Journal of Advanced Zoology

ISSN: 0253-7214
*Volume **43** Issue **1** Year **2022** Page 1300-1312*

Assessment Of Water Quality Of Selected Natural Springs And *Jhoras* Lying Within Gangtok Municipal Area

Prasanjit das[1*]

[1]Department of Zoology, Sikkim university Nagaon, Assam*

***Corresponding author:** Prasanjit das*
**mail: prasanjitdas500@gmail.com*

Abstract

The increased demand for fresh spring water, especially in the hilly regions, has evolved intensively in the recent times due to the enormous domestic, industrial, irrigational practices which typically cause depletion of water resources and deterioration of water quality and adding stress on these already scarce resources both quantitatively and qualitatively. Periodic quality assessment and monitoring of these drinking water sources is necessary to ensure the quality and security of water supply for the people. Accordingly, this study describes the physicochemical drinking water quality of some selected springs located in Gangtok municipal area together with those of *jhoras*. Analysis were done using the parameters of the Bureau of India Standard (BIS).To realize this objective, 10 springs and 3 *jhoras* were selected and samples collected from these sites from the specified period between February to May,2022. The result for pH, electrical conductivity (EC), Total Dissolved Solid (TDS) and chloride of springs showed that the water samples at all the sites were suitable for drinking and within permissible limits as determined by (BIS). Whereas, water samples of *jhoras* showed the presence of a high percentage of Total hardness, Calcium, Magnesium, Chloride and Sulfate which indicates that the water might have been contaminated by effluent discharge or by excretion of nitrogenous waste from an animal source. Based on the parameters, where values were close to or exceeded the maximum acceptable limits, it showed that the water quality status of all water samples of springs were of "good" quality whereas some spring water needed pretreatment for the purpose of drinking. Water from almost all the sampled spring sites can be considered suitable for drinking purposes.

KEYWORDS: Assessment, jhora, permissible, security, Bureau of India Standard (BIS).

1. INTRODUCTION

WATER plays an important role as an indicator of the occurrence of climate change, especially in mountainous regions. Spring water has an extraordinary importance due to its role in meeting the increasing drinking water demands (Bhat et al., 2020). Water shortage because of climate change and rising water demand across the globe has increased (Wegener et al., 2010; Burek et al., 2016), and fresh-water scarcity is increasingly perceived as a global systemic risk (Mujumdar and Tiwari, 2019). Water, an increasingly stressed resource, is witnessing a worldwide increase in consumption, especially in the last four decades, largely due to a blend of rising human population growth, socio-economic development and changing consumer choices and trends ,United Nations World Water Development Report, 2019 (WWDR). Water is very vital for human life and overall development and attracts more attention globally as 20% of the population is experiencing high water stress and another about 40% is facing severe water scarcity. This stress is bound to increase as the demand for water progresses and the impacts of projected climate change intensify. Safe drinking water and proper sanitation have been considered a basic right of an individual as they are essential for healthy living and maintaining the dignity of humans (WWDR, 2019). But, at the same time, there is a substantial percentage of the human population who does not have access to safe water to meet basic hygiene and domestic requirements.

The increasing demand for scarce water resources has further intensified the competition not only between humans and their environment but also between different socio-economic sectors (Kurian, 2017). Anthropogenic factors in the form of rising human population growth and subsequent urbanization are prominent in contributing to a rapid surge in the demand for various uses like drinking, sanitation, agriculture, energy production, industry, and environmental protection. Water and its judicial use and management are considered as one of the great challenges of the future. Groundwater being valuable, but facing continuous depletion, has a major role in meeting the demands of various sectors besides overall economic development and food security. Spring water utilization offers an array of services for people but with some costs like reduction in water quality (Howell et al., 1995). Population growth, urbanization, and unplanned application of agrochemicals and discharge of untreated sewage water are directly or indirectly impacting the quality and quantity of surface and subsurface freshwater resources, and accordingly there is a high demand for safe water for drinking, sanitation, agriculture, and environmental protection (www.en.unesco.org/wwap).

Melting glaciers supply water to lakes, rivers and springs. They are the major water resource for irrigation, not only in the mountains but also in the plains. The amount of water flow depends extensively on weather conditions. For instance, winter is often a water-scarce season in the mountains compared to the monsoon or summer. The variation in water run-off may result in either too much water or no water and therefore increase the vulnerability of livelihoods in the mountains. This also poses risks to human lives through water-borne diseases and affects infrastructure. For example, the increased frequency of landslides and flash floods, and reduced water flow in the dry season, tourism could be adversely affected due to recurring natural hazards.

Water contamination due to pathogenic agents, chemicals, heavy metals, pesticides, water disinfectants and their by-products as a consequence of industrial and agricultural activities, leaching from soil, rocks and atmospheric deposition and other human activities has become an environmental risk leading to hazard to human health in several regions of the world. Various chemicals are being introduced into water bodies or aquifers usually as a consequence of leaching from soil, rock or via atmospheric deposition, through the dissolution of mineral/ores, industrial effluents and agricultural runoff. Due to indiscriminate withdrawal of ground water causes deterioration of groundwater quality.

Natural springs are geothermal points on the surface of earth through which ground water emerges and flows and are commonly found almost all of the mountainous regions in Sikkim and around the world. Springs have their profound characteristics and can be perennial or seasonal and the temperatures vary at various geographical locations (Rothschild and Manicinelli, 2001).
Jhoras (sikkimese word for nullah) is the drainage basin, an area of land where precipitation flows and it drains off into a common outlet, such as into a river or other body of water. The drainage basin includes all the surface water from rain runoff, snowmelt, hail, sleet and nearby outlets, as well as the groundwater underneath the earth′s surface.

