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RESEARCH ARTICLE

Community based seasonally water quality testing of tributaries of Dehradun

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Abstract

The objective of the research was to assess the water quality of the Suswa river. Nine locations from the Suswa river of Dehradun were chosen for sampling. The research was carried out between 2020 and 2021. Physical and chemical parameters were analyzed by using different instruments. Turbidity (2-115 NTU), total dissolved solids (30-276 mg L^{-1}), pH (7.58– 7.88), dissolved oxygen (6.04–10.32 mg L^{-1}), hardness (124–198 mg L^{-1}), alkalinity (40–84.6 mg L^{-1}), nitrate (0.058–0.115 mg L^{-1}), and phosphate (0.015–0.080 mg L^{-1}) were among the significant parameters that were measured. The Suswa river water requires precautionary measures before use in order to prevent adverse health impacts on humans, as evidenced by the analysis of water samples obtained from several study locations around the study region. As a result, we need to keep an eye on the resources. Monitoring of the river's geomorphic, environmental, and climatic changes should be done more often, and the results should be made public.

Keywords: Biological oxygen demand, Physio-chemical parameters, Turbidity, Water quality.

Introduction

Living things need water in order to thrive. Water pollution is caused by a variety of natural processes (rock weathering, erosion, excessive rainfall, etc.) as well as human-caused processes (urbanization, agriculture, industry, population increase, etc). It is largely the weathering of rocks and incorrect sewage disposal owing to the slope of mountains in Uttarakhand that contribute to water pollution (Oluyemi *et al.*, 2010). Uttarakhand's water supply is plagued by turbidity and bacterial pollution, making drinking water unfit for human use. About 90% of the rural population relies on natural water sources for their daily water needs because of the state's huge hilly terrain (Jain *et al.*, 2010). For environmentalists and the general public alike, water quality has become a top priority these days.

There is a plethora of contaminants that might harm water supplies. There are a lot of pollution sources in Sahastradhara Dehradun, a well-known tourist destination, where there is no such environmental protection strategy. The following hazard centers have been identified as important pollution sources in the research region based on the information gathered. Observations conducted on-site and analytical findings. These include hotels, farms, municipal waste management facilities, and parking lots for buses and small cars. The waste eventually makes its way into waterways, where it deteriorates the quality. In contrast, surface water bodies are being used as dumping grounds for industrial wastewater and residential trash. Because of this, the dynamic balance between environmental segments is disrupted and filthy rivers are created (Khanna *et al.*, 2010).

East of the Asarori-Dehradun road in a clayey depression, the river Suswa rises and makes its way to the Gangotri basin. After combining with the Song, the Suswa river drains the eastern half of Dehradun and empties into the Ganga. The Suswa rivers is one of Ganga's most important tributaries. The cities of Dehradun and Doiwala are within the catchment area of the Suswa river. According to the most recent census, Dehradun has a population of 578,420 people, while the population of Doiwala is 8709 people. The Suswa river runs through 11 settlements in addition to the city (Khanna *et al.*, 2006).

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The Suswa rivers' watersheds are home to two highly polluting businesses. The distillery maintains a ZLD with a multi effect evaporator, while the sugar mill has installed an effluent treatment plant with a sufficient capacity and is adhering to discharge standards for that effluent. Sugar mill effluent falls into the Suswa river through a series of tiny nalla. On the basis of water quality data from 2016 and 2017, the Central Pollution Control Board (CPCB) has designated the river stretch between Mothrawala to Raiwala (about 31 kilometers) as a contaminated river. There has been an action plan established to restore the water quality along the contaminated Suswa river length from Mothrawala all the way to Raiwala in accordance with orders from the Hon'ble National Green Tribunal dated 20.09.2018, 19.12.2018, and 8.04.2019.

