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The hydrochemistry of the two sacred water springs, located in the mountainous region of Kangra District, Himachal Pradesh

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Abstract: Himachal Pradesh, renowned for its mountainous terrain, is also recognized for its abundant water resources, particularly natural spring. These springs serve as vital water sources for the local population and hold both mythological and medicinal significance. The present investigation aimed to examine the hydrochemistry, Water Quality Index (WQI), and resource utilization patterns of two natural cold water springs, Agojar and Kedara, located in the vicinity of District Kangra, Himachal Pradesh. Over a six-month period, a total of ten physical and chemical parameters were analyzed, revealing that all parameters exhibited positive correlations and remained within permissible limits except Iron. The WQI categorizes both springs as "good" and "excellent," indicating their safety for human consumption in various forms. Additionally, the study found that peak human activity occurs during the morning hours, particularly between 7:00 AM and 8:00 AM, at both springs.

Key words: Spring water • Water quality index • hydrochemistry • Therapeutic Properties

Introduction

A spring can be described as any natural phenomenon where water flows from below the surface to the surface of the earth (Ibeneme et al 2013), therefore, ancient cities were often found clustered near springs to ensure the reliable water supply (Stevanovic 2010). In the higher reaches of Himalayas these water bodies act as common water sources for drinking purposes (Singh and Pandey 1989) and considered as pure because it is filtered through the different layers of earth's soil. These springs water are the source of essential nutrients and minerals such as Sulphur, Potassium, Calcium, Magnesium, sodium, Iron, Zinc, Copper and Manganese etc. (Rahman and Bilal 2017). Springs water have been highly prized and known for their therapeutic benefits from many centuries and have many curative qualities, which is a gift of nature to mankind. Peoples throughout the world use mineral spring water to gain health benefits from thousands of years.

Hippocrates (460–370 BC) proposed that disease originates from an imbalance in bodily fluids. Later, Asclepiades (c. 124 BC), a Greek physician, introduced hydrotherapy, emphasizing therapeutic and preventive bathing. Galen (131–201 AD) advocated water, particularly cold water, for treating various diseases (Tubergen and Linden 2002).

Balneotherapy, derived from the Latin word "balneum" meaning "bath," involves therapeutic bathing with hot or cold water, water massage, relaxation, or stimulation. It is widely recommended for ailments like arthritis, skin conditions, and fibromyalgia (Bhateja et al 2019). Spring waters have been shown to aid digestion, metabolism, and treat gynecological, skin, and cardiovascular diseases (Tashpulatova et al 2024). In Japan, approximately 150 million people use spring water annually for health benefits (Rehman and Bilal 2017).

Himachal Pradesh is rich in springs, categorized as hot or cold. Hot springs have water temperatures ranging from 40°C to boiling, while cold springs have temperatures close to the mean annual ambient air temperature (Renaut and Jones 2000, Husain et al 2020). Research on Himachal Pradesh's hot springs has been extensive (Kumar et al 1982; Giggenbach et al 1983, Chandrasekharam et al 2005, Cinti et al 2009).

This study focuses on the hydrochemistry, Water Quality Index (WQI), and human activities associated with two sacred cold water springs, Agojar and Kedara, in Kangra district, Himachal Pradesh. These springs, believed to possess therapeutic properties, are renowned for treating skin ailments like warts and ringworm. Bathing infants under one year in these waters is traditionally believed to protect against skin diseases.

Located in Palampur Tehsil, Agojar Khas is named after Achhar Khund spring (32.0566° N, 76.5647° E), while Kedara lies in Garh Jmula village (31.9933° N, 76.4859° E). Both springs, sacred to the locals, continue to play a vital role in traditional healing practices.

Material and Methods

Samples were collected from both springs to study ten parameters: pH, conductivity, total dissolved solids (TDS), total alkalinity, total hardness, chloride, iron, calcium, magnesium, and sulfate. The sampling was conducted during the morning hours, between 7:00 AM and 9:00 AM, as this is when most human activities, such as bathing, occur from March to August. The water samples were collected in 1-liter polyethylene bottles, which were thoroughly cleaned and rinsed with spring water prior to use. All necessary precautions were taken during the filling, storage, and transportation of the samples to ensure their integrity.

Certain parameters, such as pH, conductivity, and total dissolved solids (TDS), were monitored and analyzed on-site, as they are closely related to environmental conditions. For other analyses, the samples were transported to the laboratory on ice and stored in a deep freezer until examination. The methods used for the analysis of various parameters adhered to the guidelines established by APHA-AWWA-WPCF (1981) and Saxena (2001). The analytical data for the various variables were correlated using Microsoft Excel.

