Original Research Article

Water Quality Assessment of Sahastradhara Stream, Dehradun Region, Uttarakhand

Abstract

Sahastradhara stream, Dehradun is a main attraction of tourist as well as domestic and potable water source of the region and the nearby villages. The stream is being polluted due to various anthropogenic activities and water quality is being deteriorated. During these studies, water samples were collected from the three different Site-I (reference Site), Site-II (more attraction of tourists, highly polluted Site) and Site-III (moderately polluted) for analyzed Physico-chemical parameters of water, viz temperature, pH, transparency, turbidity, DO, BOD, CO_2, alkalinity and chloride. 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-1), pH (6.1-7.2), temperature (25.6^{0}C-27.6^{0}C), transparency (14.1cm-27.5cm), BOD (1.5 mg/l-2.6mg/l), CO_2 (1.5-1.83) followed by S-~~3~~ III (temperature 26.2-27.2^{0}C, transparency 14.1-26.2 cm, pH 7.1-7.2, tur. 79.2-81.1cm, DO 8.1-8.2mg/l, CO_2 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^{0}C, transparency 25.1-27.3cm, pH 7.0-7.1, turbidity 60.2-68.2cm, DO 8.5, CO_2, 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). All the water quality variables varied significantly during the experimental period at 5% level of significance. Anthropogenic disturbances degrade the water quality at impacted Site. The study concludes that water at Site-I of Sahastradhara stream is suitable for human use and other purposes, whereas water at Site-II and Site-III ~~in~~ are unsuitable for all purposes, because of significant change in water quality of Sahastradhara stream due to different touristic activities.

***Key words*-Physico-chemical parameters, Water Quality, Water Pollution, Sahastradhara Stream, anthropogenic activities**

1. Introduction

~~A w~~Water bodies are, any significant accumulation of water, generally on ~~a~~ the planet's surface. The term most often refers to oceans, seas, and lakes, but it includes smaller pools of water such as ponds, wetlands, or more rarely, puddles. A body of water does not have to be still or contained; rivers, streams, canals, and other geographical features where water moves from one place to another are also considered bodies of water. Most are naturally occurring geographical features, but some are artificial. There are types that can be either. For example, most reservoirs are created by engineering dams, but some natural lakes are used as reservoirs. Similarly, most harbors are naturally occurring bays, but some harbors have been created through construction.

Water is essential for the survival of all forms of life found on the earth. Though 80% of the earth's surface is covered by water. India has about 4% of world's freshwater resources ranking it among the top ten water rich countries. India is presently the third largest producer of fish and is playing an important role in global fisheries. The Indian fisheries sector has grown tremendously since 1950s to the present annual production levels of over 7 million tons of fish and shellfish from capture fisheries and aquaculture. India currently produces nearly 5% of the world's total fish production, and about 7% of the total aquaculture production.

Comment [L1]: How many studies were conducted?

Comment [L2]: How do you conclude that the site is already polluted? Any previous report?

Comment [L3]: Source?

Comment [L4]: Be consistent.

Comment [L5]: Really? Your work was only restricted to physicochemical parameters, do you know whether heavy metals, coliform and other organic pollutants are high there? It is too hasty to conclude that it is safe for human use.

Comment [L6]: Really? So fishing, canoe rides and irrigation purposes? I am not too comfortable with your conclusions

Comment [L7]: No single reference?