It is a crucial part of the river Suswa's rehabilitation in order to achieve water quality standards for bathing Class-B. It's worth noting that the Bindal and Rispana rivers, which originate in Dehradun's eastern suburbs and carry municipal effluent to the river Suswa near Mothrawala, should be included. These two rivers must be intercepted and diverted before they meet the Suswa River in order to restore water quality. Class 'B' river water quality, on the other hand, is an impossibility. Improvements in river water quality will be achieved through preventative and management techniques (Bhat, 2015). In this research, we analyze the physical and chemical parameters of Suswa river to check its water quality, whether it is reliable for domestic purposes or not and how it can be improved.

Material and Methods

Sample collection

Water samples were taken from the river Suswa, as well as neighboring communities, in pre-cleaned, acid-washed plastic bottles at the same time (Table 1). The monitoring was done once a year (2021) and then kept in a refrigerator below 4°C until it was needed. Study area map of Suswa river basin is shown in Figure 1.

Table 1: The selected sampling sites were

S. No.	*Sampling sites*	*Site code*	*Distance*
1.	Upstream of suswa river from Raiwala town	Site-1	0 m
2.	Suswa river near Raiwala town	Site-2	70–80 m
3.	Downstream of suswa river from Raiwala town	Site-3	80–100 m
4.	Downstream of waterfall near a bridge	Site-4	5 km
5.	Suswa river Kurkawala	Site-5	0 km
6.	Suswa river Doodhli	Site-6	5 km
7.	Suswa river after confluence at Mothorawala	Site-7	0 km
8.	Clement town	Site-8	0 km
9.	Mothorawala (Confluence Point of Suswa with Rispana and Bindal River)	Site-9	2.5 km

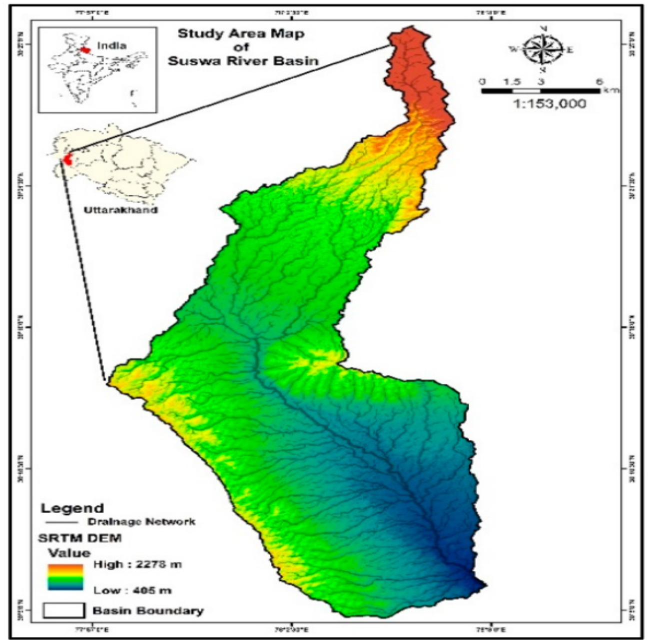

Figure 1: Study area map of Suswa river basin

Method

A centigrade (0–110°C) thermometer was used to measure the temperature of the water. The electromagnetic current meter was used to determine the average water velocity (Model-PVM-2A Montedoro-Whitney Corp., San Luis Obispo, CA). The Metzer Digital Turbidity Meter was used to measure turbidity (Model-5D1M). The Toshcon Multiparameter Analyzer was used to analyze the conductivity, pH, and TDS of the water samples. The dissolved oxygen concentration was calculated using a modified Winkler's technique. The spectrophotometer was used to determine nitrates, phosphates, and sulfates (Model- UV-VIS Systronics 117 series). A flame photometer (Model–EI 1381E) was used to measure sodium and potassium. The titration technique was used to determine alkalinity, calcium, magnesium, and hardness.

Data analysis

SPSS 26.0 was used to conduct the statistical analysis. The weight arithmetic index method (Brown *et al.*, 1970; Akoteyon *et al.*, 2011; Tyagi *et al.*, 2013) was extensively used for the calculation of WQI of water sources and calculated by using the standard values of BIS.

