RESEARCH PAPER

Spatial Assessment of River Water Quality Using Water Quality Index (WQI): A Case Study of Baldi River, Dehradun, India

Nisha Chauhan[1], Shefalee Singh[2*], Dhyal Singh[3]

[1]Department of Zoology, School of Applied and Life Sciences, Uttaranchal University, Dehradun, Uttarakhand-248007, India. ORCiD id: https://orcid.org/0009-0004-0799-9491

[2*]Department of Zoology, School of Applied and Life Sciences, Uttaranchal University, Dehradun, Uttarakhand- 248007, India. ORCiD id: https://orcid.org/0000-0001-5978-3466. Corresponding author.

[3]Department of Zoology, School of Basic and Applied Sciences, S.G.R.R. University, Dehradun, Uttarakhand-248001, India. ORCiD id: https://orcid.org/0000-0003-1565-0164

ABSTRACT

Assessment of water resources is essential not only for sustainable resource management but also for public health protection. The present study evaluates the physicochemical properties and water quality of Baldi river, Dehradun using weighted arithmetic Water Quality Index (WQI) approach. Water samples were collected monthly for a period of one year (July 2024-june 2025) and physicochemical parameters such as, pH, free CO2, DO, alkalinity, TDS, EC, hardness, chloride, sodium, potassium were analysed in lab. The evaluated WQI ranged from 56.48 to 61.09 indicating moderate spatial variation across study area. A gradual increase in WQI was observed from upstream to downstream, primarily due to increased levels of EC, TDS and hardness caused by increased anthropogenic influences on downstream locations. All sampling sites fall under the "poor" category and thus the water quality is suitable for the irrigation and industrial purposes. Thus, the observed spatial trend points out the need for continuous monitoring and management strategies to prevent further deterioration. The study demonstrates the effectiveness of WQI as a reliable and simple tool evaluating and communicating water quality in riverine system.

Keywords: Physico-chemical, Water Quality Index (WQI), Water conservation, Baldi river, Dehradun.

How to cite this article: Chauhan N, Singh S, Singh D. Spatial Assessment of River Water Quality Using Water Quality Index (WQI): A Case Study of Baldi River, Dehradun, India. Int J Drug Deliv Technol. 2026;16(18s): 319-324. DOI: 10.25258/ijddt.16.18s.33

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

Water is the basic amenity required for survival and environmental regulations. However, with rapid population growth, urbanization and aggravation of agriculture, river water quality has severely degraded worldwide, posing escalating risks to human health and ecosystem integrity.[1,2] As per a UN report, the human population is increasing exponentially globally, while available freshwater resources are rapidly reducing.[3] Despite supporting nearly 18% of the world's population, India possesses only about 4% of global freshwater resources, placing it among the world's water-stressed countries, with an annual per capita water availability of approximately 1,588 cubic meters.[4,5]

Monitoring of water quality if therefore crucial for ensuring its suitability for various purposes. Traditionally, evaluation of water quality involves multiple physicochemical parameters which can be difficult to interpret. To overcome this limitation, the Water Quality Index (WQI) as an effective and easy tool that integrates multiple parameters into single value to represent water quality conditions has been widely adopted. The WQI simplifies complex calculation and communicates the water quality conditions to policymakers and public.[6,7] The Weighted Arithmetic WQI approach is commonly used due to its reliability, simplicity and ability to incorporate different water quality parameters. This method assigns weights to parameters based on their importance in water quality evaluation and compares the observed values with standard permissible limits as recommended by the World Health Organisation.[8]

Several studies explored the water resources of Sahastradhara region of Dehradun as it is a popular tourist destination and famous for its sulphur springs and natural beauty. Few of the WQI-based studies provide a useful basis for comparison with the present study:

A study of Baldi-Sahastradhara stretch by S. Kaur et al. reported that the upstream Baldi river falls under good category than downstream sites that shows higher turbidity, alkalinity, BOD and CO2 which worsens with the increasing tourism pressure resulting the water to be unfit for drinking or domestic purposes.[9] Similarly, S. Kulshrestha evaluated water quality using NSF-WQI during the COVID lockdown period and found WQI within range 76 - 86 (‘Good’ category) at upstream as well as downstream sites with high DO, low BOD and low coliforms.[10] In contrast Weighted-WQI based analysis of Kaligad stream at Sahastradhara by S. Diwedi found river water not suitable for drinking purposes and categorised as ‘very poor’ mainly due to Ca, Mg, sulphate and TDS exceeding drinking limits.[11] Where a broader study on streams of doon valley reported strong seasonal variation in the water quality with increase in BOD, turbidity, hardness and CO2 in rainy season that make the water unfit for utilisation.[12] This study aims to analyse the water quality of Baldi River by using weighted arithmetic WQI approach by analysing physicochemical parameters across multiple sampling sites to measure the potability of Baldi river water for various domestic purposes such as drinking, washing, bathing, etc. and examine spatial variation in water quality and provide baseline data for future monitoring and management of the river system.

