



# **Water Quality Assessment of Sahastradhara Stream, Dehradun, Uttarakhand, India**

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## **Authors' contributions**

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## **ABSTRACT**

Sahastradhara stream is a main attraction of tourist as well as source of household and potable water for the region and the surrounding villages. The stream is being polluted attributable to a variety of human-made activities and water quality is being deteriorated. During these studies, water samples were collected from the three different The physical-chemical characteristics of the water, including temperature, pH, transparency, turbidity, DO, BOD, CO<sub>2</sub>, alkalinity, and chloride, were analysed at Site-I (the reference Site), Site-II (the more popular tourist destination, severely contaminated Site), and Site-III (moderately polluted). The Physico-chemical parameters were recorded highest at Site-II (DO 7.5mg/l), Turbidity (58.1-80.16 NTU), Alkalinity (245.4-308.2mg L<sup>-1</sup>), pH (6.1-7.2), temperature (25.6<sup>0</sup>C-27.6<sup>0</sup>C), BOD (1.5 mg/l-2.6mg/l), CO<sub>2</sub> (1.5-1.83) followed by S-3 (temperature 26.2-27.2<sup>0</sup>C, pH 7.1-7.2, tur. 79.2-81.1cm, DO 8.1-8.2mg/l, CO<sub>2</sub> 1.62-1.81, Alkalinity 255.6-262.2 mg/l, BOD, 2.3-2.4 mg/l, Chloride 32.1-32.5 mg/l) and S-I (temperature 25.6-26.3<sup>0</sup>C, pH 7.0-7.1, turbidity 60.2-68.2cm, DO 8.5, CO<sub>2</sub>, 1.53-1.62 mg/l, Alkalinity, 250.2-256.6 mg/l, BOD,1.5-1.6 mg/l, chloride, 30.0-30.2 mg/l). The study has shown that water at Site-I of

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Sahastradhara stream is suitable for human use and other purposes, whereas Due to a major change in the water quality of the Sahastradhara stream brought on by various touristic and anthropogenic activities, the water at Sites II and III is unfit for all uses. At the 5% level of significance, every parameter changed considerably over the study period.

**Keywords:** *Physico-chemical analysis; water quality; water pollution; sahastradhara stream; anthropogenic activities.*

## 1. INTRODUCTION

All types of life on earth depend on water for their survival. even though water covers 80% of the earth's surface. India is one of the top ten water-rich nations with around 4% of the world's freshwater resources. India is currently the third-largest fish producer in the world and is significant to global fisheries. Since the 1950s, the Indian fishing industry has expanded significantly, reaching its current annual output levels of more than 7 million tonnes of fish and shellfish from capture fisheries and aquaculture. Approximately 5% of the world's total fish output and 7% of the overall aquaculture production are being produced in India. The country is on the cusp of enormous expansion in fisheries and aquaculture, and the potential for growth is enormous. In the entire globe, rivers are the most valuable resource. In India specifically, great civilizations emerged along the banks of rivers, and even now, the majority of growth occurs in the towns that are close to rivers. The rivers supply water for household, commercial, industrial, agricultural, and aquaculture uses. Unfortunately, the same waterways are being contaminated by a variety of human activities, indiscriminate sewage discharge, and industrial waste disposal. In India, river pollution has already reached significant levels. River pollution initially has an impact on its physicochemical composition before gradually destroying the neighbourhood and upsetting the delicate food chain. Since rivers are one of the main sources of fresh water accessible for human consumption, their water quality is a major environmental problem. A state famed for its numerous small and large rivers, as well as the holy sites located on its banks, is Uttarakhand. Due to their importance in Hindu mythology, certain of these rivers are considered to have religious significance in India. These rivers' origins are the western Himalayan glaciers that border Tibet, Nepal, and India These rivers are essential to India's economic, cultural, social, and environmental problems. Numerous residences are illuminated by the hydroelectric plants on these rivers, but they are also under