The calculation of Water Quality Index (WQI) was made using weighed Arithmetic index method (Brown et al 1972) is calculated by the following equation.

$$\mathbf{WQI} = \sum_{n=1}^{n} q_n w_n \Big/ \sum_{n=1}^{n} w_n$$

The suitability of WQI values for human consumption can be checked by categorization given by Mishra & Patel 2001.

To analyze the presence of human and their activities, a fortnightly study was conducted over 3 months at both locations, observing from 6:00 AM to 12:00 Noon. The number of individuals present was counted each hour.

Results and Discussion

Table 1: Physical and Chemical parameters of sacred Agojar Spring water, units are in Mg.l $^{-1}$ and otherwise mentioned:

Sr. No.	Parameters	Minimum	Maximum	Average	SD
1	pH	7.2	7.9	7.466667	0.287518
2	Conductivity (µS.cm^{-1})	136	192	152.8333	26.4077
3	TDS	87	124	111.6667	12.97176
4	Total Alkalinity	170	240	204	28.22765
5	Total Hardness	210	230	217	9.165151
6	Chloride	6.4	8.2	7.116667	0.835264
7	Iron	2.2	2.7	2.483333	0.231661
8	Calcium	28	34	31	2.75681
9	Magnesium	12	17	14.66667	2.250926
10	Sulphate	0	0	0	0

Table 2: Physical and Chemical parameters of sacred Kedara Spring water, units are in Mg.l^{-1} and otherwise mentioned:

Sr. No.	Parameters	Minimum	Maximum	Average	SD
1	pH	7.4	8.1	7.68	0.278687
2	Conductivity (µS.cm^{-1})	160	167	163.66	2.804758
3	TDS	88	102	94.5	5.468089
4	Total Alkalinity	84	92	88.16	3.710346
5	Total Hardness	84	86	84.66	1.032796
6	Chloride	7	8.4	7.88	0.552871
7	Iron	1.4	1.7	1.6	0.126491
8	Calcium	22.2	26.4	24.26667	1.742029
9	Magnesium	4.4	4.9	4.71	0.183485
10	Sulphate	0	0	0	0

Based on Tables 1 and 2, it is evident that the pH levels of Agojar spring water ranged from 7.2 to 7.9, while Kedara spring water ranged from 7.4 to 8.1, indicating an alkaline nature. Elevated pH levels can cause irritation to the eyes, skin, and mucous membranes; however, the values observed in this study fall within the normal range. Water with pH higher than 8.5 can cause gastrointestinal problems, skin irritation, and other health issues (Wang et al 2019).

Conductivity of Agojar spring water ranged from 136(µS.cm^{-1}) to 192 (µS.cm^{-1}), while Kedara spring water shows higher value than Agojar i.e. 160(µS.cm^{-1}) to 167(µS.cm^{-1}). The conductivity is related to ion concentration, ion charge number, ion migration rate and temperature (Yang et al 2021). According to WHO standards, EC value should not exceeded

400 µS cm^{-1} (Meride and Ayenew 2016). This study indicates that water is suitable for human, there is no organic pollution and not too much suspended clay material.

TDS indicates the amount of organic substances dissolved in water (Ibeneme et al 2013). The present study shows that the parameter values in Agojar spring water ranged from 87 to 124 Mg.l^{-1}, while in Kedara spring water, it ranged from 88 to 102 Mg.l^{-1}. The mean value for this parameter was 111.67 Mg.l^{-1}in Agojar and 94.5 Mg.l^{-1} in Kedara, respectively. According Kavindra et al (2020) the consumption of low TDS water alone by a healthy individual is unlikely to result in adverse health effects and reported that If homeostasis is not maintained because of major diet deficiencies, disease, or hormonal dysfunction, it would act as a minor (if any) factor in any observed symptoms. Our investigation found that the TDS values are within the permissible range for human consumption, which is < 500 Mg.l^{-1} (Davis and De Wiest 1966).

The total alkalinity of Agojar spring water ranged from 170 to 240 Mg.l^{-1}, while Kedara spring water ranged from 84 to 92 Mg.l^{-1} during whole study period. It helps to regulate the pH as well as metal content (Panchagnula and Vunguturi 2016). Alkalinity in water causes nutritional imbalance to human health (Canon 1908). All collected water samples were found to be within the permissible limits according to the standard guidelines set by the Bureau of Indian Standards (Indian standard, Drinking Water- Specifications, IS 10500 2012). In Agojar spring water it is higher than acceptable limit but less than permissible limits. According to Chilicka et al (2021) treatment with alkaline water may be useful as a complementary therapy in cooperation with a dermatologist.