MATERIALS AND METHODS

Study area

The Baldi stream is a freshwater perennial hill river and major tributary of the Song River, which flows through the east Doon Valley in the Garhwal Himalayas of India (Figure 1). It is situated at approximately 30°23′N latitude and 78°08′E longitude within the Raipur Block of Dehradun district in the state of Uttarakhand.[13] Along the banks of this stream lies Sahastradhara, one of the well-known tourist spots of Dehradun. The area is popular for its sulphur springs and natural scenic beauty.[9] Four sampling sites were selected along the stretch of Baldi river and those were site 1- Patali Village, site 2- Sera village, site 3- Sahastradhara Tourist point and site 4- Maldevta.

Water samples collection

For the physicochemical analysis, the river water samples were collected from the selected four sites during the morning hours (9:00-11:00 a.m.), monthly for a period of one year (July 2024-June2025). Water samples were collected from a subsurface depth of approximately 0.3 meters using plastic containers through direct immersion. The following water quality parameters were recorded on the site: temperature (°C), pH, electrical conductivity (µS/cm), dissolved oxygen (mg/L), total alkalinity, and free CO_2. Then the water samples were taken to the labs for further analysis.

Analytical procedures

Eleven water quality parameters –Water temperature, pH, electrical conductance, TDS, total alkalinity, free CO_2, dissolved oxygen (DO), chloride, hardness, sodium and potassium were analysed in the laboratory as per the standards methods of APHA (Table 1).[14] The WQI was calculated for nine of these parameters as per the standards of drinking water quality suggested by the World Health Organization (WHO) and Bureau of Indian Standards (BIS).[8,15]

Table 1. water quality parameters and methods used.

S.no.	Parameters	Units	Method Used
1	Water temperature	Celsius	Thermometer
2	pH	-	pH meter
3	Electrical conductance (EC)	µs/cm	Conductivity meter
4	Total Dissolved Solids (TDS)	Ppm	TDS meter
5	Total Alkalinity (TA)	mg/l	Titration with HCl
6	Free CO2	mg/l	Titration with NaOH
7	Dissolved Oxygen (DO)	mg/l	Winkler Method
8	Chloride	mg/l	Silver Nitrate Method
9	Hardness	mg/l	EDTA Titration
10	Sodium	mg/l	Flame Photometry
11	Potassium	mg/l	Flame Photometry

Calculation of Water quality index (WQI)

The numeric representation that demonstrates the combined influence of multiple physicochemical parameters into a single value to show the overall water quality for human consumption is called Water Quality Index (WQI). To calculate the WQI, nine parameters were selected depending on the purpose for which water will be used and based on data availability and their significance in determining the water quality for human consumption. The WQI tool describes successfully the overall water quality in a simple manner.[11,16-18] The method used here for WQI calculation is Weighted Arithmetic Water Quality Index Method, which is most common method used in India.[19] This method is explained as follows:

Calculation of quality rating (Q_i): For each selected water quality parameter, the standard permissible value (S_i), observed value (V_i) and ideal value (V_0) were identified. Then the water Quality rating (Q_i) for each parameter is calculated using the following formula:

$$Q_i = \frac{(V_i - V_0)}{(S_i - V_0)} \times 100$$

where, V_i = observed value of the parameter

V_0 = ideal value of the parameter

S_i = standard permissible value of the parameter.

The value of rating scale varies from 0 to 100. When the quality rating value is proportional to 0 that means ideal quality and if the value is proportional to 100 that means the parameter is at permissible limits.