fire from environmental groups for upsetting the biological balance. Because they are used for agriculture, drinking water, energy, fishing, trade, etc., these rivers serve as the foundation of the Indian economy. Rivers like the Ganga, Tonnes, Yamuna, and Kalie are well known for providing a broad array of water activities in several areas of Uttarakhand. Until they hit the tarai zone, the majority of these rivers are pristine and hardly contaminated. Dehradun is a land blessed with diverse natural beauty, and thus attracts hordes of tourists to its boundaries every year. Amidst the several attractions that make up the natural charm of Dehradun City, one of the most prominent ones is Sahastradhara. It is located at a distance of about 14 kilometers from the city and is one of the most popular travellers attractions here. The name Sahastradhara translates into 'Thousand fold spring' and is characterized by a beautiful waterfall. River Baldi flows through a great height with caves on each side. It is best that you visit this spot during the monsoon season when the river gushes off the cliff, offering spectacular scenery. Also, something that makes this spot more special is that there are limestone stalactites here, and the spot turns into a sulfur spring when water drips through these. Many people think that this water has therapeutic qualities that can treat many skin conditions. A significant tributary of the Song River, the Sahastradhara stream is located in Uttarakhand, 15 km from Dehradun. It is quite significant as a picnic destination for travellers in the area, despite the fact that there is little industrial and agricultural pollution there. The region's hill streams serve as a nursery for nutrients, particularly ions of calcium and magnesium. Specifically, tourist-related activities and watershed runoff may have an impact on the index of nutrients in stream water. As of the sectors with the quickest growth rates worldwide, tourism also provides a significant portion of the foreign exchange profits and jobs in many developing nations. Although technology has the ability to positively impact socioeconomic advancements, its rapid and occasionally unchecked expansion may also play a significant role in environmental degradation and the loss of

biodiversity. The things that draw visitors are really the biological and physical resources. People who live in distant locations near popular tourist destinations have switched from unproductive [1]. Due to activities created by tourists, tourism has identified significant causes of environmental stress. In terms of the local biological species and physical circumstances, the permanent reconfiguration of the environment caused by various building operations and the replacement of a natural habitat with a new constructed environment has a range of far-reaching and long-lasting effects. The visual amenity may also undergo major alterations as a result. Recreational activities have a significant negative environmental impact, which includes soil erosion and compaction as well as changes in plant cover and species variety [2]. River water quality and its suitability for different uses are influenced by anthropogenic activities including urban, industrial, and agricultural development as well as natural processes like precipitation inputs, erosion, and weathering of crystal minerals.

Pollutants can come from a wide range of sources, which could lower the quality of water supplies. Similar to this, there are several pollution sources in Sahastradhara Dehradun, a popular tourist destination where there is no such environmental protection practise, which consistently degrades the quality of surface water. The following risk areas can be regarded as the research area's main category of pollution sources. These include lodging facilities, agricultural pursuits, municipal garbage, and parking lots for buses and small cars. Finally, the wastes reach the water bodies, where they degrade the water's quality. On the other hand, home and industrial wastes end up being dumped in surface water bodies. As a result, the dynamic balance between various environmental segments is disturbed, which results in the condition of contaminated rivers [3].

Aquatic animals are well adapted to the Physico-chemical conditions of water, but large scale mortalities occur due to pollution caused by the touristic activities. Over the past few decades, there has been growing concern about the contamination of fresh waters with a variety of heavy metals that are released from human-made domestic, industrial, and other activities. This contamination could have disastrous effects on water quality, the ecological balance of the recipient environment, and a variety of aquatic organisms. The conservation of these water

resources has been given high attention in the 21st century due to the limited supply of freshwater in the globe and the part that anthropogenic activities play in the degradation of water quality [4]. The World Health Organisation claims that [5]. Pathogenic organisms and poisonous compounds should not be present in the water that people drink. Despite the abundance of freshwater resources in lakes and rivers and the favourable monsoon, Sahastradhara and the adjacent villages consistently experience water shortages, droughts, and high levels of pollution. It is a proven fact that people born into environments with higher water quality tend to live longer. The Baldi River is Sahastradhara's lifeblood as a tourist destination, a significant source of money for the local populace, as well as for those who base their businesses here. Its water is also used for residential and agricultural uses. It is therefore necessary to maintain water quality effectively by suitable measures. Sometimes during accidents, terrible pictures of dead fish floating on the water's surface make river pollution evident. But more frequently, it manifests as pervasive pollution that comes from various human activities. All around the world, rivers' overall health deteriorates as a result of pollution. Monitoring the river's water quality in various areas of our nation is necessary to improve the waste quality due to the rising issue of river pollution [6].

