

Lansi is a small village in the Udhampur district of Jammu and Kashmir state. It is situated 9 km away from Udhampur city. Dabreh is the gram panchayat of Lansi village as per 2009 statistics. Lansi village has a total geographical area of 153.8 hectares and a population of 843 people living in 158 houses. The major potable water sources in the study area are springs. In the present study, we have studied two important springs/bowlis used for domestic and drinking purpose (Figure 1). The Landuse pattern in the vicinity of the first spring (S1) is scrubland while the second spring (S2) is surrounded by moderate settlement and also having an iron bridge nearby. Both the springs are in the form of sacred bowlis having fully cemented structures along with carvings of demigods on the walls of bowlis.

Methodology

The water samples (six grab samples from each spring were collected on the same day at 1 hr interval and then mixed to form composite samples) from the bowlis were collected in polyethylene bottles and analyzed for physical and chemical parameters by following the standards procedures. The parameters like pH, EC were monitored at the spring site by using a standardized multi-parameter water analysis kit/portable meter. Alkalinity, carbonate, bicarbonate, magnesium, calcium, and chloride content were measured by titration method, nitrate, sulphate, iron, fluoride contents were measured by spectrophotometric methods, while Na^+ and K^+ were estimated using a flame photometer (APHA, 2005). The suitability of studied water samples was examined by comparing them with Indian (BIS, 1991) and WHO (2004) standards. To get an overall view of the water quality of the studied springs, WQI was used. "WQI is defined as a rating reflecting the composite influence of different water quality parameters on the overall quality of water" (Taloor et al., 2020). WQI is computed to turn compound water quality data into easily understandable instructions which can be used by the public. Hence, WQI is a convenient and capable tool that provides us an easy-to-understand water quality indicator that depends on a few major parameters. In the present investigation, for calculation of WQI specified Indian standards for drinking water were used (BIS, 1991). The WQI was computed using three steps- first of all, weight (W_i) was given to every selected parameter depending on its relative importance in the overall water quality for drinking purposes (Table 1). In the 2nd step, the relative weight of chemical parameters is computed by using the following equation.

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i}$$

Where, W_i= relative weight

w_i= weight of each parameter

n = number of parameters

In the 3rd step, q_i (quality rating scale) is computed by using equation-

$q_i = (C_i/S_i) x 100$

Where, q_i= quality rating scale

C_i= concentration of each chemical parameter in water sample in mg/L

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

Finally, for WQI, the sub-index (SI) is determined for each chemical parameter as-

$SI_i = w_i \times q_i$

$WQI = \sum SI_{i-n}$

Where, SI_i= sub-index of i^{th} parameter

W_i= relative weight of i^{th} parameter

q_i= rating based on the concentration of i^{th} parameter

n = number of chemical parameters

The calculated WQI values are classified into 5 categories: WQI= 0-50 (excellent water quality); WQI= 50-100 (good water quality); WQI= 100-200 (poor water quality); WQI= 200-300 (very poor water quality); and WQI >300 (water unsuitable for drinking purpose) (Ramakrishnaiah et al., 2009).

Results and discussion

The surplus of dissolved anions and cations in water sources is due to weathering, geological rock type surrounding the water body (Singh & Hasnain, 1999), and inputs from human interference. To know the level of these dissolved constituents physico-chemical analysis is a major tool (Barakat et al., 2018). The present study comprises a comparison of the physico-chemical parameters of the spring water of the study area with Indian standards (BIS, 1991) and WHO (2004) for appropriateness of drinking water which is summarized in Table 2.

The outcomes of pH values in the studied spring sites ranged from 7.1 at S1 to 7.3 at S2 which was almost neutral and under the permissible limit. The maximum value of EC was 500 µS/cm at S2 while it was 421 µS/cm at S1. For both the spring sites value of EC was above the permissible limit, which depicts moderate to low mineralization in the studied sites (Batabyal & Chakraborty, 2015). For total dissolved solids (TDS), a higher value was 320 mg/L at S2 while at S1 it was 269.44 mg/L which was well within the permissible limits. These values revealed that spring water at both sites was hydrochemically suitable for drinking purposes. Total alkalinity value ranged from 196 mg/L at S1 to 200 mg/L at S2 which was under the permissible limit and showed a low level of bicarbonate present in the study sites. Total hardness was observed in the range of 43.2 to 52.2 mg/L at sites S1 and S2, respectively which was within the safe limit for drinking water as well as showing that spring water was soft water. In addition, it also indicated the minimal anthropogenic activities around the springs.

The study of ion chemistry in the study area reveals that all the studied anions (Ca^{2+}, Mg^{2+}, K^+, Na^+) were within safe and permissible limits when compared to Indian and WHO standards. In the present study, calcium concentration for both sample sites was 10.56 mg/L. Chauhan et al. (2020) also found the average value of 10.9 mg/L for calcium while studying the springs of Uttarakhand. Magnesium ranged from 19 mg/L at S1 to 24.28 mg/L at S2. Both the elements are necessary to human health but in limited amounts. In the studied samples, the concentration of magnesium was more than calcium which might be related to the weathering process of minerals and rock content as well as the pH value of each source (Ameen, 2019). The value of sodium ranged from 1.72 mg/L at S1 to 2.23 mg/L at S2 and for potassium, it was 0.36 mg/L at S2 while 0.82 mg/L at S1. In both the studied spring sites, the concentration of sodium was higher than the concentration of potassium. This may be because potassium is locked by clay minerals and takes part in the evolution of secondary minerals (Scheytt, 1997).