Results

Physical Parameters

The Suswa river's average physical parameter values show notable variations across different sites In Table 2.

Table 2: Suswa river's average physical parameter value

Parameters	*Sites*								
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Temperature (°C)	23.21 ± 0.59	23.66 ± 0.18	24.66 ± 0.89	18.7 ± 22	22 ± 25.1	19.1 ± 24.6	17.5 ± 18.0	18.9 ± 24.2	17.6 ± 23.7
Velocity (m/s)	0.28 ± 0.047	0.33 ± 0.06	0.32 ± 0.03	0.28 ± 0.04	0.32 ± 0.06	0.39 ± 0.01	0.34 ± 0.02	0.23 ± 0.05	0.27 ± 0.04
TDS (mg/l)	580 ± 600	574 ± 625	550 ± 580	600 ± 625	219 ± 114	541 ± 570	545 ± 540	580 ± 600	550 ± 580

Table 3: The Suswa river's average chemical parameters

Parameters	*Sites*								
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
pH	7.34 ± 0.05	7.38 ± 0.11	7.54 ± 0.11	6.88 ± 7.3	7.3 ± 8.7	7.5 ± 7.9	7.17 ± 7.3	6.9 ± 7.89	7.06 ± 7.4
Oil & grease	21 ± 10	22 ± 11	23 ± 11	21 ± 10	22 ± 12	21.3 ± 3	2.0 ± 4	22 ± 12	31 ± 12
Total hardness (mg/l)	234.22 ± 2.60	245.81 ± 7.92	229.49 ± 8.56	62.2 ± 64	79.2 ± 124	42 ± 58	59 ± 69	50 ± 72	72 ± 90
Total alkalinity (mg/l)	266.55 ± 19.81	281.38 ± 10.52	255.51 ± 1.03	15 ± 70	21.1 ± 23.6	35 ± 60	20 ± 90	10 ± 40	45 ± 60
Free CO2 (mg/l)	2.98 ± 0.66	2.84 ± 0.63	4.79 ± 0.46	3.17 ± 1.0	2.86 ± 1.11	2.97 ± 0.96	4.97 ± 1.77	1.18 ± 0.62	0.77 ± 0.01
COD (mg/l)	4.79 ± 0.46	3.11 ± 0.29	2.58 ± 0.75	2.40 ± 0.22	2.90 ± 0.07	3.40 ± 0.57	2.90 ± 0.50	3.30 ± 0.23	2.53 ± 0.31
BOD (mg/l)	0.58 ± 0.18	0.71 ± 0.10	1.10 ± 0.32	0.6 ± 1.2	0.43 ± 5.0	0.8 ± 1.4	0.9 ± 1.7	1.0 ± 1.5	0.8 ± 1.8
Dissolved oxygen (mg/l)	7.5 ± 0.32	7.2 ± 0.31	7.59 ± 0.20	1.4 ± 1.16	4.2 ± 5.3	1.8 ± 2.8	2.1 ± 2.4	1.6 ± 1.23	1.8 ± 2.6
Chloride (mg/l)	18.21 ± 1.95	17.05 ± 1.11	19.53 ± 1.72	11.2 ± 0.04	57.8 ± 8.2	9.8 ± 1.09	10.6 ± 2.21	11.4 ± 2.0	17.06 ± 1.25
Magnesium	41.57 ± 2.12	43.87 ± 4.74	41.13 ± 4.43	19.44 ± 100.3	26 ± 12	37.08 ± 92.26	59.7 ± 25.33	70.1 ± 119. 6	5.01 ± 75.63
Calcium	61.79 ± 4.28	62.00 ± 3.80	63.10 ± 3.612	59.86 ± 141.86	18 ± 32	13.32 ± 137.76	91.3 ± 187.333	37.6 ± 81.19	115.7 ± 160.2
Sulphate	1211 ± 298	1282 ± 308	1287 ± 308	1211 ± 298	1234 ± 302	320 ± 182	326 ± 182	1234 ± 302	1244 ± 302
Phosphate	4.1 ± 2.0	4.3 ± 2.2	4.2 ± 2.2	4.1 ± 2.0	4.3 ± 2.0	2.0 ± 1.0	2.1 ± 1.0	4.3 ± 2.0	4.4 ± 2.0
Nitrate	434 ± 365	495 ± 365	496 ± 365	434 ± 365	456 ± 365	211 ± 150	224 ± 156	456 ± 365	467 ± 365
Chloride	372 ± 633	667 ± 389	672 ± 389	633 ± 372	646 ± 377	237 ± 118	231 ± 119	646 ± 377	663 ± 381
Fluoride	3.2 ± 1.7	3.4 ± 1.9	3.7 ± 1.9	3.2 ± 1.7	3.7 ± 1.8	0.8 ± 0.4	0.9 ± 0.4	3.7 ± 1.8	3.9 ± 1.8
Iron	1.3 ± 0.9	1.3 ± 0.9	1.7 ± 0.9	1.3 ± 0.9	1.7 ± 1.0	0.33 ± 0.3	0.4 ± 0.3	1.7 ± 1.0	1.9 ± 1.0
Total coliform (MPN/100 ML)	38 ± 30	130 ± 387	120 ± 380	38 ± 30	44 ± 30	180 ± 110	1700 ± 1100	44 ± 30	49 ± 32
Fecal coliform (MPN/100 ML)	90 ± 80	761 ± 5400	780 ± 4400	80 ± 90	80 ± 110	30 ± 100	30 ± 120	80 ± 110	88 ± 132