## 2. METHODS

The study's goal is to examine the physico-chemical characteristics of the Sahastradhara stream, which flows through Dehradun, in order to assess the effects of anthropogenic activities on water quality.

### 2.1 Study Area

The Sahastradhara stream in Dehradun, Uttarakhand, was the subject of the current study. One of the most well-known tourist spots is Sahastradhara, which is situated near Dehradun in the Indian state of Uttarakhand. It is located at 30.39 latitude and 78.14 longitude, 11 km from Dehradun. The area is famed for its sulphur springs because of the spectacular natural beauty it offers. Water falls from the limestone stalactites there, producing the water rich in sulphur. It is a sulphur spring with water that is substantially cooler than the air around it. It is a treasure trove of breathtaking natural beauty, including caverns, waterfalls, and terrace

farming on steppe by the locals. People from remote areas are drawn to it by its outstanding natural beauty.

## 2.2 Sampling Area

The renowned sulphur stream "Sahastradhara" in Dehradun served as the subject of the current investigation. Every two weeks, between the hours of 10:00 and 12:00, water samples were taken from three distinct locations along the Sahastradhara stream.

## 2.3 Sample Collection

Samples were collected about between 10:00 and 12:00 from each of the three sample locations, fortnightly and inserted in sampling

bottles for further analysis. Physical parameters analyzed directly on the Site while chemical parameters of water analyzed in laboratory. Analysis of chemical parameters has been done as per the standard method prescribed to analyses the water samples [7].

## 2.4 Measurement of Physico-chemical Parameter of Water Sample

The data recorded for physiochemical parameters were provided as mean values, and descriptive analysis was used to analyse them. Data was analysed using one-way analysis of variance (ANOVA) at the 5% level of significance to see whether there were any significant differences between the Sites for any water quality indicators.

**Table 1. Sampling sites of study area**

Site name	Distance
1- Non polluted Site, upstream side(Site-I)	0-m
2- Highly polluted, Sahastradhara water fall(Site-II)	70-80m
3- Moderately polluted, Sahastradhara bus stand(Site-III)	200-250m



**Site-II highly Polluted Site**



**Site-III Moderately Polluted Site**



**Collection of Samples**



**Dissolved oxygen Fixation**

**Plate 1. Sampling sites and sample fixation**

### 3. RESULTS AND DISCUSSION

#### 3.1 Observation of Physical Parameters of Sampling Water

##### 3.1.1 Temperature

One of the most significant environmental elements is temperature, which is one of the physical parameters one experiences while touching water. Temperature is a crucial factor that affects both the interior physico-chemical processes of living things as well as their exterior behavior. Certain species, especially aquatic creatures, thrive at higher temperatures. By regulating molecular dynamics (infusibility, solubility), as well as the rate of biochemical response, temperature regulates the rate of metabolism. In water, temperature has a role. Since oxygen solubility diminishes as temperature rises, summertime O<sub>2</sub> concentrations are often lower. The average temperature varied between somewhat low

levels of 26.60C at Site III and extreme 25.90C and 27.30C at Sites I and II, respectively. All of the sites' water quality metrics considerably improved during the investigation.

##### 3.1.2 pH

it measures the amount of hydrogen ions in water and tells us how acidic or basic the water is. The pH scale has a scale of 0 to 14, with 7 being neutral. The pH will be lower than 7 and the water will be acidic when there are more hydrogen ions (H<sup>+</sup>) present. More hydroxyl ions (OH<sup>-</sup>) make water more basic (alkaline). Aquatic species' physiological processes and metabolism are impacted by water pH. The overall maximum and minimum pH values were 7.2 and 6.3 in the months of March to April at Site-III, Site-II, and moderate at Site III, respectively, throughout the current investigation. During the experimental period, at the 5% level of significance, all the water quality measures were substantially different from one another.