Calculating the unit weight (W_i): The unit weight or specific weight for each selected parameter is calculated using the following formula:

$$W_i = \frac{K}{S_i}$$

Where, W_i = unit weight for selected parameter

S_i = recommended standard value of the parameter

K = proportionality constant, assumed as 1 for simplifying the calculation

Where, the constant K can be calculated by: $K = \frac{1}{\Sigma(1/S_i)}$

Then the weighted value for each selected parameter can be measured by multiplying the quality rating and unit weight and water quality index can be evaluated using following formula:

WQI = $\frac{\Sigma(W_i Q_i)}{\Sigma(W_i)}$

Here, W_iQ_i = weighted value and W_i = unit weight.

Therefore, the WQI values ranges from good to unfit on their acceptability for human use (Table 2).

Table 2. Water Quality Index – WQI (Brown et al. 1972)

WQI Range	Water Quality Status	Possible Usage
0-25	Excellent Quality	Drinking, Industrial, Irrigation
25-50	Good Quality	Domestic, Industrial and Irrigation
50-75	Poor Quality	Irrigation and Industrial
75-100	Very Poor Quality	Restricted use
Above 100	Not Potable	Requires treatment

Results and Discussion

The water quality index (WQI) was measured for four sampling sites along the Baldi river stretch using weighted arithmetic method and the WQI values ranged from 56.48 to 61.09 suggesting moderate spatial variation in water quality over study area. The lowest recorded WQI value was at Site 2 (Sera village - 56.48) due to least human interference whereas the highest WQI value was observed at Site 3 (Sahastradhara tourist point - 61.09), as it is the main tourist point and many anthropogenic activities occurs there. All sampling sites fall under the “Poor” water quality category, indicating that the water is suitable for irrigational and industrial purposes and unfit for domestic use. The WQI of different sites is depicted in Table 4(a) – 4(d) given below:

Table 3. Standard values (S_i) and unit weight (W_i) used for WQI calculations.

S.no.	Parameters	WHO/BIS Standard values (S_i)	Unit Weight (W_i)
1	pH	8.5	0.267
2	Electrical Conductance (EC)(µS/cm)	300	0.0076
3	TDS (ppm)	500	0.0045
4	Total Alkalinity(mg/l)	200	0.0113
5	DO (mg/l)	5	0.454
6	Chloride(mg/l)	250	0.0091
7	Hardness(mg/l)	300	0.0076
8	Sodium(ppm)	200	0.0113
9	Potassium(ppm)	10	0.227
			∑Wi = 0.9994 ~ 1

Table 4(a). WQI at sampling site 1 (Patali village)

S. no.	Parameters	V_i	Q_i	W_iQ_i
1	pH	8.25	83.3	22.24
2	Electrical Conductance (EC)(µS/cm)	794.41	264.8	2.01
3	TDS (ppm)	387.25	77.45	0.35
4	Total Alkalinity(mg/l)	45.29	22.64	0.26
5	DO (mg/l)	10.2	45.83	20.82
6	Chloride(mg/l)	35.06	14.02	0.13
7	Hardness(mg/l)	359.42	119.8	0.91
8	Sodium(ppm)	3.92	1.96	0.02
9	Potassium(ppm)	5.15	51.5	11.69
	WQI = 58.43			∑WiQi = 58.43

Table 4(b). WQI at sampling site 2 (Sera village)

S. no.	Parameters	V_i	Q_i	W_iQ_i
1	pH	8.18	78.67	21
2	Electrical Conductance (EC)(µS/cm)	922.62	307.54	2.34
3	TDS (ppm)	446.83	89.37	0.4
4	Total Alkalinity(mg/l)	45.5	22.75	0.26
5	DO (mg/l)	10.46	43.55	19.77
6	Chloride(mg/l)	34.18	13.67	0.12
7	Hardness(mg/l)	360.56	120.19	0.91
8	Sodium(ppm)	4.31	2.16	0.02
9	Potassium(ppm)	5.14	51.4	11.66
	WQI = 56.48			∑Wi Qi = 56.48

Table 4(c). WQI at sampling site 3 (Sahastradhara tourist point)

S. no.	Parameters	V_i	Q_i	W_iQ_i
1	pH	8.16	77.33	20.64
2	Electrical Conductance (EC)(µS/cm)	972.53	324.17	2.46
3	TDS (ppm)	464.85	92.97	0.42
4	Total Alkalinity(mg/l)	43.54	21.77	0.25
5	DO (mg/l)	9.36	54.17	24.6
6	Chloride(mg/l)	35.79	14.32	0.13
7	Hardness(mg/l)	358.19	119.9	0.91
8	Sodium(ppm)	4.25	2.13	0.02
9	Potassium(ppm)	5.14	51.4	11.66
	WQI = 61.09			∑Wi Qi = 61.09