Sikkim, a northeastern state in the lap of the Eastern Himalaya, has cardinal importance not only because it shares boundaries with three nations, viz. Nepal, Bhutan and China, but also due to their immense biodiversity (Dhakal et al., 2020). This mountainous state has its own glory and gloom when it comes to water. On the one hand waterfalls, springs, rivers and religious lakes (for e.g., Khecheopalri, Gurudongmar, Changu lakes, etc.) attract tourists and revenue and on the other, recurring landslides, blocked roadways, water contamination and scarcity. Despite the presence of contaminants, the quality of water remains better than that in the lowlands of India. The water runoff in the state flows through various geological structures such as joints, fractured and weathered zones, Rainfall remains the principal mode of recharge of surface water. Due to mountainous slopes, most of the precipitation causes surface runoff resulting in streams, springs and *jhoras*. Spring water is further tapped through pipelines and distributed by the gravity method for domestic use. As the major portion of water supplied to the locals is in continuous contact with the surface, it further increases the risk of microbial presence in the water and elemental contamination from country rocks. Drinking water contaminated by human or animal waste and also due to breakage of pipelines.

Over the past few decades, the Indian Standard for Drinking Water as per BIS specifications has been considered as an effective tool that provides information on the quality of water for use by concerned citizens and policymakers, and has been utilized in surface and groundwater quality evaluation. The outcome indicates the quality of water, in which represents the overall quality of water in relation to specific standards for specific uses. BIS is the National Standards Body of India under the Ministry of consumer affairs, Food & Public Distribution, Government of India. This standard was first published in the year 1983 with the objective of assessing the water quality of water resources and to check the effectiveness of water treatment and supply by the concerned authorities. This standard specifies the acceptable limit and permissible limits in the absence of alternate source (http://cgwb.gov.in). Accordingly, numerous WQIs have been formulated and approved around the world (Brown et al., 1970; Ganiyu et al., 2017; Reza and Singh, 2010; Shigut et al., 2017), which vary in terms of statistical incorporation and translation of parameter values (Abbasi and Abbasi, 2012; Alobaidy et al., 2010). Springs are the primary source of water for drinking, agricultural, and domestic purposes in Gangtok. Although spring water is considered inexpensive and of high-quality due to its filtration through the soil layers, the quality of this water source is based on certain physicochemical parameters. In the present, the study criteria for selecting a particular spring is that from the spring a minimum of 25 households must depend on it and it is found that spring water is mainly used for drinking and rural domestic use; hence, it should be tested and compared against domestic water quality standards to ensure safe drinking water. BIS's standard have been applied to assess the overall water quality within a particular region in India quickly and effectively. However, it is noted that there are few studies have been conducted on spring water. In addition, to that there was no such study recorded for *jhoras* in Sikkim for its physicochemical parameters of our knowledge; the spring water quality of many villages in the area was left un-assessed. The present study, therefore, evaluates the drinking water quality of springs and the chemical and toxicant level in *jhoras* and comparative study for water in Gangtok within municipal area.

2. REVIEW OF LITERATURE

Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking water can result in tangible benefits for health. Every effort should be made to achieve drinking water that is as safe as practicable. Increased public awareness of environmental issues has caused consumers to be conscious of the quality of drinking water. This is reflected by the large increase in the sales of bottled water and home treatment systems .Natural water quality varies from place to place, with the seasons, climate and the types of soils and rocks through which water moves. Though spring water has been considered to be pure because of its filtration through layers of soil, it has its own health and acceptability problems based on the concentration level of certain chemical parameters. It is therefore important to understand the level of toxicity of the chemical elements and compounds in water used for domestic purposes. It is also important to know the quality of water in any community and the 'quality requirements' for various water users. While most chemical elements in groundwater such as Copper, Manganese and Lead are potentially toxic, other essential elements like fluoride and Iron (at required levels) may give rise to health problems due to their deficiency in water. The toxicological and deficiency problems of the chemical constituents in water continue to become more apparent as people progressively switch from traditional supplies of surface water to biologically safer groundwater. It is consequently important to understand groundwater characteristics in terms of its chemical constituents. The basic requirements for drinking water are that it should be free from pathogenic organisms, containing no compounds that have an adverse effect in the short or long term on human health, fairly clear i.e. low turbidity and little colour, not saline. It should contain no compounds that cause an offensive taste or smell and not cause corrosion or encrustation of the water supply system or staining of clothes washed in it.

Several studies have been completed in the past and several studies are going on. There is no static result for water quality but its studies provide a potential basis and create an opportunity to study further and regularly.

3. MATERIAL AND METHOD

3.1. STUDY AREA

In this study, water samples were collected from 10 different springs and 9 spots from 3 different *jhoras* within Gangtok municipal area. Gangtok is the capital city of the state of Sikkim.Sikkim lies in the Northeastern Himalayan region. It spreads over a geographical area of about 7096km² (which accounts for 0.2% of the total area of India). Geographically, the state extends from 27⁰03`N to 28⁰07` N latitude and 88⁰03` E to 88⁰57` E longitude. The state shares an international border with Nepal in the West, the Tibetan Autonomous Region of the Republic of China in the North, the Kingdom of Bhutan in the East and West Bengal in the South. It is situated in the lower Himalayas at an elevation of 1,650 m (5,410 ft.). The names and geographic coordinates of the investigated springs and *jhoras* are presented with the help of ARC-GIS in Map 1 and Table 2. The town lies on one side of a hill, with "The Ridge", a promenade housing the Raj Bhawan, the governor's residence, at one end and the palace, situated at an altitude of about 1,800 m (5,900 ft.), at the other. The city is flanked on east and west by two streams, namely Rora Chu and Ranikhola, respectively. These two rivers divide the natural drainage into two parts, the eastern and western parts. Both the streams meet the Ranipool and flow south as the main Ranikhola before it joins the Teesta River at Singtam. The geography of the area is mountainous, and the climate is considered semiarid, characterized by hot, dry summers and cold, wet winters and is usually snowy with more rainfall in the north than in the central and southern parts. The area receives an annual rainfall of 3894 mm (2020) (www.sikenvis.nic.in).The major water sources in this area are springs and rivers, and a great proportion of the population obtains water from springs for drinking and domestic purposes.