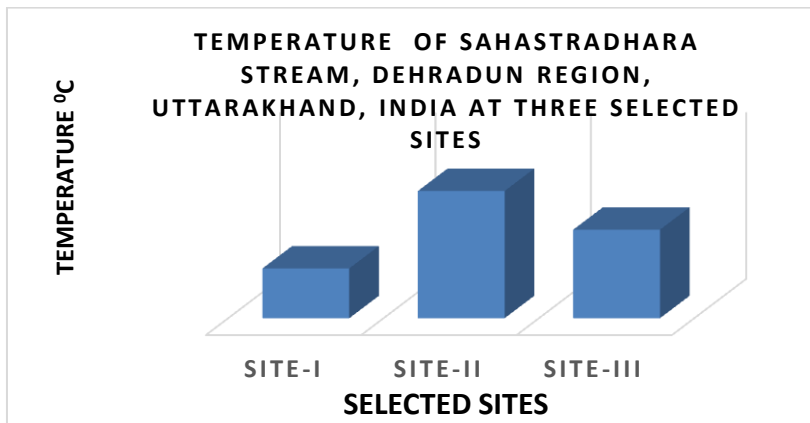


Fig. 1. Fortnightly fluctuation in temperature of three different Site

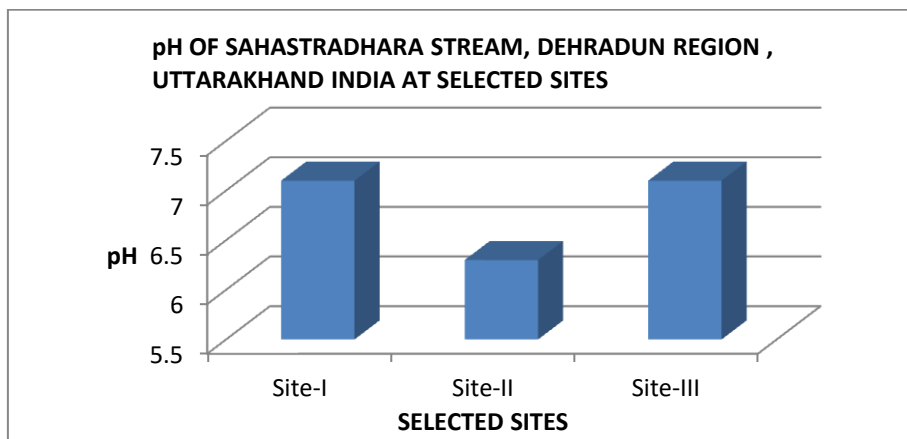


Fig. 2. Fortnightly fluctuation in temperature of three different Site

### 3.1.3 Turbidity

The word used to describe the cloudiness or muddiness of water is fairly broad. Any water sample's turbidity is the loss of clarity brought on by the presence of tiny creatures such as plankton, lay or slit particles, finely split organic debris, and other particulate matter. The greatest and minimum values of turbidity were recorded during the current investigation at Sites I and II, respectively, and intermediate values at Site III (3.3). At the 5% level of significance, all the water quality metrics during the experiment were substantially different from one another.

## 3.2 Observation of Chemical Parameters of Sample Water

### 3.2.1 Dissolved oxygen (DO)

Dissolved oxygen (O<sub>2</sub>) that has been dissolved refers to small bubbles that are present in water and used by aquatic organisms for respiration. For practically all creatures, it is an essential step. Through diffusion at the air-water interface and photosynthesis by aquatic plants, mostly phytoplankton, oxygen enters the water. At Site-II and Site-I, respectively, the present study's lowest and highest mean values of dissolved oxygen were found to be 7.2 mg/l and 8.5 mg/l. While moderate at Site-III (3.4). DO show negative correlation with temperature. All the water quality variables were significantly different to each other during the experimental period at 5% level of significance.

### 3.2.2 Dissolved carbon dioxide

As a dissolved gas, carbon dioxide may be found in water. While most ground waters have a free carbon dioxide content of less than 10 ppm, surface waters typically have a lower limit. In

water, carbon dioxide is easily soluble. The Site-II (1.82) and Site-I (1.58) in the current investigation had the lowest and highest mean levels of dissolved carbon dioxide, respectively, of 1.83 mg/l and 1.53 mg/l. While moderate at Site-III The value of all Sites were significantly different to each other. During the experimental period at 5% level of significance.

### 3.2.3 BOD

The term "Biological Oxygen Demand" (BOD) describes how much dissolved oxygen (DO) aerobic organisms require to gradually decompose organic matter in water. The overall lowest and greatest mean values of biochemical oxygen demand throughout the current investigation were 1.5mg/l and 2.6mg/l at the Site-I and Site-II, respectively, while moderate at Site-III. At the 5% level of significance, all the water quality metrics during the experiment were substantially different from one another.