Hard water contains high value of salts like Calcium and Magnesium along with the minerals. Consuming hard water can lead to dry skin and hair, as it may disrupt the skin's pH balance. This imbalance can make the skin less healthy, reducing its protective barrier against bacteria and infections. Skin issues often arise from the presence of excessive minerals in hard water (Welfare Universe India 2022). The mean value of hardness in both the springs under permissible limit i.e. 217 and 84.66 Mg.l^{-1} which is less than 600 Mg.l^{-1} (Indian standard, Drinking Water- Specifications, IS 10500 2012). So, water is safe for human use.

Chloride is a non-toxic substance found in water that can impart a detectable salty taste (Ibneme et al 2013). According to the guidelines established by the Bureau of Indian Standards, the acceptable limit for chloride is 250 Mg.l^{-1}. In the present study, very low chloride Mean values were observed at study sites, measuring 7.11 Mg.l^{-1} and 7.88 Mg.l^{-1}, respectively. Therapeutic effect of this mineral is to Balance of intestine, bile ducts and liver; laxative effect, and is often present in combination with sodium and they may be used for hydropinic therapy (Quattrini et al 2016). Chlorobicarbonate waters are used in rheumatology (Kawtar Fikri-Benbrahim et al 2021).

There are two principal types of ferrous waters: sulphate-ferrous/ferric waters and bicarbonate ferrous waters (Quattrini et al 2016). In present study the value of Iron observed very low in both the study stations. In Agojar water spring the value ranged between 2.2 to 2.7 Mg.l^{-1}, while in Kedara its value ranged between 1.4 to 1.7 Mg.l^{-1}, but still is higher than acceptable limits. The bioavailability of iron in water is high due to the presence of other trace elements: copper, zinc, manganese, lithium and aluminum (Casado et al 2015). Iron is an essential mineral necessary for several bodily functions, including oxygen transport, participation in the oxyhemoglobin mechanism, supporting metabolism, and maintaining healthy skin and hair (Rahman 2023).

Calcium and magnesium-rich thermal spring water are known to improve skin barrier

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function, accelerate wound healing (Proksch 2005). The acceptable limit for calcium is less than 75 Mg.l^{-1}, while for Magnesium, it is 30 Mg.l^{-1}, according to the Indian standard for drinking water (IS 10500 2012). In this study, Calcium content in Agojar spring water ranged from 28 Mg.l^{-1} to 34 Mg.l^{-1}, and Magnesium content ranged from 12 Mg.l^{-1} to 17 Mg.l^{-1}. In Kedara, Calcium levels ranged from 22.2 Mg.l^{-1} to 26.4 Mg.l^{-1}, while Magnesium levels were between 4.4 Mg.l^{-1} and 4.9 Mg.l^{-1}. All values for both springs were within the acceptable limits. Magnesium helps in skin regeneration, anti-inflammatory and bactericidal activities, while Calcium improves the natural defense for the protection of skin (Cacciapuoti et al 2020).

Sulphate comes in groundwater from mineral deposits in the rocks in form of sulphates and form oxides, in contact with water (Kothari et al 2021). Sulfate was found to be absent in both springs throughout the entire study period. While previous research has indicated that hot water springs typically contain high levels of sulfur, but it was undetectable in both of these springs. When all the water parameters of both springs were statistically correlated with each other it is found that they all positively correlated with each other (From Table No. 3 and 4). Correlation results indicates that increase or decrease in one parameter, will positively affect the increase and decrease of other parameters, this type of results also reported by Kothari et al (2021) and Tambekar et al (2007) and many workers in different water bodies of whole country.

The Water Quality Index (WQI) was calculated for both study stations using the weighted arithmetic index method. The WQI for Agojar spring water was determined to be 31.72, while the WQI for Kedara spring water was found to be 18.99. Upon comparison with the categorization framework established by Mishra and Patel (2001) (Table 5), it was determined that the WQI of Agojar spring water falls within the "good" quality category, whereas Kedara spring water is classified as "excellent."

Anthropogenic Activity

The presence of human and their activities, a fortnightly study was conducted over 3 months at both locations, observing from 6:00 AM to 12:00 Noon. The numbers of individuals present were counted on each hour and their average is finding out and shown in Fig. 1.

Figure 1 illustrates that the maximum number of individuals was recorded between 7:00 AM and 8:00 AM at both springs, while the minimum was observed between 11:00 AM and 12:00 Noon. Both springs are recognized for their therapeutic properties, and it is believed that the water from these sources is utilized to treat various skin diseases. Many visitors, particularly families with children, frequent these springs based on cultural beliefs surrounding their healing effects.