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The potential for growth is immense and the Country is on the threshold of massive development in fisheries and aquaculture. Rivers are the most important resources in the world in general and in India in particular, great civilization developed along the bank of rivers and even today most of development has taken place in the cities located near the rivers. The rivers provide water for industries, agriculture, and aquaculture, commercial and domestic purpose. Unfortunately the same rivers are being polluted by indiscriminate disposal of sewage and industrial wastes and plethora of human activities. River pollution has already acquired serious dimensions in India. Pollution of rivers first affects its physicochemical quality then systematically destroys the community disrupting the delicate food web. River water quality is of great environmental concern since it is one of the major available fresh water resources for human consumption. [1] Uttrakhand is a state which is known for its hundreds of small and big rivers, holy places situated on the banks of river. Some of these rivers have religious significance in India because of their relevance in Hindu mythology. The sources of these rivers are glaciers of the western Himalayas situated in India, Nepal and the Tibet bordres.These rivers play a vital role in the economical, cultural, social and environmental issues of India. The hydroelectric projects on these rivers are illuminating thousands of homes, but they are also facing the flak from environmental lists for disturbing the ecological balance. These rivers are the backbone of Indian economy, because of their usage for farming, drinking water, electricity, fishing, trading etc. In some parts of Uttrakhand Rivers like Ganga, tons, Yamuna and Kalie are famous for offering a wide variety of water sports. Most of these rivers are clean and less- polluted till the enter in the tarai region. 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 tourist 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. This water is believed to have many medicinal properties that cure many skin ailments. Sahastradhara stream is a major tributary of river Song, 15 Km. far from Dehradun city in Uttrakhand. It has a great importance as a picnic tourist spot of the region, whereas there is not much industrial and agricultural pollution. Hill streams of the area are the cradle of nutrients especially calcium and magnesium in the form of ions. Anthropogenic factors mainly tourist activities and catchments runoff may influence the index of nutrients in stream water. Tourism is one of the world's fastest growing industries as well as the major source of foreign exchange earnings and employment for many developing countries. It has the potential to contribute in a positive manner to socio-economic achievements but, at the same time, its fast and sometimes uncontrolled growth can be the major cause of degradation of the environment and loss of biodiversity. Biological and physical resources are in fact the assets that attract tourists. Dwelling the remote areas in and around the touristic places people have shifted for the unproductive agricultural and pastoral practices to small business related to tourism e.g. small huts stalls have been opened at places where no one could have imagined these facilities [2]. Tourism has identified major sources of environmental stress due to tourists generated activities. The permanent restructuring of the environment brought about by a variety of construction activities and replacement of a natural environment by a new built environment has a variety of far reaching and long lasting result, in term of existing biological species and physical conditions in the area. It may also cause significant changes in the visual amenity. The important environmental impact concern recreational activities, the effect of these activities include soil compaction and erosion, change in plant cover the species diversity [3]. Anthropogenic activities such as urban, industrial and agriculture as well as natural processes, such as precipitation inputs, erosion and weathering of crystal materials affect river water quality and determine its use for various purposes

The fresh water supply has increasingly become a limiting factor because of various reasons. The expansion of industrialization and exploding population are the major once. Acute shortfall of heavy rains, poor watershed management, abundant use of water for household and agricultural and hotel purposes have led to the overexploitation of the surface water sources especially from the river bodies. Many perpetual rivers become short-lived and even dried up. Water quality characteristics of aquatic environments arise from a massive amount of physical, chemical and biological interactions. The water bodies: rivers, lakes and estuaries are continuously subjected to a dynamic state of change with respect to their geological age and geo chemical characteristics. This dynamic balance in the aquatic ecosystem is upset by human activities results in pollution, which manifests dramatically changes in physico-chemical parameters of water as fish kill, bad taste of drinking water, offensive odors and unchecked growth of aquatic weeds, etc. Quality of water is now a great concern for environmentalists as well as the common publics in all parts of the world. There are numerous sources of pollutants that could deteriorate the quality of water resources Likewise, in Sahastradhara Dehradun, a famous tourist place where there is no as such environmental protection practice, there are number of pollutant sources that continuously deteriorate the quality of surface water. The following hazard centers may be considered as major category of sources of pollutants in the study area. These are Hotel establishment, agricultural activities, municipal wastes, parking stations for buses and small vehicles. The wastes finally enter into the water bodies and deteriorate the quality of water. On the other hand, surface water bodies become the dumping source for industrial effluent and domestic wastes. As a result, the naturally existing dynamic equilibrium among the environmental segments get affected, leading to the state of polluted rivers [4].