3.2. GENERAL GEOLOGY OF STUDY AREA

Sikkim is a part of the lesser Himalayan terrain of the eastern sector. Tectono-stratigraphically it has been classified under four tectonic belts (i) Foothil belt (ii) Inner belt (iii) Axial belt and (iv) Trans-axial belt (www.sikenvis.nic.in). The state is predominantly covered by unfosslliferous metamorphic and crystalline rocks grouped under the inner and axial tectonic belts. The inner belt is essentially made up of the precambrain Daling and Darjeeling groups of meta-sediments and minor development of the Buxa group of rocks. The axial belt exposes the crystalline of the Central region and intrusive granites. There are two predominant zones viz. gnessic and Daling group. The entire state is a young mountain system with highly folded and faulted rock strata in many places. It encompasses the lesser Himalayas, Central Himalayas and Tethys Hima1ays. Great mountains ranging from 3000 meters to 8500 meters in height separate the state from its surroundings.

3.3. SITES

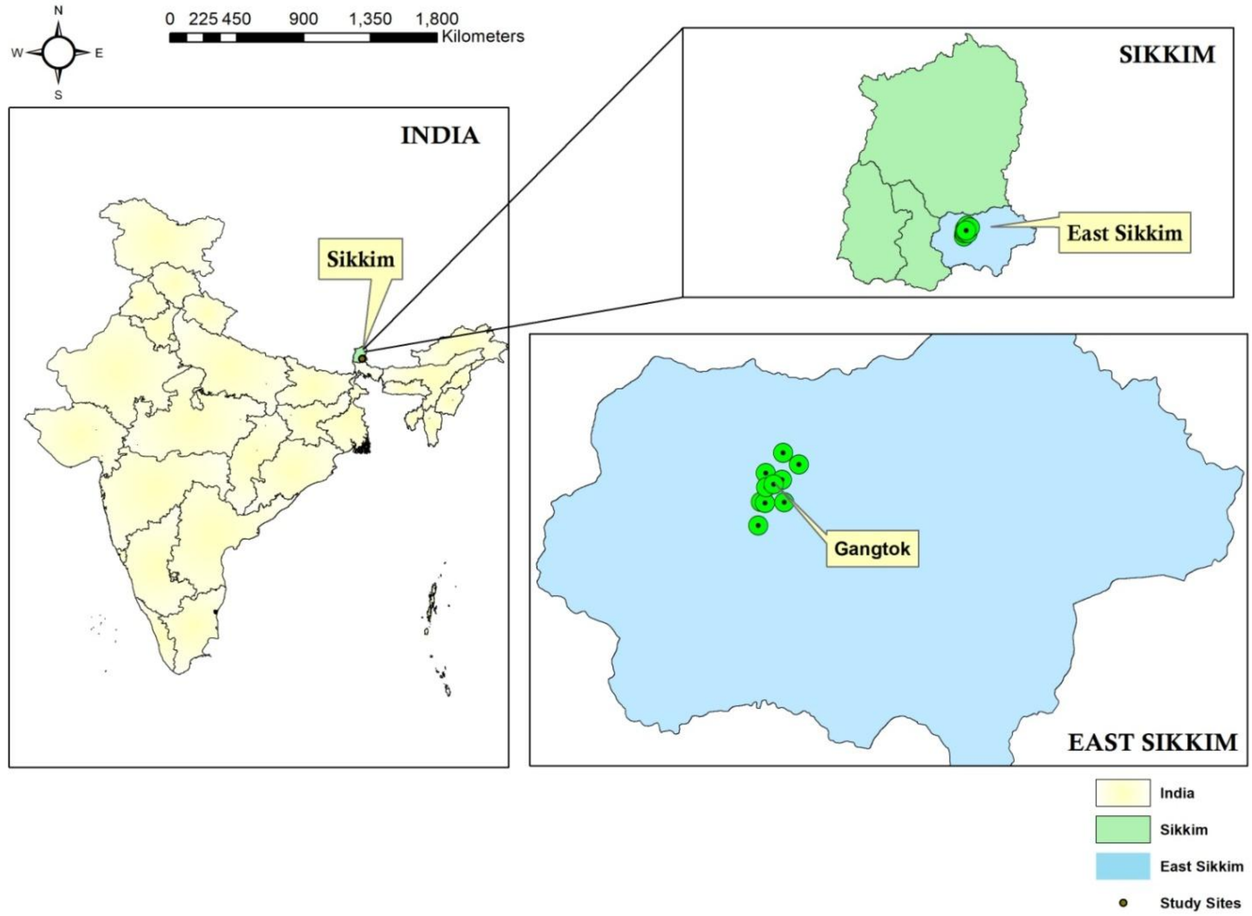
In the study the spring was selected on the basis that from the springs a minimum of 25 household is depend directly or indirectly. All the name and their respective geographic coordinate are as follows (for the convenience each spot has been designated with site code):

1. 7th Mile (S1) 27°17′58″N and 88°35′31″E
2. Entel (S2) 27°18′50″N and 88°35′38″E
3. 5th Mile(S3)27°18′47″N and 88°35′48″E
4. Manipal(S4) 27°19′53″N and 88°35′51″E
5. Dzongri(S5) 27°19′22″N and 88°35′52″E
6. KV(S6) 27°18′48″N and 88°36′35″E
7. Deorali(S7) 27°19′38″N and 88°36′31″E
8. Vajra(S8) 27°20′37″N and 88°36′34″E
9. Enchey(S9) 27°20′11″N and 88°37′13″E
10. Lingding(S10) 27°19′28″N and 88°36′10″E

And name of the three *jhoras* are not designated so we name the *jhoras* according to location it flows through; namely *jhora*1 (Deorali), *jhora* 2 (Manipal), *jhora* 3(6th mile). The sample thus obtained were subject to analysis in the laboratory using standard methods and following standard procedures to ensure data quality consistency (Wetzel and Likens, 2000), APHA (American Public Health Association, 2012).

3.4. Map

Map: 1. Map of sampling site of spring



3.5. ANALYSIS OF SAMPLE COLLECTION METHOD

Spring water was collected and on the spot water temperature, pH, electrical conductivity and TDS were measured and also water was obtained in high-density polyethylene (HDPE) bottles and brought to the laboratory for further analysis.

The instrument used for measuring the geographical coordinates of the spring site and *jhoras* is, Global Positioning System- GPSMA78S, while for the measurements of water temperature, scientific mercury thermometer were used and for determination of pH, electrical conductivity and the TDS Henna HI199130P digital meter used. Calibration of the electrode is done in the laboratory before measuring the sample, with the buffer pH 4.0 and pH 9.2.