### 3.2.4 Alkalinity

Alkalinity, which is distinct from basicity, which is an absolute measurement on the pH scale, is the ability of water to withstand pH changes that would cause the water to become more acidic. The strength of a buffer solution made up of weak acids and their conjugate bases is known as alkalinity. Titrating a solution with a monoprotic acid, such as HCL, until its pH rapidly changes or it reaches a predetermined endpoint where that happens is how conjugate basest is measured. Alkalinity is measured in milliequivalents per litre (meq/L), which is equal to the millimoles of monoprotic acid supplied as a titrant per litre. The present study's overall lowest and highest mean pH values were 250mg/l and 308.1mg/l, respectively.

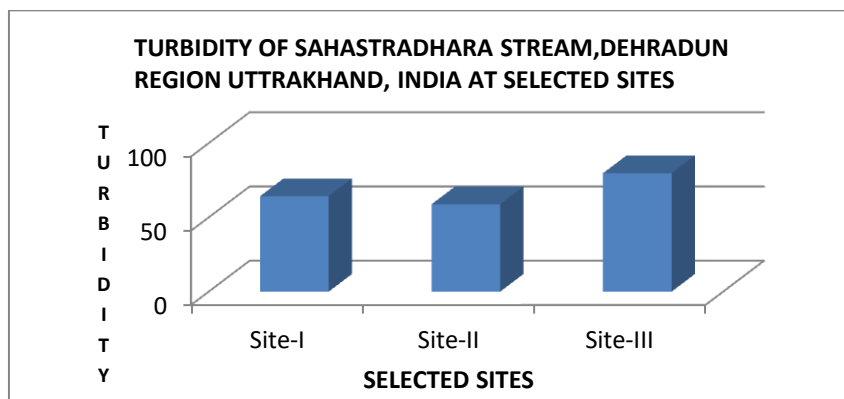


Fig. 3. Fortnightly fluctuation in turbidity Of the different Site

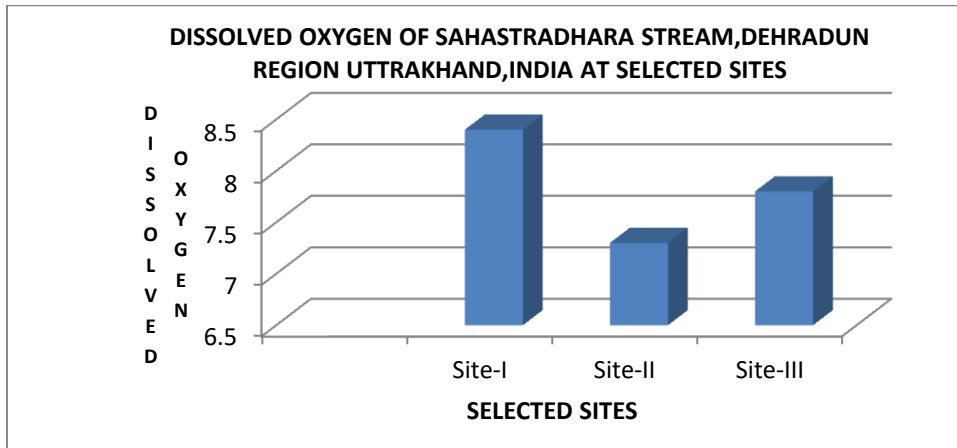


Fig. 4. Fortnightly fluctuation of DO of the different Site

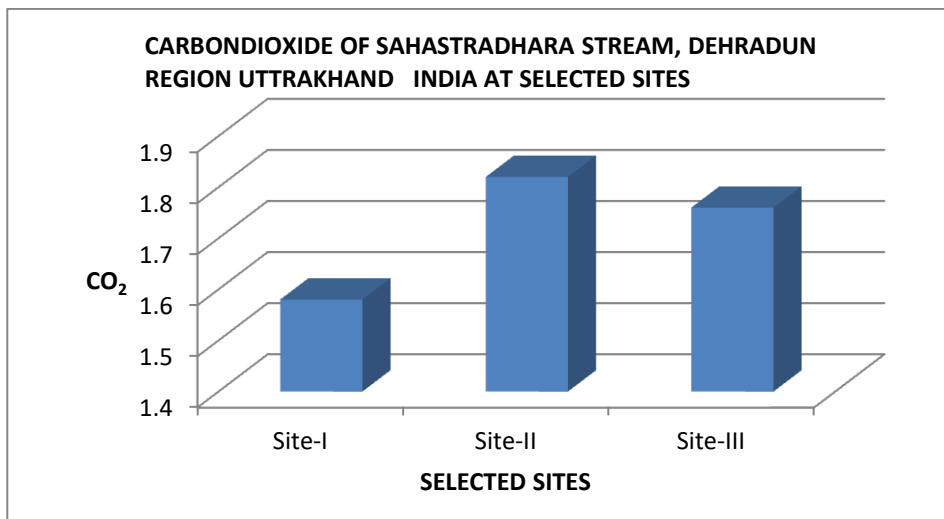


Fig. 5. Fortnightly fluctuation in CO<sub>2</sub> of different Site

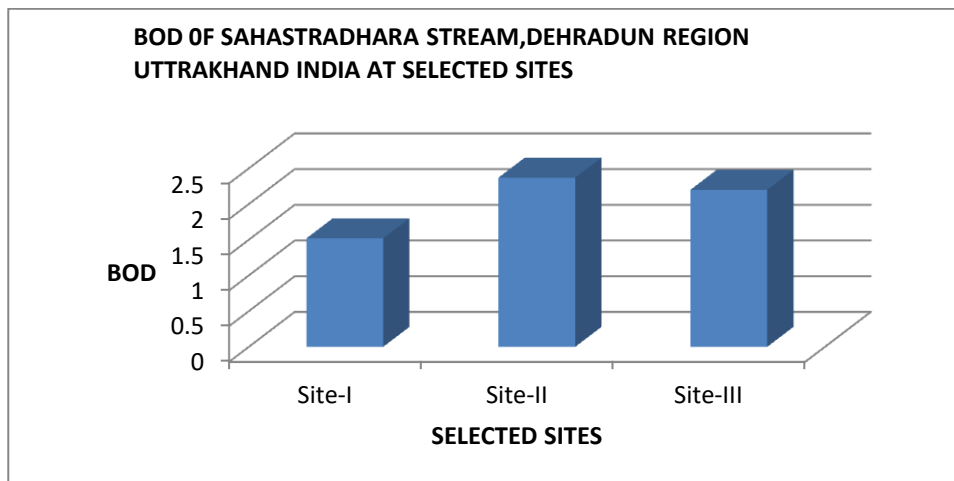


Fig. 6. Fortnightly fluctuation in BOD of different Site



All the water quality variables were significantly different to each other during the experimental period AT 5% level of significance.

### 3.2.5 Chloride

In order to eliminate disease-causing organisms like bacteria, viruses, and protozoans that frequently flourish in water supply reservoirs, on the walls of water mains, and in storage tanks, chloride, a very effective disinfectant, is added to public water supplies. A crucial ion that photosynthesizing cells require is chloride concentration. Human excrement water contains a lot of chlorides. Each day, the human body excretes between 8.0 and 15.0 grammes of chloride. As a result, the concentration of chlorides might indicate contamination. The overall lowest and highest mean values of chlorides were observed throughout the current investigation. 30.2mg/l at the Site-I, Site-II and moderate at Site-III(32.0mg/l), respectively. All the water quality variables were significantly different to each other during the experimental period at 5% level of significance.