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. The contamination of fresh waters with a wide range of heavy metals released from domestic, industrial and other man made activities has become a matter of concern over the last few decades, which may have devastating effects on water quality, ecological balance of the recipient environment and a diversity of aquatic organisms. In view of the limited stock of freshwater worldwide and the role that anthropogenic activities play in the deterioration of water quality, the protection of these water resources has been given top most priority in the 21st century [5]. According to World Health Organization's [6]. water for the consumers should be free from pathogenic organisms and toxic substances. In spite of vast water resources in lakes and rivers and good monsoon, Sahastradhara and the nearby villages faces perennial problems of water shortage and droughts and high pollution of fresh water resources. It is a fact that good water quality produces healthier humans than one with poor water quality. Baldi River is life line of Sahastradhara as a tourist spot and a major source of income for the local people and the people who depot their business in this Area and its water is used for domestic and agriculture purposes. Therefore, effective maintenance of water quality is required through appropriate measurements. Physico-chemical and micro-biological characteristics may describe the quality of water. Therefore, the present study was focus on various physic-chemical water parameters (Temperature, Transparency, and Dissolved Oxygen (DO), Carbon di oxide CO_2, pH, Turbidity, chloride and BOD three different. However, living organisms such as fish also be noticed for the detection of water pollution changes in their behavior in Baldi River of Sahastradhara region. Of all the Earth's ecosystems, rivers are the most dynamic having as their primary functions the transportation of water. Rivers and their landscapes are complex ecosystems that can be seen as an interaction between five main components: physical habitat, flow regime, the energy or food base of the system, biological interactions and water quality. All contribute to the maintenance of the biological or ecological integrity of the system which refers to the capacity to support and maintain a balanced, integrated, and adaptive biological system having the full range of elements and processes expected in a region's natural habitat. River pollution becomes apparent at times during accidents through horrifying scenes of dead fish floating on the surface of water. But more often, it exists as chronic and insidious pollution originating from different human activities. Pollution causes a general deterioration in the state of health of rivers across the entire planet. The growing problem of river

pollution has necessitated the monitoring of the Water quality of the river in different states of our country to restore the waste quality [7].

Comment [L9]: Not grammatically well expressed. Scanty references and incomplete sentences. Authors need to engage an English editor for articulate and comprehensive article.

Methods

2.Objective of the Study:

1- To study the physical parameters of water of Sahastradhara stream in Dehradun region during the experiment.

2-To study the chemical parameters of water of Sahastradhara stream in Dehradun region during the experiment

Comment [L10]: These are supposed to be merged with introduction, not under methodology

3.Material and methods

Study area:

The present study was carried out on Sahastradhara stream in Dehradun strict, of Uttrakhand. Sahastradhara (meaning ~~thousand fold~~thousand-fold springs), is one of the most popular tourist destinations located in Dehradun in Uttrakhand ~~state~~ State of India. It lies on 30.39 latitude and 78.14 longitudes. The place has magnificent beauty of nature where water drips from the limestone stalactites, making the water abundant in sulphur and thus the place is known for its sulphur springs. It is sulphur water spring of relatively lower temperature than its surroundings. It is a warehouse of excellent beauty of caves, waterfalls and terrace farming on steppe by the local people. Its magnificent nature attracts people from faraway places. It rejuvenates the soul and mind. This place is at about 11 km from the city of Dehradun.

3.2 Sampling area:

The present study was conducted on the famous sulphur stream 'Sahastradhara' at Dehradun district during March 2018 to April, 2018. The water samples were collected between 10.00 and 12.00 hrs. From three each different Sites of Sahastradhara stream fortnightly**. (Plate-1)**

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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

Comment [L12]: Not comfortable with your description of sites. You can only describe them based on activities going on there, not pollution at this level.

3.3 Sample collection:

Samples were collected between 10.00 and 12.00 hours from each of the three sampling Sites, fortnightly and placed in sampling bottles for further analysis. Physical parameters analyzed directly on the Site while chemical parameters of water analyzed in laboratory of fisheries ~~department~~ Department of Doon (P.G.) College of ~~agriculture~~ Agriculture ~~science~~ Science and ~~technology~~ Technology Selaqui Dehradun-. Analysis of chemical parameters ~~has been~~were done as per the standard method prescribed ~~in to~~for analyses ~~the~~ of water samples [8]. **(Plate-2)**

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3.4. Measurement of ~~physical~~ Physical ~~parameter~~ Parameters of ~~water~~ Water ~~sample~~Samples:

3.4.1-Measurement of Temperature- The water temperature ~~is usually~~was measured with the mercury filled centigrade thermometer. **(Plate-3)**

Materials

Precision thermometer, 0-50^{0}c or any electronic temperature meter with a probe.

Both centigrade (Celsius) or Fahrenheit thermometers can be employed for recording the water temperature.