The dissolved oxygen (DO) in the sample water was analyzed using the Winkler's method.

The total carbon-di-oxide (CO_2) is measured using a volumetric analysis method in which CO_2 in its acidic condition is neutralized using sodium carbonate (Na_2CO_3) as a neutralizing agent.

The Hardness of water is due to the presence of combinations of major ions, calcium and magnesium, which forms a soluble chelated complex with Ethylene diamine tetra acetic acid (EDTA) and Eriochrome Black T form as an indicator. Total hardness is determined using this indicator and when the indicator is added to the solution, the color changes from red wine to blue, due to the formation of a complex between metal ion and indicator. When EDTA is added to the solution color changes from red wine to blue indicating the end point of titration. Calcium and magnesium in water are present in the form of carbonate and bicarbonate, they have the tendency to form complex with EDTA. Calcium and magnesium ions develop wine red colour with Erichrome Black T in aqueous solution when EDTA is added as a titrant. At higher pH i.e. at 12 Mg^{2+} ions precipitate out as insoluble magnesium hydroxide [Mg (OH_2)] and only Ca^{2+} ions remain in the solution. At this pH, Murexide (ammonium purpurate) indicator forms a pink colour with Ca^{2+}. When EDTA is added, Ca^{2+} forms a complex with EDTA resulting in a change in color from pink to purple, which indicates the end point of reaction and for the estimation of magnesium from the total value of total hardness, calcium values is subtracted to get the result for each spot.

The estimation of chloride in water is done with an argentometric method where silver nitrate ($AgNO_3$) reacts with chloride present in water to produce a white precipitate. When the entire chloride ion combines with silver, the excess silver present combines with a chromate indicator to generate a pinkish orange colored silver chromate. This point of change in colour of the precipitation is used to specify the end point in chloride determination.
The estimation of sulfate ions in water is estimated using the turbidimetric method where sulfate ions are precipitated in the form of $BaSO_4$ by adding $BaCl_2$ in slight excess of water acidified with HCL. The light absorbance $BaSO_4$ suspension is measured by photometer using at 420nm and sulfate concentration is determined by comparing the reading with a standard curve.
The estimation of phosphate using the analytical method where it's principal based on molybdophosphoric acid, which is reduced to the intensity colored complex, molybdenum blue. Water forms a complex reaction to produce a color that complex of molybdate and phosphorus. This complex is formed when phosphate is heated with the ammoniummolybdate in the presence of acid and excess asorbate ions. The colored is formed is dependent on the initial phosphate concentration in the sample. The amount of phosphate is determined using comparison of the blue colour with known standards of phosphate, subjected to the same reaction with molybdate reagent.

3.6. NATIONAL STANDARDS RELATED TO ASSESSING THE QUALITY OF WATER

To compare the obtain data with the Indian Standard for Drinking Water as per BIS specifications have been considered. This standard specifies the acceptable limit and permissible limits in the absence of alternate source

Table: 1. National standards related to assessing the quality of spring water (BIS, 2012)

Sl No	Characteristics	Requirement (Acceptable limit)	Permissible limit in the absence of alternative source
1	pH	6.5-8.5	No relaxation
2	Conductivity(µs/cm)	750	1400
3	TDS(mg/l)	600	2000
4	DO(mg/l)	-	-
5	Total CO_2 (mg/l)	-	-
6	Total hardness (mg/l)	300	600
7	Ca^{2+} (mg/l)	75	200
8	Mg^{2+} (mg/l)	30	100
9	Chloride(mg/l)	250	500
10	Sulfate (mg/l)	200	400
11	Phosphate(µg/l)	-	-

4. RESULT AND DISCUSSION

The relative abundance of major dissolved chemical constituents in water is dependent upon weathering process, type of geological rock (Singh and Hasnain, 1999), and also inputs from anthropogenic activities. The physico- chemical analysis is used for detecting the levels of these dissolved constituents in water (Barakat et al., 2018). Accordingly, in the current study, the collected samples from the spring water in different point were analyzed for 11 physicochemical parameters. The summary of the results derived for the various physiochemical parameters of the springs and *jhoras* are summarized in table 3 and table 4. Water quality degradation is a problem growing in complexity as prosperity expands and new contaminants emerge (Damania et al., 2019). The relative constancy of water temperature across the springs indicates the thermal stability owing to the lesser amount of solar radiation reaching the water due to shade and thermally buffered water emanating from the underlying rock (van der Kamp, 1995; Grasby et al., 2000; Glazier, 2014). Based on water temperature, springs under investigation fall under cold water springs (Nathenson et al., 2003; Bhat and Pandit, 2010; Glazier, 2014), whereas water temperature of the *jhoras* are slightly more as compared to springs as the *jhoras* are directly exposed to sun and causes water to evaporate, so the amount of water vapor in the air, or humidity is higher at the water surface. Another possible region is that the sun heats up material holding the water including ground under the water. The variation in annual air temperatures seems behind the sinusoidal pattern in spring water temperatures with maxima in summers and minimum in winters (Liu et al., 2007)

pH: Spatio-temporal variability in pH shows a characteristic relation between precipitation, rock water interaction, biological activity, and organic matter decomposition (Hem, 1992; Wetzel 2001; Ojha and Mandloi, 2004; Oki and Akana, 2016). pH refers to the degree of acidity or alkalinity of a solution or water. pH is a crucial indicator that can be used for assessing water quality and degree of contamination in water bodies. The results of pH values in all the sampling sites were ranged from 6.9-8.0, lowest at S4 and highest at S10 (Table 3). On this basis, all the water samples were almost neutral to slightly alkaline. As the pH of water sources in the S10 area are characterized by a shift more toward the alkaline side as compared to other site this might be due to the geological composition of the region, which consists largely of calcium carbonate($CaCO_3$) as well as less discharge of water seen at the time of sample collection. The pH of all other springs, which approached towards neutrality, is due to an increase in flow at the time sample collection in the upper areas that do not get enough time to percolate through the soil before reaching the spring. The pH values in all the study sites were within an acceptable range (6.5–8.5) (BIS, 2012).

