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Survey and Water Quality Analysis of Springs in Kupwara Region of Kashmir Himalayas

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Abstract: The present study describes water quality scenario and discharge studies of springs of Kupwara district in Kashmir Himalayas. The key parameters measured included pH, conductivity, calcium hardness, total hardness, nitrite, nitrate, ammonium, iron, phosphate, turbidity, salinity, total dissolved salts (TDS) and temperature. The pH levels ranged from 6.74 to 7.60, indicating generally neutral conditions. Conductivity varied from 215 to 380 µS, reflecting mineral content differences. Calcium hardness varied from 13 to 26 drops of reagent while total hardness ranged from 95 to 165 mgL^{-1}. Nitrite levels were consistently low with varying nitrate and ammonium levels. Iron concentrations were minimal, and phosphate levels ranged from 0.1 to 1 mgL^{-1}. Turbidity was low, indicating clear water with salinity levels ranging from 162 to 214.3 mgL^{-1}. Total dissolved salts varied between 49.6 ppm and 96.1 ppm. This study provides a comprehensive assessment of spring water discharge and quality in Kupwara, offering valuable insights for managing water resources and addressing potential climate change impacts on water availability.

Keywords: Water quality, Springs, Himalayas

In mountainous regions like Kupwara district in Jammu and Kashmir, India, springs are an important source of water for drinking, irrigation, and other domestic uses. The springs which are in thousands in Kashmir landscape have the potential to offer viable solution to the rising drinking water demand and therefore merit an attention for their protection and management (Bhat et al., 2022). Understanding the seasonal variations in spring discharge and their underlying causes is crucial for managing water resources effectively and ensuring water security for local communities. Seasonal fluctuations are a natural phenomenon that significantly influence various environmental and hydrological processes. The changes in the trend of precipitation, temperature and glacier melt are expected to impact the quantity and quality of spring water significantly (Panwar 2020). Kupwara district, situated in the scenic Kashmir Valley of India, offers a compelling case study for analyzing the interplay between seasonal changes and spring water availability, particularly concerning drinking water purposes. The district is endowed with a network of springs that serve as crucial freshwater sources for its population. These variations pose particular challenges for drinking water supply, as springs are often the primary source of potable water for rural communities, especially in hilly areas where surface water bodies are minimal (Prem et al., 2021). The importance of consistent spring discharge for drinking water cannot be overstated, given its role in supporting daily life and public health. The study comprises of the discharge of springs and the quality parameters of spring water. The outcomes will provide valuable insights for local authorities and stakeholders, facilitating the development of adaptive management strategies to address water supply challenges throughout the year.

MATERIAL AND METHODS

Study area: The Kashmir Valley is home to hundreds of springs that draw tourists and, by offering them a variety of experiences, significantly boost the local economy offerings. Kupwara district situated in the northernmost part of Kashmir valley is characterized by its unique topographical features, climatic conditions and rich hydrological sources .The district has an area of 2379 square kilometres .The longitude and latitude of district sprawls between 74° 35´ to 74° 45´ E longitude and 34° 15´ to 34° 45´ N latitude. Kupwara's temperate climate, marked by extreme cold winters and warm summers, introduces significant variability in the hydrological dynamics of these springs. Seasonal fluctuations impact the water table and discharge rates, leading to variable availability of spring water. Winters are typically harsh , lasting from mid-November to march with temperature dropping as low as -5^{0}C. The district receives an average annual precipitation of about 869nm. Kupwara geomorphology is marked by the presence of Pirpanjal mountain range which contributes to districts dramatic elevation changes .The region's topography plays a pivotal role in shaping its hydrological pattern including the formation and discharge of springs. Our study area encompasses six springs situated across different locations in Kupwara district. These include Astannaag in Tirch Natnussa, Checkigam in Checkigaam, KVK Spring in Kupwara, Farrnaag in Kandi, Waninaag in Natnussa, and Shewaling in Drugmulla. Each spring represents a unique hydrological site, contributing to a diverse dataset for analyzing seasonal variations in spring water availability.