A complex chain of biological and chemical responses may be sparked by the introduction of contaminants into an aquatic environment. A thorough understanding of the structure and fundamental operations of any ecosystem is essential for comprehending how and why these responses occur as well as for properly managing any ecosystem. The findings of this study, conducted between March and April 2018 at three chosen sites in Sahastradhara, Dehradun, namely Sites I, II, and III. The water temperature varied in the current investigation between a minimum of 25.60C and a maximum of 27.60C. Site-I recorded a minimum temperature of 25.60C, while Site-II recorded a high temperature of 27.60C. The reference site

among the three chosen sites is Site II, where it was noted that there are often no visitor activities but where 98% of tourists come at Site- II. A complex chain of biological and chemical responses may be sparked by the introduction of contaminants into an aquatic environment. A thorough understanding of the structure and fundamental operations of any ecosystem is necessary to comprehend how and why these responses occur as well as to properly manage any ecosystem. It's possible that this is the result of a shift in air temperature, which naturally impacts water temperature and results in thermal changes in water [8]. The reported minimum air temperature was 21.20 degrees Celsius (C) in January, while the reported maximum was 35.40 degrees Celsius (C) in July, with Site C recording the highest temperature. The average temperature was high in the summer and low in the winter on an average. As we moved downstream of the Sahastradhara, the temperature rose gradually. By using numerous eco-friendly strategies, water pollution may be reduced. A study of several techniques and the importance of bioremediation, a sustainable approach to pollution control, was done. [9].