As studied the pH of *jhoras* water is more than springs which is expected as the all point of sample collection it was observed it get polluted by the garbage, discharge of drainage water by the household nearby into the *jhoras*, at the higher elevation pH was less at the point 1 site of the respective 3 *jhoras* as 7.9, 7.5 and 6.9, as the *jhoras* runs though the middle of the city the pH of the *jhoras* water also increased subsequently, whereas at the meet point of *jhoras* with the khola (river) pH is the highest ranged from all the 3 *jhoras* are 9.2, 8.1 and 7.8 respectively.

Electrical Conductivity: The EC values of the spring water varied from 195-648µS/cm and fell well within the desirable limits of the (BIS, 2012) (Table 1). The spring waters were alkaline with moderate to high electrical conductivity, which is typical for water on carbonate bedrock (Jeelani, 2008). Lower electrical conductivity in some site is attributed to the dilution effect caused by the increased discharge due to rainfall runoff (Jeelani, 2008; Moore et al., 2008).

In *jhoras* the EC ranges from 411-613µS/cm, which is quite high as compared to springs value. This is due to presence high concentration of chemical constituent.

Total Dissolved Solid: TDS which is a measure of the salinity of groundwater is also frequently used as a useful parameter for evaluating the quality of water and for classifying drinking and irrigation water (Barakat et al., 2018). TDS is usually estimated by electrical conductivity (EC) and there is a strong relationship between EC and TDS. EC can be seen refers to the direct measure of TDS (Abdul wahid, 2013). According to (Barakat et al., 2018), the concentration of dissolved chemical substances and mineral contamination in water are controlled by the level of EC of the water. The TDS ranged from 123 mg/l to 457 mg/l, lowest at site S4 while highest at site S7 (Table 3) during the time of collection. All the samples fell into the desirable limit of BIS standards (2012).It was reported that there exists an inverse relationship between water hardness and cardiovascular diseases. It may also affect the taste of water due to increase in TDS (Yang et al., 1998)

In terms of *jhoras* TDS value were ranged 250-378mg/l, this higher value could be due to the natural weathering of certain sedimentary rocks or a certain anthropogenic source, e.g., irrigation discharge, domestic effluents, and sewage effluent. The TDS values in most sampled point were significantly higher except *jhoras* 2 point 1site 250 mg/l (Table 5).

Dissolved oxygen: DO refer to the concentration of oxygen gas incorporated in water. Oxygen enters water by direct absorption from the atmosphere, which is enhanced by turbulence. The amount of DO values show variation within almost anoxic conditions at S8 3.2 mg/L (Table 3) and highest at S2 site 9.6 mg/L. The lower DO concentration recorded is possibly due to effect of mineral turbidity caused by the large amount of clay particles stirring up the underlying rock, the biogeochemical process.

DO of the *jhoras* were seen ranged from 0 mg/l t 6.5 mg/l (Table 6), less then compared to *springs* because with temperature increase that has a stronger effect on organic matter decomposition and dominates over the photosynthetic activity besides that warm water relatively hold less oxygen than cold water (Goldman and Horne, 1983; Metcalf and Eddy, 1979; Kumar et al., 1996; Joshi and Kothyari, 2003).

Total Carbon di oxide: The amount of total CO_2 in spring water ranges from 14.6- 32 mg/l, with highest value found in site S4 (table 3). The acidity of normal water is sample is mainly due to the presence of dissolved CO_2. Natural water contains total CO_2 as dissolved from atmosphere. It is also formed by the decomposition of bicarbonates in water. The amount of dissolved CO_2 in *jhoras* ranges from 45-97 mg/l (table 5) higher than the spring range as because of *jhoras* water content higher amount chemical constituent.

Total Hardness: TH of water is another essential indicator for estimating water quality for domestic, industrial and agricultural purposes (Al-Jiburi and Al-Basrawi, 2015). The development of hardness in water is primarily derived from dissolved alkaline earth metals, such as calcium and magnesium, with all other divalent cation also contributing to the concentration (Barakat et al., 2018). The rocks surrounding the water body are largely the source of TH, although some anthropogenic activity could contribute to varying concentrations (Bouslah et al., 2017). The TH values of spring ranged from 76 to 167.6mg/L whereas *jhoras* values ranged from 179 to 408 mg/L and the minimum and maximum values of TH were recorded at the sites S10 and S9. The TH values of all the water spring samples in the present study were below the permissible limit (600mg/L) as per (BIS, 2012) (Table 1), although the values were close to the allowable level. Since the TH depends mainly on the geological context, the high values observed could be related to the lithological nature of the aquifer formation which corresponds to crystalline rocks of the mountains in the study area. At these TH levels, there could be adverse effects on human health in the long-term (Barakat et al., 2018). Therefore, a simple physical treatment of the study spring water is preferable to minimize hardness. There is significant variation in the TH values and almost all of the sites *jhoras* showed significantly higher. This could be attributed to the solvent action of rainwater coming into contact with soil and rocks capable of dissolving calcium and magnesium and that promote water hardness (Vilane and Dlamini, 2016), as well as due the detergent discharge from the household.

Calcium and magnesium: Ca^{2+} and Mg^{2+} are also important parameters for assessing water quality because of their direct relationship with the development of water hardness. The concentrations of these two elements in natural water depend upon the type of rocks. They are both essential to human health in limited amounts. In the current study, the values of Ca^{2+} ranged from 45mg/l to 113 mg/L and *jhora* ranges from 102mg/l to 257 mg/L during the testing. On the other hand, the Mg^{2+} values ranged from 32mg/l to 89.6 mg/L and *jhora* ranges from 77mg/l to 169 mg/L. The results revealed that this variation in Ca^{2+} and Mg^{2}+ levels might be related to the weathering of rocks and mineral content of each ion, such as sedimentary rocks, limestone, dolomite, gypsum, aragonite, and the mineral of igneous rock, feldspars, amphibole and pyroxene, and the pH value of each source (Hem, 1985). Therefore, a simple physical treatment of the study spring water is preferable to minimize loads of these nutrients. In the present investigation, in general, it was also observed that the level of Ca^{2+} and the level of Mg^{2+} in *jhora* were much higher as compared to springs it could be attributed due to the chemical properties of the soil and geological origin of water source (Toma et al., 2013).