Sampling and water quality: Water samples were collected from the springs in three different months viz; January, April and June from six different locations viz; Astannaag in Tirch Natnussa, Checkigam in Checkigaam, KVK Spring in Kupwara, Farrnaag in Kandi, Waninaag in Natnussa, and Shewaling in Drugmulla in 1-liter plastic bottles. The physicochemical parameters *viz*; temperature, pH, total soluble solids (TSS),total dissolved salts (TDS), salinity, turbidity, conductivity, total hardness, calcium hardness, nitrite, nitrate, ammonium, iron and phosphate were examined for each sample (APHA 2005). Water samples were analyzed in a laboratory to determine their discharge rates and other relevant parameters. To measure the discharge rate of various spring outlets, a volumetric flask was used and stopwatch was used to estimate the time.

Table 1. Standard analytical methods adopted for different quality parameters

Parameters	Analytical techniques/ Methods	Units
pH	Electronic pH meter	------
TSS	Filtration method	Mg/L
TDS	Evaporation method	Ppm
Salinity	Salinometer/Conductivity meter	g/kg
Turbidity	Turbidity meter/Nephelometer	NTU
Conductivity	Electronic conductivity meter	mS
Total hardness	EDTA Titration method	Mg/L
Calcium hardness	EDTA Titration method	ppm
Nitrite	Open Colorimeter	ppm
Nitrate	Open Colorimeter	ppm
Ammonium	Open Colorimeter	ppm
Iron	Test kit	Mg/L
Phosphate	Test kit	Mg/L
Temperature	Digital Thermometer	^{0}C
Elevation	GPS Device	msl
Carbonates	Titration	Mg/L
Discharge	Volumetric flask	L/s

RESULTS AND DISCUSSION

Water quality analysis: The pH value ranged from 6.74 at 8.8 ^{0}C (Chekigam) to 7.55 at 7.6 ^{0}C (Farrnag) (Table 2). Most springs have a basic pH, which can be somewhat because of the limestone-rich geology of the Kashmir valley (Barakat *et al*., 2018). Conductivity ranged from a minimum of 272 µs(Waninag) to a maximum of 380µs (KVK Kupwara). The range of electrical conductivity (EC) indicate low to moderate mineral content /The concentration of Ca^{2+} and Mg^{2+} ions in water is the primary factor influencing its hardness. Hardness solely reflects the quality of the water; it is not a pollution indicator parameter. The overall range of 95 to 165 mg L^{-1} indicate that all of the springs' water is naturally hard. Calcium hardness was recorded at all six locations and ranged between a minimum of 110 ppm (moderately hard) (KVK Kupwara) to 180 ppm (hard) (Waninag). The WHO (World Health Organization) scale for calcium hardness in drinking water classifies water hardness based on the concentration of calcium and magnesium salts, which classifies it as soft water: 0 - 60 mg/L as $CaCO_3$; moderately hard water: 61 - 120 mg/L as $CaCO_3$; hard water: 121 - 180 mg/L as $CaCO_3$; Very hard water: > 180 mg/L as $CaCO_3$. Lacustrine deposits, which are sedimentary rocks like limestone, gypsum, and dolomite, are the source of Ca^{2+} and Mg^{2+}.

Nitrite content was absent in all springs studied except Astanaag (5 ppm). Nitrate content (5 ppm) was recorded in KVK Kupwara, Farnaag and Waninaag springs and zero in other springs. Ammonium concentration of 1 ppm in KVK Kupwara and Shewaling springs was recorded and 0.5 ppm in rest of the springs (Astanaag, Checkigam, Farrrnaag and Waninaag). Nitrogen in the form of nitrate (NO3 −), nitrite (NO2 −), and ammonia (NH3 +) present in natural water evoke great interest because of their nutrient values, thereby being limiting factors for many bio-chemical processes. Excessive fertiliser use and the addition of human and animal waste are the causes of a higher concentration of nitrate in groundwater (Mondal et al., 2008). Lower nitrate concentration was in Astanaag, Checkigam and Shewaling (0.00 ppm) because there are less agricultural activities in the