Table 4(d). WQI at sampling site 4 (Maldevta)

S. no.	Parameters	V_i	Q_i	W_iQ_i
1	pH	8.16	77.33	20.64
2	Electrical Conductance (EC)(µS/cm)	992.16	330.72	2.51
3	TDS (ppm)	495.13	99.03	0.45
4	Total Alkalinity(mg/l)	46.62	23.31	0.26
5	DO (mg/l)	9.55	52.6	23.88
6	Chloride(mg/l)	34.58	13.83	0.13
7	Hardness(mg/l)	359.23	119.74	0.91
8	Sodium(ppm)	4.37	2.18	0.02
9	Potassium(ppm)	5.14	51.4	11.66
	WQI = 60.46			∑Wi Qi = 60.46

The analysis of physicochemical parameters showed a gradual increase in values of electrical conductance

(EC), TDS and hardness from site 1 to site 4, indicating increasing mineralization along the course of river. The levels of dissolved oxygen (DO) remained relatively high across all sites, reflecting low organic pollution and good aeration. The evaluation of WQI indicates spatial variation and highlights the influence of both anthropogenic activities and ecological processes on water quality. The slightly higher WQI at site 3 and 4 can be due to increased concentrations of EC, TDS and hardness, suggesting higher mineral dissolution and ionic content or anthropogenic inputs. The comparably lower WQI at site 1 and 2 can be due to less human interferences at these sites. The WQI across all sites remains within "poor" category suggesting that the river water is increasingly polluted over time. The relatively high DO levels further support the absence of organic contamination and ensure healthy aquatic environment for survival and growth of fish. However, increased TDS and EC downstream may indicate impacts of domestic discharge, agricultural runoff or geological contribution. Sodium and potassium with very low concentrations contribute negligibly to overall WQI. This indicates that major influence on water quality is due to major ion and oxygen balance and not due to trace elements.

A comparison with WQI levels noted for few major rivers of India revealed the relative status of the present study. The CCME-WQI values for the Ganga River (Haridwar) ranged from 38–80, indicating water quality varying from "fair" to "poor" for drinking purposes.[20] Similarly, studies on rivers in Gujarat, including the Tapi River (35–70), Narmada River (28–52), Sabarmati River (42–65), and Mahi River (30–50), have documented WQI values ranging from "good" to "poor".[21] In contrast, the Kali River in Uttar Pradesh has shown degraded conditions, with WQI ranging from 204-262, categorizing it as "very poor" and unsuitable for most uses.[22] The Mahananda River has WQI values ranging from 18 to 95 with wide spatial variation in water quality, indicating conditions from "excellent" to "very poor".[23] Overall, under reduced human pressure, the Baldi river water quality and ecological health is better than many major rivers of India but when assessed for domestic and drinking purposes, it drops to poor/very poor category due to high EC, TDS and hardness and the main contributors to this are tourism and local sewage.

Conclusion

The physicochemical analysis of Baldi river water suggests that while the water quality is acceptable for irrigation and industrial purposes and suitable for proper respiration, growth and survival of fish life but continuous monitoring is essential for preventing future degradation and pollution of river water.

References:

1. Anh NT, Nhan NT, Schmalz B, Le Luu T. Influences of key factors on river water quality in urban and rural areas: A review. Case Studies in Chemical and Environmental Engineering. 2023 Dec 1; 8:100424. https://doi.org/10.1016/j.cscee.2023.100424
2. Giri S. Water quality prospective in Twenty First Century: Status of water quality in major river basins, contemporary strategies and impediments: A review. Environmental Pollution. 2021 Feb 15; 271:116332. https://doi.org/10.1016/j.envpol.2020.116332
3. Ahmed T, Imdad S, Butt NM. Bacteriological assessment of drinking water of Islamabad Capital Territory, Pakistan. Desalination and Water Treatment. 2015 Nov 27;56(9):2316-22. https://doi.org/10.1080/19443994.2014.963154
4. UNICEF F, Waters S. Water in India: situation and prospects. New Delhi: UNICEF. 2013.
5. United Nations. World population prospects: The 2008 revision population database.
6. Horton RK. An index number system for rating water quality. J Water Pollut Control Fed. 1965 Mar;37(3):300-6.
7. Brown RM, McClelland NI, Deininger RA, Tozer RG. A water quality index-do we dare. Water and sewage work. 1970 Oct;117(10).
8. Edition F. Guidelines for drinking-water quality. WHO chronicle. 2011;38(4):104-8.
9. Kaur S, Naseer S. Water Quality Assessment of Sahastradhara Stream, Dehradun, Uttarakhand, India. Asian Journal of Environment & Ecology. 2023 Jul 26;22(1):29-39. https://doi.org/10.9734/ajee/2023/v22i1473
10. Kulshrestha S. Assessment of the effect of COVID-19 Lockdown on Water Quality of Baldi River Sahastradhara Sulphur Spring, Dehradun, Uttarakhand, India. Ecology, Environment and Conservation. 2022 Oct 17; 28(3):1345-1356. http://doi.org/10.53550/EEC.2022.v28i03.035
11. Dwivedi S. Assessment of drinking water quality status by water quality index: a case