Chloride: Cl is one of the important water quality indicators and is widely found in nature in the form of salts of sodium (NaCl), potassium (KCl), and calcium ($CaCl_2$). There are numerous natural and anthropogenic factors that contribute to chloride levels in groundwater, including geological weathering, leaching from rocks, domestic effluent, irrigation discharge, agricultural use, etc. (Barakat et al.,2018). In the present investigation, the values of in springs Cl^- ranged from 6.9 to 40.4 mg/l while *jhoras* sample ranged from 61 to 91 mg/l. This elevated range in *jhoras* could be due to the variations in geology, rainfall, dissolution of fluid inclusions, Cl^- bearing minerals at these sites, or the existence of potentially polluted sources, such as domestic effluent, fertilizers, and septic tank effluent.

Sulfate: The amount of sulfate present in spring water ranges from 1.4-7.0 mg/l with lowest value in S4 and highest in spot S5. Sulfate is found in almost natural water sources. It occurs naturally with some soils and rocks containing sulfate minerals the amount of sulfate in *jhoras* ranges from 202-567 mg/ l which is quiet high in ranges from springs as because the polyatomic anion is widely used in a number of industries, including pharmaceutical, cleaning supplies and beauty products. They are used as sulphuric acid, cleaning agents and fertilizer. Sulfate is predominately a contaminant that makes its way into our water supply and in *jhoras*, rivers etc through waste and industrial discharge. Drinking water containing Sulfate, (Saleh et al., 2001) mentioned that intake of high concentration of sulfate can cause dehydration, catharsis and gastrointestinal irritation. In present study, the concentration of chloride and sulfate in springs' water were below the permissible limit which refers it safe for human consumption

Phosphorus: The amount of phosphate ranges from 284-582mg/l (Graph 9) in the spring water while in *jhoras* it ranges from 697-897 mg/l (Table 6). Phosphorus enters water from human and animal waste, phosphorus rich bedrock, laundry and cleaning waste water.

Table: 2. Details of all sites (demographic details)

Location / Sl No	7th mile (S1)	Entel (S2)	5th mile (S3)	Manipal (S4)	Dzongri (S5)	KV (S6)	Deorali (S7)	Vajra (S8)	Enchey (S9)	Lingding (S10)
Altitudes (m)	1126	1133	1220	1233	1121	1302	1194	1393	1857	1459
Coordinates	27°17′58″N 88°35′31″E	27°18′50″N 88°35′38″E	27°18′47″N 88°35′48″E	27°19′53″N 88°35′51″E	27°19′22″N 88°35′52″E	27°18′48″N 88°36′35″E	27°19′38″N 88°36′31″E	27°20′37″N 88°36′34″E	27°20′11″N 88°37′13″E	27°19′28″N 88°36′10″E

(A) Hydraulic character	Gravity contact	Gravity contact	Gravity contact	Gravity contact	Gravity contact	Gravity contact	Gravity contact	Gravity contact	Gravity contact	Gravity contact
(B) Topography	Pool type	Pool type	Pool type	Pool type	Pool type	Pool type	Pool type	Pool type	Pool type	Pool type
(C) Permanence	Perennial	Perennial	Perennial	Perennial	Perennial	Seasonal	Perennial	Perennial	Perennial	Perennial
(D) Character of opening	Filtration type	Filtration type	Filtration type	Filtration type	Filtration type	Filtration type	Filtration type	Filtration type	Filtration type	Filtration type
Substrate composition	Pebbles, sand, rocks, leaves	Sand, rocks, clay	Rocks, boulders, leaves	Pebbles, rocks, sand, clay	Rocks, boulders	Twigs, clay, rocks	Sand, rocks	Pebbles, rocks, clay	Cobbles, sand, clay	Cobbles, clay
Usage	Washing, bathing, drinking	Multiple purpose	Washing, bathing, drinking	Washing, bathing	Multiple purpose	Washing, bathing, agriculture	Washing, bathing, drinking	Washing, bathing, drinking	Washing, bathing, drinking	Washing, bathing, agriculture
Values	Cultural	Cultural, religious	Cultural	Cultural	Cultural, religious	Cultural	Cultural	Cultural	Cultural, religious	Cultural
Control	Administrative	Local	Administrative	Local	Administrative	Local	Local	Local	Local	Local
Depth(m)	0.5	0.2	1	0.6	1.2	0.3	0.5	0.6	0.9	1.2

Table 3: Values of all parameter of springs

Locations / Parameters	**7th mile (S1)**	**Entel (S2)**	**5th mile (S3)**	**Manipal (S4)**	**Dzongri (S5)**	**KV (S6)**	**Deorali (S7)**	**Vajra (S8)**	**Enchey (S9)**	**Lingding (S10)**
Atmospheric temperature (°c)	22.5	21.8	22.5	22.5	20.6	21	21.1	22.3	18.7	21.3
Water temperature (°c)	14.5	13.2	15	15.5	16	15.5	14.2	13.9	13.5	14.1
Humidity (%)	68	72	72	68	65	67	58	56	56	67
pH	7.5	7.2	7.6	6.9	7.3	7	7.9	7.1	7.3	8
Conductivity (µs/cm)	556	308.3	345	210.2	335	373	648	324	389	195
TDS (mg/l)	399	232	222	123	224	207	457	217	281	130
DO (mg/l)	7.4	9.6	7.1	7.2	7.9	5.7	8.5	3.2	9.5	6.7
Total CO_2 (mg/l)	16	14.6	14.7	32	23.6	21.9	25.9	23.1	17.5	19.7
Total hardness (mg/l)	161	167.6	160	89	109	121	172	117	157	76
Ca^{2+} (mg/l)	100.5	78	104	53	59	87	113	76	91	45
Mg^{2+} (mg/l)	60.5	89.6	46	36	65	34	59	41	66	32
Chloride (mg/l)	30.9	8.9	10.7	11.4	12.1	8.8	40.4	6.9	10.7	13.6
Sulfate (mg/l)	4.1	6.2	6.5	1.4	7.0	5.3	6.9	3.5	5.7	4.9
Phosphate (µg/l)	417	546	324	435	284	398	564	582	510	403