Temperature ranges from 17.5°C at site 7 to 24.66°C at site 3, indicating significant fluctuations likely influenced by local environmental factors or seasonal changes. Water velocity varies as well, with the highest at site 6 (0.39 m/s) and the lowest at site 8 (0.23 m/s), suggesting differences in river flow dynamics due to variations in riverbed gradient, width or external inputs. TDS levels also display significant differences, with the highest at site 4 (600 mg/l) and the lowest at site 5 (219 mg/l), indicating varying degrees of water quality and potential contamination sources.

Chemical Parameters

The Suswa river's average chemical parameters exhibit significant variability across different sites, as shown in Table 3. The pH levels range from 6.88 at site 4 to 7.54 at site 3, affecting aquatic life. Oil and grease are consistently low except at site 7, which is notably lower (2.0 ± 4 mg/l). Total hardness is highest at sites 1 (234.22 mg/l) and 2 (245.81 mg/l), while sites 4 and 6 are lowest, indicating geological variations. Total alkalinity is higher at sites 1 (266.55 mg/l) and 2 (281.38 mg/l), reflecting water's buffering capacity. Free CO_2 peaks at site 7 (4.97 mg/l) and is lowest at site 9 (0.77 mg/l), influenced by organic matter decomposition. COD and BOD are moderate, with site 1 having the highest COD (4.79 mg/l) and site 3 the highest BOD (1.10 mg/l), indicating varying organic pollution levels. DO is highest at site 3 (7.59 mg/l) and lowest at site 4 (1.4 mg/l), often linked to organic pollution and turbidity. Chloride concentrations vary, with site 3 (672 mg/l) and site 2 (667 mg/l) being highest. Magnesium is highest at site 8 (70.1 mg/l) and calcium at site 9 (115.7 mg/l), showing geological influences. Sulfate levels are high across sites, peaking at site 3 (1287 mg/l). Phosphate and nitrate levels vary moderately, with nitrate highest at site 3 (496 mg/l). Iron peaks at site 9 (1.9 mg/l). Total coliform and fecal coliform levels vary significantly, with site 7 showing extremely high values (1700 MPN/100 mL and 780 MPN/100 mL, respectively), indicating higher pollution, likely from human or animal waste

Discussion

Rivers with little or nonexistent water movement and an abundance of untreated sewage are prone to become breeding grounds for diseases. Monitoring the physico-chemical characteristics is crucial for investigating the impact of these factors on the distribution of different components of biodiversity in headwater. The tables show the concentrations of main elements and associated physico-chemical properties at nine specific locations.