The availability of many hazardous and nutritive compounds to aquatic species is impacted by the pH of water, which also impacts their solubility. Most metals become more water soluble and poisonous as acidity rises. The progressive rise in pH from Sites (I-III) throughout the current research (7.5-7.6) was linked to an increase in pollution pressure as a result of tourist activities in the Sahastradhara stream basin in the Dehradun valley. Due to the impact of tourism, [10] observed a similar pH result (7.5-7.8) at downstream S-II and S-III in the water of the River Ganga at Kanpur (India) at intervals of one month during the year 1977.

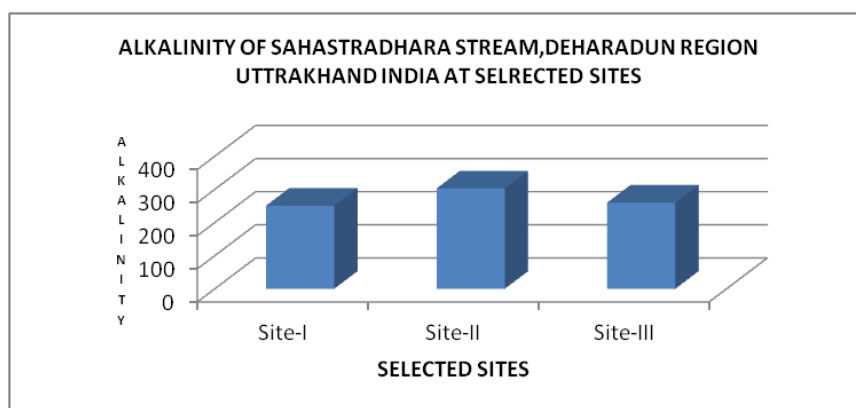
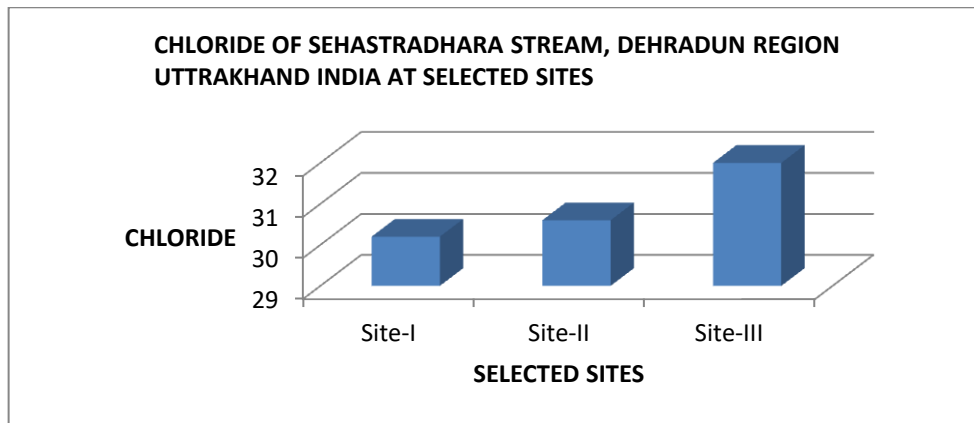