Table: 4. Observed range for the sampled sites of spring

Sl No	Characteristics	Requirement (Acceptable limit)	Permissible limit in the absence of alternative source	Observed range for springs
1	pH	6.5-8.5	No relaxation	6.9-8.0
2	Conductivity(µs/cm)	750	1400	195-648
3	TDS(mg/l)	600	2000	123-457
4	DO(mg/l)	-	-	3.2-9.6
5	Total CO_2 (mg/l)	-	-	14.6-32
6	Total hardness (mg/l)	300	600	76-167.6
7	Ca^{2+} (mg/l)	75	200	45-113
8	Mg^{2+} (mg/l)	30	100	32-89.6
9	Chloride(mg/l)	250	500	6.9-40.4
10	Sulfate (mg/l)	200	400	1.4-7
11	Phosphorus (µg/l)	-	-	284-582

Table: 6. Observed range for the spring and *jhoras*

Sl No	Characteristics	Observed range for springs	Observed range for jhoras
1	pH	6.9-8.0	6.9-9.2
2	Conductivity(µs/cm)	195-648	411-613
3	TDS(mg/l)	123-457	250-378
4	DO(mg/l)	3.2-9.6	0-6.5
5	Total CO_2 (mg/l)	14.6-32	45-97
6	Total hardness (mg/l)	76-167.6	179-408
7	Ca^{2+} (mg/l)	45-113	102-257
8	Mg^{2+} (mg/l)	32-89.6	77-169
9	Chloride(mg/l)	6.9-40.4	61-91
10	Sulfate (mg/l)	1.4-7	202-567
11	Phosphate(µg/l)	284-582	697-897

Table 5: Values of all parameter of *jhoras*

LOCATION	JHORA 1				JHORA 2				JHORA 3		
	point 1	point 2	point 3		point 1	point2	point 3		point 1	point 2	point 3
Atmospheric temperature(°c)	22.6	22.6	22.4		21	22	21.6		23	23.1	23
Water temperature(°c)	15.3	16.3	16.2		16.1	16.2	16.9		15.6	15.8	15.6
Humidity (%)	68	68	71		68	65	68		62	62	65
pH	7.9	8.8	9.2		7.5	7.5	8.1		6.9	7.7	7.8
Conductivity (µS/cm)	556	587	613		421	567	598		411	423	489
TDS(mg/l)	389	556	534		250	312	409		321	567	578
DO (mg/l)	6.5	5.4	4.3		4.1	2.1	0.7		1.2	0	0.7
Total CO_2 (mg/l)	46	55	76		49	65	87		45	68	97
Total hardness(mg/l)	179	256	324		322	356	408		314	365	399
Ca_{2+} (mg/l)	102	159	209		194	211	239		210	241	257
Mg_{2+} (mg/l)	77	97	115		128	145	169		104	124	142

Chloride (mg/l)	67	82	89		67	88	91		61	63	71
Sulfate (mg/l)	202	432	497		328	421	567		297	374	467
Phosphorus (mg/l)	701	697	872		743	797	876		697	765	897

Table: 7. Classification for the sampled sites

Site code	Site Name	Water Quality
S1	7th mile	GOOD
S2	Entel	Mg^{2+} high
S3	5th mile	GOOD
S4	Manipal	GOOD
S5	Dzongri	Mg^{2+} moderate
S6	KV	GOOD
S7	Deorali	GOOD
S8	Vajra	GOOD
S9	Enchey	Mg^{2+} moderate
S10	Lingding	GOOD

6. CONCLUSION

The current study has been conducted to evaluate the quality of spring water based on several physicochemical parameters and condition of the *jhoras*. Based on individual parameters, the majority of water samples were found to be suitable for drinking purposes and within permissible limits according to the chosen standard, except for a few samples, where Mg^{2+}were close to the permissible limits of BIS standard, which indicates the water need some physical treatment before use of drinking purpose. The overall water quality revealed that, by including all physicochemical parameters (Table 7), all spring water samples were classified as "good" quality during time test performed. Based on the results of the present study, the physicochemical parameters concentrations of *jhoras* have high concentrations of chemical constituent which may have some noticeable negative impact on human health in the long term and also particularly for the agricultural purpose it may have some negative adverse effect.
Therefore, it is recommended that a simple physical treatment such as filtration of the study spring water is desirable to reduce nutrient loads and to ensure a better quality water supply for the rural people. Furthermore, it is mandatory to regularly monitor these water sources in order to detect any changes in water quality parameters. This spring can be very helpful in fulfilling the rising demand for access to safe drinking water and hygiene because of rising pollution scenario and threats operating at various levels of surface water resources. Future explorations on spring must look at risks operating at various scales to safeguard the sustainability of these systems closely tied to continued human existence and cultural wellbeing. The present study was restricted to water quality evaluation and with only few spring in light of some important of physicochemical characteristics, but there is an urgent need to have a thorough study on how fertilizers, pesticides, and heavy metals have impacted the spring water quality.

REFERENCES

- Abdulwahid, S. J. (2013). Water quality index of Delizhiyan springs and Shawrawa River within Soran District, Erbil, Kurdistan region of Iraq. *Journal of Applied Environmental and Biological Sciences*, 3(1): pp. 40–48.
- Ahmed, S., Jayakumar, R., & Salih, A. (2008).Groundwater dynamics in hard rock aquifers. 1st ed., New Delhi. Springer Dordrecht
- Al Obaidy, A., Abid H., & Maulood B. K. (2010), Application of Water Quality Index for Assessment of Dokan lake ecosystem, Kurdistan region, Iraq. *Journal of Water Resource and Protection*, 2: pp.792–798.
- Al-Khashman, O. A. (2008). Assessment of the spring water quality in The Shoubak area, Jordan. *The Environmentalist*, 28: pp.203–215
- APHA (1998). Standard methods for the examination of water and wastewater. 20th ed., Washington, DC. American Public Health Association,