The concentration of chloride in our samples ranged from 14.91 mg/L at S1 to 24.85 mg/L at S2 which was within the permissible limits. Sulphate values in the sampled springs were from 2 mg/L to 16 mg/L at S1 and S2, respectively which was under permissible limit. The values of sulphate revealed that studied springs have no bad odour or taste, as it has a direct effect on the taste and odour of potable water (Bouslah et al., 2017). Drinking water with increased sulphate values might have an undesirable taste and could be responsible for laxative effects in consumers (WHO, 2017). Further nitrate concentration in the analyzed samples varied from under range at S1 to 1.9 mg/L at S2. The low value of nitrate in studied springs indicates only the natural addition of nitrate in the spring water. Tripathi et al. (2015) also found low nitrate concentration while studying the springs of Dehradun. Bicarbonate ranged from 239.12 mg/L at S1 to 244 mg/L at S2 which was within permissible limit and showing minimal microbial decomposition. In our study, a maximum value of fluoride was reported as 0.23 mg/L at S2 while at S1 fluoride was under range. This was similar to a study carried out by Kour and Kour (2016), during the assessment of groundwater quality of Udhampur district with special reference to fluoride, they found that most samples of groundwater were under the permissible limit and there was no need for defluoridation of groundwater. We have found elevated iron concentration at S2 that was 1.6 mg/L, exceeding the permissible limit (0.3 mg/L) while at S1 it was under range. Elevated concentration of iron may occur in the study area as iron leached out of rock formations and soil due to precipitation (Batabyal and Chakraborty, 2015). Also, there was an iron bridge present near the S2 which might be the cause of high iron content in spring as a result of corrosion of bridge and then leaching of this into spring. Murtaza et al. (2020) also found that most of the physico-chemical parameters studied for groundwater in the Udhampur district were under permissible limits and water was safe for drinking purposes. Kanwar and Khanna (2014) analyzed groundwater samples of the Udhampur-Dun terrace belt and found samples readings in accordance with BIS standards. Further, they revealed that the maximum number of groundwater samples was acceptable for drinking.

Table 1 Relative weight of chemical parameters.

Chemical parameter (mg/L)	Indian standards	Weight	Relative weight $W_i = \frac{w_i}{\sum_{i=1}^{n} w_i}$
pH	6.5-8.5	4	0.0952
TDS	500-2000	4	0.0952
Total hardness	300-600	2	0.0476
Bicarbonates	244-732	3	0.0714
Akalnity	200	4	0.0952
Chloride	250-1000	3	0.0714
Sulphate	200-400	4	0.0952
Nitrate	45-100	5	0.1190
Fluoride	1-1.5	4	0.0952
Iron	0.3-1.0	5	0.1190
Calcium	75-200	2	0.0476
Magnesium	30-100	2	0.0476
		$\sum w_i = 42$	$\sum W_i = 1.000$

[a]*Chemical parameters in mg/L.*

[b]*Lower value indicates desirable limit, and higher value indicates permissible limit in absence of alternate source (Bureau of Indian Standards, 1991)*

Table 2 Comparison of groundwater quality with drinking water standards (Bureau of Indian Standards, 1991; World Health Organization, 2004).

Parameters	Indian standards (desirable limits)	WHO standards (2004)	Spring1 (S1)	Spring2 (S2)
pH	6.5-8.5	6.5-8.5	7.1	7.3
EC	-	400	421	500
TDS	500	500-1000	269.44	320
Total hardness	300	500	43.2	52.2
Bicarbonates	-	125-350	239.12	244
Akalnity	200	-	196	200
Sodium	-	200	1.72	2.23
Potassium	-	20	0.82	0.36
Chloride	250	250	14.91	24.85
Sulphate	200	250	2	16
Nitrate	45	50	Under range	1.9
Fluoride	1	-	Under range	0.23
Iron	0.3	0.3	Under range	1.16
Calcium	75	100	10.56	10.56
Magnesium	30	50	19	24.28

Note: Electrical conductivity in µS/cm, all other parameters in mg/L except pH.

The WQI evaluates the suitability of drinking water (Ramakrishnaiah et al., 2009; Varol & Davzaz 2015; Shah et al., 2018). In the current study, WQI values ranged from 35.99 at S1 to 88.19 at S2 which falls into "excellent" and "good" water quality respectively. This is due to the reason that almost all the parameters were under permissible limits provided by BIS (1991) and WHO (2004) standards. The higher value of WQI at S2 was due to the elevated level of iron. Further, the excellent status of S1 was because of its location and formation. Water at S1 comes through the closed pipe which protects it from contamination from different non-point sources while S2 was surrounded by moderate settlement which might be the reason for higher values of studied parameters at this site. By this study, we found that both the springs are suitable for drinking water purpose. The findings of our work are in accordance with the results of Murtaza et al. (2020) and Taloor et al. (2020).

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 effects on human beings health but might have adverse effects on human well-being by prolonged use of drinking water with higher iron concentrations. Hence, it is recommended that proper treatment of spring water with higher concentrations of iron should carry out to reduce the elevated concentration of iron and to make sure pure water supply for the people depending on that spring. In addition, regular monitoring of spring water quality should be made mandatory to spot any change in water quality parameters.

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