Fig. 7. Fortnightly fluctuation of alkalinity of the different Site





**Fig. 8. Fortnightly fluctuation of chlorine of the experimental period**

Any water sample that is turbid loses clarity because of tiny creatures like plankton, lay or slit particles, finely split organic debris, and other particulate matter. The sites-II and Site-III in the current investigation had the overall lowest and highest mean turbidity values, respectively, of 58.1NTU and 81.1NTU. Due to tourism-related activities on Sahastradhara, the largest relative variation in turbidity was discovered at Site-II. The excessive turbidity may be caused by rainy season runoff of surface water and dirt washing into the stream from the bank. Similar to this, the Ganga River's downstream (Site-I-II and Site-III) was observed to have excessive turbidity as a result of human activity [11]. The metabolic activities of plant and animal populations are regulated by oxygen, and water quality is indicated by oxygen levels. The most significant gas produced by the phytoplankton during photosynthesis in an aquatic environment is oxygen. In the current investigation, Site II recorded the lowest mean DO value (7.2 mg/L), whereas Site I recorded the highest mean DO value (8.5 mg/L). Due to human activity, DO in SII decreases in the current research. Compared to Site-I and Site-III, where there is no pollution, Site-II may be the result of a significant amount of organic matter being released by tourist activities in the form of polythene plastic bottles and rappers of synthetic items in Sahastradhara stream. These two Sites did not have any anthropogenic activities, so they are not affected by pollution. Similarly, [12] stated that (DO 8.05 mg/l) was valued at during the month of January for river Yamuna.

In the current investigation, the free carbon dioxide values varied from 1.55 to 1.83 mg/l-1. Carbon dioxide (CO<sub>2</sub>) enters water from the environment at the air-water interface and is normally present in solution as a byproduct of

metabolism. At Site-I, carbon dioxide levels were lowest (1.55 mg/l-1in), whereas at Site-II, they were highest (1.83 mg/l-1in). Due to anthropogenic activity in the Sahastradhara stream, the free carbon dioxide in the water rose along its downstream course. Considerable changes were recorded during the research period. Likely at Site-III and Site-II on the river Ram Ganga, [13] recorded the value of (CO<sub>2</sub> 1.87-1.95 MG/L-1). The best test currently available for determining organic pollution's level is the biochemical oxygen demand (BOD) measurement. In the current study, Site-I recorded the lowest mean value of BOD (1.5 mg/L), whereas Site-II at Sahastradhara stream recorded the highest mean value (2.6 mg/L). Because of tourist activities, there were significant oscillations during the study period. Similar to this, [14] reported the BOD value (2.8-3.5 mg/l) for the month of January along the Narmada River's down streams (Site-III and Site-IV). Alkalinity is the ability to neutralize acids, and the salts of weak acids are the main source of alkalinity in natural water. For most natural alkalinity, bicarbonates and hydroxyl carbonates are the main sources. Significant volumes of bicarbonates are produced in the soil when carbon dioxide reacts with calcium or magnesium carbonate. Humic acid, among other organic acids, forms salts that raise alkalinity. Alkalinity levels in the current research varied from 245 to 308,2 mg-1, with the smallest value being 245 mg/l-1 at Site I and the maximum being 308,2 mg/l-1 at Site 2. The Sahastradhara stream in Dehradun had significant changes during the research period as a result of human activity. Similar to this, [15] reported the alkalinity value (98-248mg/l-1) at Site-I and Site-II, respectively, in the water quality of the Ganga in Kanpur city between July 2002 and June 2004.

One of the main inorganic anions in water is chloride. When present, unpolluted rivers, trade and industrial effluents, sediments, and sewage drains also contribute to the river's chloride concentration. The chloride in the current research varied from 30.2 to 37.2mg/l. The lowest level of chloride was 32.2 mg/l at Site I, whereas the highest was 37.2 mg/l at Site II. Due to Sahastradhara's tourism-related activities, significant changes were seen during the research period. Similar to this, [16] reported the value of chloride at Site-III and Site-IV of Luming Town, Assam (32-38.5 mg/l).

#### 4. CONCLUSION

The water quality was adversely affected by the conduct of tour activities at the Sahastradhara river catchment in Dehradun. The increase in tourist flows, which lead to increased pollution levels due to the outflows of waste water from catchment areas, sewage disposal and bathing or washing operations close to the river, is one of the main factors that have affected the quality of the stream Sahastradhara. Increased nutrient content was caused by the discharge directly into the Sahastradhara stream of waste water from neighboring areas. In addition, the water of the Sahastradhara is used by households and irrigation systems as well as other commercial sectors whose main impact on water quality in the rivers is hotels located along the river. As a result of this study, the pollution load associated with tourism in Dehradun is found to have increased. Therefore, wastes should be managed and disposed of properly arising from tourism should be taken into consideration to monitor the river Sahastradhara at regular intervals in order to protect it.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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