- Barakat, A., Meddah, R., Afdali, M., & Touhami, F. (2018). Physicochemical and microbial assessment of spring water quality for drinking supply in Piedmont of Béni-Mellal Atlas (Morocco). *Physics and Chemistry of the Earth*, 104: pp. 39–46.
- Batool, A., Samad, N., Kazmi, S., Ghufran, M. A., Imad, S., Shafqat, M., & Mahmood, T. (2018). Spring water quality and human health: an assessment of natural springs of Margalla hills Islamabad zone-III. *International Journal of Hydrology*, 2(1): pp. 41–46
- Bhat, S. U., Mushtaq, S., Qayoom, U., & Sabha, I. (2020). Water quality scenario of Kashmir Himalayan Springs—a case study of Baramulla District, Kashmir Valley. *Water Air Soil Pollution*, pp. 231:454
- Bhat, S. U., Pandit, A. K. (2011). Limnochemistry of Three Freshwater Springs of Kashmir Himalaya. *Hydro Nepal Journal of water Energy and Environment*, issue no (7)
- Bora, M., & Goswami, D. C. (2017). Water quality assessment in terms of water quality index (WQI): case study of the Kolong River, Assam, India. *Applied Water Science*, 7: pp.3125–3135
- Brown, R. M., McClelland, N. I., Deininger, R. A., Tozer, R.G. (1970). A water quality index-do we dare. Water Sewage Works. 117: pp. 339–343
- Burek, P., Satoh, Y., Fischer, G., Kahil, M. T., Scherzer, A., Tramberend, S., Nava, L. F., Wada, Y. (2016). Water futures and solution: Fast Track Initiative (final report). IIASA working paper. Laxenburg, Austria, International Institute for Applied Systems Analysis (IIASA).
- Chauhan, J. S., Badwal, T., & Badola, N. (2020). Assessment of potability of spring water and its health implication in a hilly village of Uttarakhand, India. *Applied Water Science*, 10: pp.73
- Damania, R., Desbureaux, S., Rodella, A. S., Russ, J., & Zaveri, E. (2019). Quality unknown: the invisible water crisis. The World Bank, Washington, DC
- Ganiyu, S. A., Olurin, O. T., Ojo, A. P., Badmus, & Jegede, O. A. (2017). Quality assessment of spring and well waters: an approach using water quality index and multivariate statistical analysis. *The African Review of Physics*. 12: pp. 47–64
- Glazier, D. S. (2014). Is metabolic rate a universal 'pacemaker' for biological processes?. *Biological Reviews*. 90(2): pp. 377–407
- Grasby, S. E., Hutcheon, I., & Krouse, H. R. (2000). The influence of water-rock interaction on the chemistry of thermal springs in Western Canada. *Applied Geochemistry*. 15(4): pp. 439–454.
- Hem, J. D. (1992). Study and interpretation of chemical characteristics of natural water. 3rd ed., USGS water-supply paper. pp. 2254
- Howell, J. M., Coyne, M. S., & Cornelius, P. L. (1995). Fecal bacteria in agricultural waters of the blue grass region of Kentucky. *Journal of Environmental Quality*. 24(3): pp 411– 419.
- http://cgwb.gov.in
- http://cgwb.gov.in/Documents/WQ-standards.pdf
- http://cpcb.nic.in
- http://en.unesco.org/themes/water-security/wwap/wwdr
- http://www.cwc.gov.in
- http://www.en.unesco.org/wwap
- http://www.epa.gov
- http://www.sikenvis.nic.in
- Jeelani, G. (2008). Hydrogeology of hard rock aquifer in Kashmir Valley: complexities and uncertainties. pp. 243-248
- Liu, Z., Li, Q., & Wang, J. (2007). Seasonal, diurnal and storm-scale hydrochemical variations of typical epikarst springs in subtropical karst areas of SW China: soil CO^2 and dilution effects. *Journal of Hydrology*. 337: pp.207–223
- Mujumdar, P. P., & Tiwari, V. M. (2019). Water futures of India: status of science and technology. IISc/INSA, India
- Nathenson, M., Thompson, J. M., & White, L. D. (2003). Slightly thermal springs and non-thermal springs at Mount Shasta, California: chemistry and recharge elevations. *Journal of Volcanology and Geothermal Research*. 121: pp. 137–153
- Ojha, P., & Mandloi, A. K. (2004). Diurnal variation of pH in freshwater fish culture pond. *Ecology, Environment Conservation*.10(1): pp. 85–86
- Oki, A. O., & Akana, T. S. (2016). Quality assessment of groundwater in Yenagoa, Niger Delta, Nigeria. Geosciences. 6(1): pp.1–12

- Reza, R., & Singh, G. (2010). Heavy metal contamination and its indexing approach for river water. *International Journal of Environmental Science and Technology*. 7: pp. 785–792
- Saleh, M. A., Ewane, E., Jones, J., & Bobby, L. (2001). Wilson Chemical evaluation of commercial bottled drinking water. *Journal of Food Composition and Analysis*. 14(2): pp. 127−152
- Shigut, D. A., Liknew, G., Irge, D. D., & Ahmad, T. (2017). Assessment of physicochemical quality of borehole and spring water sources supplied to Robe Town, Oromia region, Ethiopia. *Applied Water Science*. 7: pp. 155–164
- Singh, A. K., & Hasnain, S. (1999). Environmental geochemistry of Damodar River basin, east coast of India. *Environmental Geology*. 37: pp.124–136
- Thapa, B., Pant, R. R., Thakuri, S., & Pond, G. (2020). Assessment of spring water quality in Jhimruk River Watershed, Lesser Himalaya, Nepal. *Environmental Earth Sciences*. 79: pp. 504
- Van der Kamp, G. (1995) .The hydrogeology of springs in relation to the biodiversity of spring fauna: a review. In Ferrington LC Jr (eds) Biodiversity of aquatic insects and other invertebrates in springs. *Journal of the Kansas Entomological Society*. 3(1): pp. 4–17
- Wegener, T., Sivapalan, M., Troch, P. A., McGlynn, B. L., Harman, C. J., & Gupta, H. V. (2010). The future of hydrology: an evolving science for a changing world. *Water Resources Research*. 46(5): pp. 34-67
- Wetzel, R. G. (2001). Structure and productivity of aquatic ecosystems. *Limnology Academic Press*, San Diego. pp. 132–133
- Yang, C. Y. (1998). Calcium, magnesium, and nitrate in drinking water and gastric cancer mortality. *Japanese Journal of Cancer Research*. 89(2): pp. 124-130