Calculation

To find degree ^{0}C, substract 32 from degree ^{0}F and divide by 1.8 and add 32 or use the following formula for conversion:

C/5=F-32/9

3.4.2- measurement of transparency: Transparency was measured with the help of Secchi Disc Materials. Secchi Disc is a metallic disc with black and white markings. **(Plate-4)**

Procedure:

I) Slowly lower the disk into the water until it just disappears- note this depth-A.

II) Lower the disk somewhat further, then slowly raise it until it reappears-note the depth-B.

Calculation

Average value of two readings is taken for the final Secchi disk visibility.

A+B

3.4.3-measurement of pH:

pH was measure with the help of pH strips**. (Plate-5)**

Procedure:

Take a 5ml of water sample in each test tube (in replicate of two). Add 2 drops of universal indicator in each tube, shake gently. Wait for two minutes. Match the color developed in the sample with the standard color chart provided with the indicator bottle. Record the corresponding pH value. Universal indicator are commercially available.

3.4.4- measurement of turbidity-

High purity water will cause some light scattering, which is detected by nephelometers as turbity.

Procedure: Calibrate nephelometers with the Turbidity standard of 100 NTU. Run at least one standard in each instrument range to be used. Gently agitate the sample. Wait until air bubbles disappear and pour sample into cell. Read turbidity directly from instrument display. Dilute the sample if turbidity goes above 40 NTU and apply dilution factor.

Calculations

Turbidity (NTU) = Turbidity of Diluted Sample x Dilution factor

3.5- measurement of chemical parameters of water-

3.5.1- measurement of O_2 (Dissolved oxygen)

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Dissolved oxygen is one of the most important parameters in water quality assessment and reflects the physical and biological process prevailing in water**.**

Materials.

I) Manganous sulphate solution
(dissolve 182g of $MnSO_4$ in distilled water, filter and make the volume up to 500ml- solution A)

II) Alkaline iodide- azide solution.
a) Dissolve separately 350g KOH and 75g KI in distilled water. Mix the solution and make the volume up to 500ml.
b) Dissolve 5g sodium azide (NaN_3) in 20ml distilled water mix solution a and b
solution- B

III) Sodium thiosulphate titrant 0.025N.
(Dissolve 6.205g of $Na_2 S_2 O_3$ in distilled water make the volume to 1 liter by adding Distilled water.

IV) Starch indicator 1%
(1g of starch in 100 ml of warm (80-90^{0}c) distilled water.

v) Sulphuric acid concentration (Sp. Gr. 1.84)

Procedure:

Collect the water sample in 250ml stoppered bottles, avoiding entrapping of air bubbles. Keep the bottles submerged in water. Remove the stopper and dispense 2ml each of manganous sulphate (solution A) and alkaline iodide- azide solutions (B) one after the other, by keeping the pipettes well below the surface of water. Replace the stopper and shake the contents well by inverting the bottles. Dissolve oxygen present in the water gets precipitated in the form of yellowish brown precipitates. Allow the precipitates to settle. Dissolve the precipitates by adding 2ml of conc. H_2SO_4 and shake the stoppered bottle.

For estimation of DO, take a suitable aliquot (50ml) in a flask and titrate against sodium thio- sulphate solution till the color changes to pale straw. Add 2 drops of starch solution (freshly prepared) and titrate further till the blue color disappears. Note the amount of titrant used.

(Plate-6)

calculations

$$\textbf{DO in mg } 1^{-1} = \frac{8 \times 1000 \times N\ (0.025) \times V^*}{V}$$

Where,

V^* = volume of water sample taken (ml).

V = volume of titrant (sodium thiosulphate) used (ml).

N = normality of the titrant.

3.5.2- measurement of CO_2-(dissolved carbon dioxide)

Materials.

i) sodium hydroxide titrant 0.02N (0.909g NaOH in one L of CO_2 free distilled water)

ii) Phenolphthalein indicator
(0.5g of phenolphthalein in 150 ml of ethanol (95%) and 50ml of distilled water. Add to it 0.02N NaOH drop wise until faint pink color appears).