Table 2. Discharge rates of springs (l/s)

Month	Astannag	Checkigam	KVK Spring	Farrnaag	Waninaag	Shewaling
January	0.27	0.70	0.09	0.2 0	0.13	0.70
April	0.5 0	1.10	0.17	0.22	0.25	1.3 l
June	0.50	1.10	0.2 0	0.28	0.30	1.7 l

immediate catchment, however, KVK Kupwara, Farrnaag and Waninaag had nitrate concentrations of 5ppm because fertilizer sewage and organic matter decomposition is significant source of nitrates in spring water.

According to United States-, Environment Protection Agency (US- EPA), the recommended limit for iron content in portable water is 0.30 ppm., Waninaag and Shewaling had 0.3 mgL^{-1} iron content and 0.00 mgL^{-1}in Astanaag, Chekigam, KVK Kupwara and Farnaag which means that all the samples pass EPA recommendations . Apart from the organic matter enrichment, the iron (Fe) source could also be attributed to the iron-rich rocks found in the springs' catchment area (Rao 2007).

The concentration of phosphorus varied between 1 mg L^{-1} in Astanaag and Waninaag, 0.5 mg/L in Chekigam, KVK Kupwara and Farnaag and 0.1 mg L^{-1} in Shewaling. Phosphate sources can be man-made or anthropogenic, contingent on local human activity. In the catchment of these springs, where phosphate fertilisers are heavily used, there is convincing evidence of the direct influence of agricultural and horticultural activities due to the slightly greater concentration of phosphates in some springs (Kipngetich et al., 2013).

Turbidity values were almost non-significant in concentration differences. Because there was no surface disturbance, the springs exhibited low turbidity values. In the case of these springs, the lack of surface disruption meant that minimal external debris or pollutants were introduced into the water, resulting in clear and relatively undisturbed water quality. Additionally, the absence of rainfall or human activity, such as construction or agricultural runoff, likely prevented the introduction of particles that could cloud the water. Therefore, the stable, calm conditions allowed the springs to maintain their low turbidity levels, which is often a key indicator of cleaner, well-preserved water systems (Joshi and Agarwal 2022). Maximum salinity was 214.3 mg L^{-1} at 14.7 ^{0}C (KVK Kupwara) followed by Waninaag, Checkigam, Farrnaag. and Shewaling and minimum was 162 mg L^{-1} at 14.5 ^{0}C (Astanag). Salinity concentration is directly correlated with the chemical properties and geology of the aquifer (Naeem 2015).

The maximum total dissolved salts (TDS) was n KVK Kupwara (96.1 ppm at 25^{0} C) and minimum was in Astanaag (49.6 ppm at 25 ^{0}C). Total dissolved salts in water originates from irrigation returns, urban runoff, natural sources, municipal, road deicing, industrial wastes, chemicals used in water treatment and the actual plumbing infrastructure (Hach solids. 2023). Drinking water with high concentrations of dissolved solids may affect the taste of water. In addition, high TDS levels can cause scaling and corrosion in any application, particularly in cooling water and boilers, and therefore need to be monitored in water systems (Adjovu et al., 2023).

Further it was observed that there was no presence of carbonates in any of the springs. Carbonates may be absent in some water samples because water may not have been in contact with carbonate rich rocks like limestone, meaning there no source to dissolve the carbonate minerals, or the