The value of total hardness is governed by the content of Ca and Mg salts largely combined with bicarbonates, sulfate, and chlorine. A higher value of temperature was found at site 1. A direct relationship was established between the water temperature and free carbon dioxide. Total solids dissolved were found maximum at site 4, due to the gradual increases in the velocity of river, which favored effective sedimentation.

In the Suswa river, notable variations were observed across different sites in terms of water temperature, dissolved oxygen (DO), pH, velocity, total solids, biochemical oxygen demand (BOD), and various chemical parameters. Temperature fluctuations were influenced by Himalayan snowmelt, impacting DO levels, which were highest at site 6 due to factors like dissolved organic matter and plankton. High pH was noted at site 3, essential for aquatic flora and fauna. Velocity increased due to snowmelt, and maximum total solids were recorded where lower velocities favored sedimentation. BOD levels were moderate across sites, indicating organic pollution influenced by heavy metals. Chloride concentration was highest at site 4, with calcium and magnesium levels varying due to bedrock geology. Calcium was highest at site 3 and magnesium at site 8. Other significant variations were observed in iron, phosphate, sulfate, fluoride, chloride, and nitrate concentrations, suggesting different environmental impacts. Total coliform contamination also varied, indicating diverse pollution sources and environmental factors affecting coliform presence in the river water.

Similarly, in a comprehensive study conducted by Kumar *et al*. in 2020, a detailed analysis of various water quality parameters along the study sites revealed significant findings. Temperature variations were observed, with the highest recorded at sampling site 1 (24.2°C) in April and the lowest at site 4 (17.5°C) in February. The trend showed a gradual increase in water temperature from February to March, followed by a slight decrease in April.

The study presented by Hirsch, Slack, & Smith, in 1982 showed nonparametric methods for analyzing monthly water quality data, which are robust against complications such as seasonality and non-normal distributions. It introduces the seasonal Kendall test and seasonal Kendall slope estimator for trend analysis and emphasizes their applicability despite serial correlation issues.

In monitoring water quality in agricultural drainages, the study by Murphy, Hicks, & Stocks, 2020 used event-based data and bootstrapping techniques to assess the impact of best management practices on water quality. It found mixed results, with some constituents showing significant changes post-implementation, emphasizing the complexity of water quality assessment in agricultural landscapes.

The quality of water in a stream is affected by natural, hydrological, climatic, and human variables. All the examined parameters exhibited increased levels. Conversely, the DO exhibited a contrasting trend by reaching its highest levels, perhaps because oxygen is more soluble at colder temperatures. The presence of bacteria was unequivocally shown by the elevated level of BOD, beyond the established threshold. This poses a significant risk to public health, as it may lead to the development of life-threatening illnesses.

Conclusion

The Doon Valley was characterized by land use and carbonate bedrock, which created an environmental context with a significant potential for increased levels of soluble nutrients, fluctuations in nutrient concentrations, and elevated nutrient concentrations. The stream water's chemistry is mostly influenced by carbonate weathering, with minor contribution from run-off and tourist activities. This is evident from the significant amounts of alkali earth metals, high alkalinity, and a high (Ca + Mg)/ (Na + K) ratio in the water. The variations in ionic concentrations are attributed to the influence of climate and lithology, which in turn are determined by the geographical changes in total dissolved solids (TDS). All nine sample locations utilized in the experiment showed very slight changes in their physical, chemical, and heavy metal properties. The investigation was carried out using a randomized trial. Nevertheless, the increasing concentration of pollutants indicates that the stream is getting increasingly contaminated.

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