study of Sahastradhara, Dehradun, Uttarakhand, India. International Journal of Research in Pharmacy and Chemistry. 2022; 12(4):433-439.
DOI: 10.33289/IJRPC.12.4.2022.12(40)

12. Rana D, Gupta SK, Rana R. Water quality assessment of streams of Doon Valley Dehradun, Uttarakhand. InAdvances in Environment Engineering and Management: Proceedings of the 1st National Conference on Sustainable Management of Environment and Natural Resource Through Innovation in Science and Technology 2021 Sep 3 (pp. 1-12). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-79065-3_1
13. Singh N, Sharma RC. Assessment of physicochemical parameters of Mountain River Baldi, Garhwal Himalayas. International Journal of Fishries and Aquatic Studies. 2016;4(2):88-93.
14. American Public Health Association (APHA), American Water Works Association (AWWA) and Water Environment Federation (WEF), Standards for Examination of Water and Wastewater. 23rd Ed., American Public Health Association, Washington, DC, USA, 2017.
15. Bureau of Indian Standards (BIS), Specification for Drinking Water, IS: 10500, Bureau of Indian Standards, New Delhi, 2012.
16. Dwivedi, S. Assessment of Drinking Water Quality Status by Water Quality Index: A Case Study of Bhatta Waterfall, Dehradun, Uttarakhand - India. International Journal of Science and Research. 2023 Feb; 12(2): 47-52. https://doi.org/10.21275/sr23131202028.
17. Bharti N, Katyal D. Water quality indices used for surface water vulnerability assessment. International journal of environmental sciences. 2011 Jan 1;2(1):154.
18. Akoteyon IS, Omotayo AO, Soladoye O, Olaoye HO. Determination of water quality index and suitability of urban river for municipal water supply in Lagos-Nigeria. European Journal of Scientific Research. 2011 Mar;54(2):263-71.
19. Brown RM, McClelland NI, Deininger RA, O'Connor MF. A water quality index—crashing the psychological barrier. In: Indicators of Environmental Quality: Proceedings of a symposium held during the AAAS meeting in Philadelphia, Pennsylvania, December 26–31, 1971 (pp. 173-182). Boston, MA: Springer US. https://doi.org/10.1007/978-1-4684-2856-8_15.
20. Gani A, Pathak S, Hussain A, Ahmed S, Singh R, Khevariya A, Banerjee A, Ayyamperumal R, Bahadur A. Water quality index assessment of river Ganga at Haridwar stretch using multivariate statistical technique. Molecular Biotechnology. 2025 Aug;67(8):3130-53.https://doi.org/10.1007/s12033-023-00864-2
21. Nihalani S, Meeruty A. Water quality index evaluation for major rivers in Gujarat. Environmental Science and Pollution Research. 2021 Dec;28(45):63523-31. https://doi.org/10.1007/s11356-020-10509-5
22. Said S, Khan SA. Remote sensing-based water quality index estimation using data-driven approaches: a case study of the Kali River in Uttar Pradesh, India. Environment, Development and Sustainability. 2021 Dec;23(12):18252-77.
https://doi.org/10.1007/s10668-021-01437-6
23. Shil S, Singh UK, Mehta P. Water quality assessment of a tropical river using water quality index (WQI), multivariate statistical techniques and GIS. Applied water science. 2019 Oct;9(7):168. https://doi.org/10.1007/s13201-019-1045-2