Table 3. Chemical analysis of various springs

Parameter	Astanaag	Chekigaam	KVK Kupwara	Farrnaag	Waninaag	Shewaling
pH	7.O3 at 6.8^{0} C	6.74 at 8^{0} C	7.17 at 7.6^{0} C	7.55 at 7^{0}C	7.43 at 7^{0}C	7.35 at 7.3
Conductivity	215 µs	332 µs	380 µs	282 µs	272 µs	290 µs
Calcium hardness	130 ppm	125 ppm	110 ppm	150 ppm	180 ppm	165 ppm
Total hardness	135 mg L^{-1}	110 mg L^{-1}	95 mg L^{-1}	145 mg L^{-1}	165 mg L^{-1}	150 mg L^{-1}
Nitrite	5 ppm	0.0 ppm	0.0 ppm	0.0 ppm	0.0 ppm	0.0 ppm
Nitrate	0.0 ppm	0.0 ppm	5 ppm	5 ppm	5 ppm	0.0 ppm
Ammonium	0.5 ppm	0.5 ppm	1 ppm	0.5 ppm	0.5 ppm	1 ppm
Iron	0.00 mg L^{-1}	0.0 mg L^{-1}	0.00 mg L^{-1}	0.0 mg L^{-1}	0.3 mg L^{-1}	0.3 mg L^{-1}
Phosphate	1 mg L^{-1}	0.5 mg L^{-1}	0.5 mg L^{-1}	0.5 mg L^{-1}	1 mg L^{-1}	0.1 mg L^{-1}
Turbidity	004 NTU At 12.2^{0} C	005 NTU At 12.3^{0} C	006 NTU At 11.9^{0} C	006 NTU At 11.9 ^{0}C	006 NTU At 12.9^{0} C	006 NTU At 12^{0} C
Salinity	162 Mg/L at 14.5 ^{0}C	185.6 Mg/L at 14.8^{0} C	214.3 Mg/L at 14.7^{0} C	183.8 mg L^{-1} at 14.8 ^{0}C	194.7 mg L^{-1} at 14.8 ^{0}C	174.6 mg L^{-1} at 14.4^{0} C
Total Dissolved Solids	49.6 ppm at 25^{0} C	54.4 ppm at 25^{0} C	96.1 ppm at 25^{0} C	62.9 ppm at 25^{0}	55.8 ppm at 25 ^{0}C	70 ppm at 25 0C
Elevation	1689 msl	1706 msl	1591 msl	1682 msl	1623 msl	1680 msl
Temperature	10. 3^{0} C	9.9^{0} C	11.8^{0} C	10.5^{0} C	9.7 ^{0}C	11.3 ^{0}C
Carbonates	Absent	Absent	Absent	Absent	Absent	Absent

water chemistry could be too acidic, preventing carbonate ions from forming and remaining stable in solution (Shmeis 2018).

Discharge of springs

The discharge values of springs was studied in January, April and June so as to know about variations in discharge due to different seasons. The values of discharge rates in KVK Kupwara spring was 0.08, 0.17 and 0.2 l/s in January, April and June, respectively. Similarly, the discharge values of Checkigam (0.7, 1.0 and 1.0 l/s), Astanag (0.27, 0.5 and 0.5 l/s), Shewaling (0.7, 1.3 and 1.7 l/s), Waninaag (0.13, 0.25 and 0.3 l/s) and Farnag (0.2, 0.22 and 0.28 l/s) in January, April and June, respectively. The discharge in springs varies seasonally and is influenced by hydro-geological conditions, climate change and anthropogenic factors like ground water abstraction (Casati *et al*. 2024). The relationship between precipitation and spring discharge is influenced by seasonal changes in high altitude recharge areas. From December to March, precipitation accumulates as snow, resulting in minimal ground water recharge due to frozen conditions. A temperatures rise in April, snow melt begins, infiltrating the ground and increasing spring discharge. After June the discharge is seen to be maximum in all the springs (Chang at al., 2021) (Gao et al., 2016).

CONCLUSIONS

This study provides a comprehensive analysis of spring discharge and water quality in the Kupwara District. Studies were conducted on the differences in the water quality analysis and discharge rates of 06 springs located throughout the district. The measured discharge rates showed variability among springs but did not significantly change across different seasons, indicating stable hydrological conditions. Water quality assessments revealed generally hard water with pH values leaning towards basic, attributed to the region's limestone geology. It is crucial to implement sustainable water management practices to safeguard springs from depletion and contamination. This involves regulating land use changes and reducing deforestation in catchment areas, as these activities can interfere with the natural hydrology.

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