Conclusion

This study concludes that the physical and chemical parameters of both spring waters fall within acceptable limits except Iron. The Water Quality Index (WQI) categorizes the water as "good" and "excellent," indicating its suitability for human consumption. Additionally, these springs possess therapeutic properties due to the presence of minerals such as iron, calcium, magnesium, and chloride, which may function as healing agents. This finding is consistent with previous research conducted on various springs across different regions of the country.

Table 3: Coefficient of Correlation (r) among Physical and Chemical parameters of sacred Agojar Spring water (Correlation is significant at the 0.05 level)

	Cond.	TDS	Total Alkal.	Total Hard.	Chloride	Iron	Calcium	Magnesium
pH	0.818331	0.495136	0.956141	0.455383	0.635704	0.650586	0.252324	0.38114*
Cond.		0.376972	0.649292	0.304094	0.525145	0.283879	0.447796	0.580961
TDS			0.605196	0.644303	0.598685	0.683295	0.738241	0.728348
Total Alkal.				0.531868	0.690487	0.813551	0.257009	0.377725
Total Hard.					0.903946	0.810096	0.759897	0.707705
Chloride						0.869949	0.720904	0.780093
Iron							0.469745	0.524178
Calcium								0.966904

Table 4: Coefficient of Correlation (r) among Physical and Chemical parameters of sacred Kedara Spring water (Correlation is significant at the 0.05 level)

	Cond.	TDS	Total Alkal.	Total Hard.	Chloride	Iron	Calcium	Magnesium
pH	0.375274	0.977762	0.119275	0.602213	0.659838	0.453882	0.71956	0.436753
Cond.		0.378179	0.794366	0.36823	0.808253	0.845602	0.283806	0.945662
TDS			0.142938	0.708288	0.638407	0.549399	0.70127	0.468449
Total Alkal.				0.278356	0.430612	0.553986	0.46208	0.817675
Total Hard.					0.233507	0.612372	0.326078	0.351799
Chloride						0.772164	0.437468	0.851049
Iron							0.199681	0.861727
Calcium								0.47137

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Table 5. The suitability of WQI values for human consumption according to Mishra & Patel 2001.

Sr. No.	WQI Range	Water Quality
1	0-25	Excellent
2	26-50	Good
3	51-75	Bad
4	76-100	Very Bad
5	100 & above	Unfit

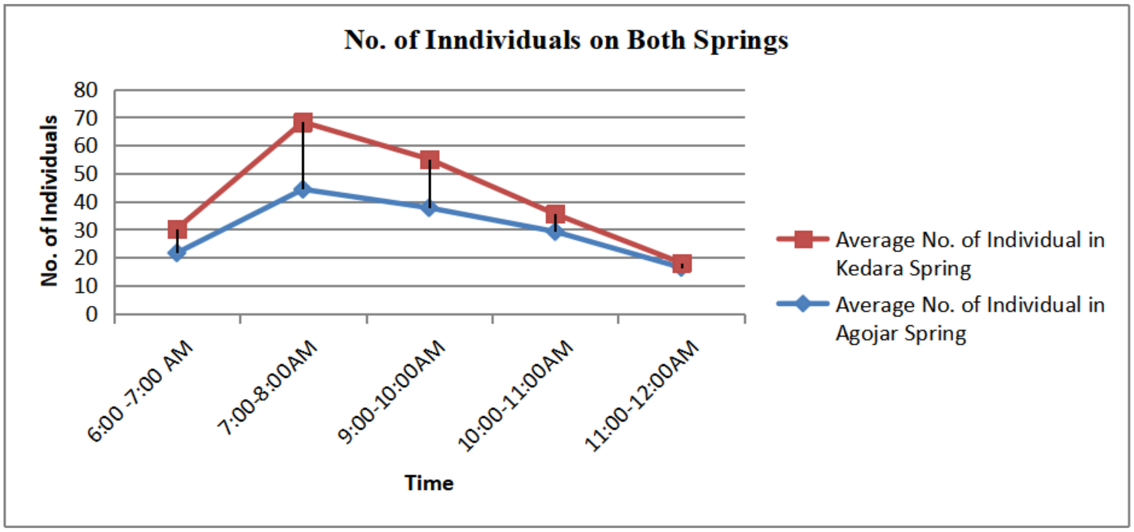

Fig.1. Anthropogenic activities on Agojar and Kedara Springs

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