Procedure:

Add 2 drops of phenolphthalein indicator in a 50ml of water sample (if slight pink color develops then free-carbon-di-oxide is absent). If the solution remains colorless, titrate using NaOH (0.02N) until a slight pink color appears. Record the end point.**(Plate-7)**

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Calculation:

$$\text{Free } C0_2 \text{ mg } 1^{-1} = \frac{\text{ml of titrant used} \times 1000}{\text{ml of sample taken}}$$

3.5.3- Measurement of Alkalinity

Reagents-

I) Sulphuric acid titrant 0.02N

(dilute 2.8ml of conc. H_2SO_4 to 1 liter-solution-A. take 200 ml of solution-A and dilute to I liter).

ii) Phenolphthalein indicator.

(0.05g of phenolphthalein in 50 ml of 95% ethanol and 50ml of distilled water. Add to it 0.02N NaOH drop wise until faint pink color appears)

iii) Methyl orange indicator

(0.01g of methyl orange in 200 ml of distilled water)

Procedure-

- take 50ml of water sample in Erlenmeyer flask and add 2 drops of phenolphthalein indicator.

If the color changes to pink, titrate it with 0.02N H_2SO_4, until the color disappears. Note the end point-A. This is phenolphthalein carbonate alkalinity. (if the solution remains colorless on the addition of phenolphthalein indicator, phenolphthalein alkalinity i.e., carbonates are absent).

Now add 2-3 drops, of methyl orange to the same sample and continue to titrate till the color from yellow to orange. Note the amount of titrant used-"B". this is total alkalinity.(Plate-3.5.3)

Calculations-

Phenolphthalein alkalinity mg^{-1} = ml of titrant 'A'/ml of sample x1000

Total alkalinity mg^{-1} = ml of titrant 'B'/ml of sample x1000

3.5.4- Measurement of BOD (biological oxygen demand)-

Regents.

I) Sodium thiosulphate solution (0.025N)
II) Managanous thiosulphatesolution
III) Alkaline iodide azide solution
IV) Starch indicator

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V) Dilution water
(Prepared by bubbling compressed air in distilled water for about 1h. Add 1 ml each of magnesium sulphate 8.25%, anhydrous calcium chloride 2.75%, Ferric chloride 0. 025% and phosphate buffer to one liter of dilution water and mix thoroughly).

vi) Phosphate buffer (dissolve 8.5g KH_2PO_4, 21.75g K_2HPO_4 and 1.70g NH_4

CL in distilled water. Make the volume to 1 liter by adding more distilled

Water. Adjust pH to 7.2)

Procedure: As soon as the water samples are brought to the laboratory, prepare different dilutions of the unfiltered water samples in BOD bottles (300ml capacity) by adding dilution water. Prepare two sets of each dilution. Determine initial dissolved oxygen in the first set of BOD bottles and keep the second set for incubation in BOD incubator at 20^0C for five days. After five days, remove the bottles from the BOD indicator and determine DO from the incubated set bottles and note the readings.

Calculations.

BOD_5 I mg$1_{.1}$ = (D_1 –D_5) X dilution factor

D_1 = initial DO in the sample (mg1^{-1})

D_5 = DO after days of incubation (mg1^{-1})

3.5.5- measurement of chloride-
Procedure:
Add five drops of potassium chromate indicator to 50ml of water sample in a conical flask. This gives yellow color. Titrate the contents against 0.014N $AgNO_3$ until a brick red color appears. Note the end point.

Materials.

i) Silver nitrate titrant **,** 0.014N

(Dissolve 2. 39g of $AgNO_3$ in some distilled water and make the volume to 1 liter

_ Store in a dark bottle)

ii) Potassium chromate indicator, 5%
(Dissolve 5g of K_2CrO_4 in 100 ml of distilled water)

Calculations

ml of titrant used x N x 35.5 x 1000
Chloride in mg 1^{-1} =ml of sample (50ml)

N = normality of the titrant

3.4.6 -sStastical ~~method~~ Analysis

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Comment [L16]: Please, compress the procedures and make them brief. Just mentioned the instrument used and refer the details procedure to previous reports or manuals (references)

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The data recorded for physiochemical parameters of water samples were presented as mean values and analyzed using descriptive analysis. To evaluate significant differences among the Sites for all water quality variables, data was analyzed using one- way analysis of variance (ANOVA) at 0.05% level of significance.

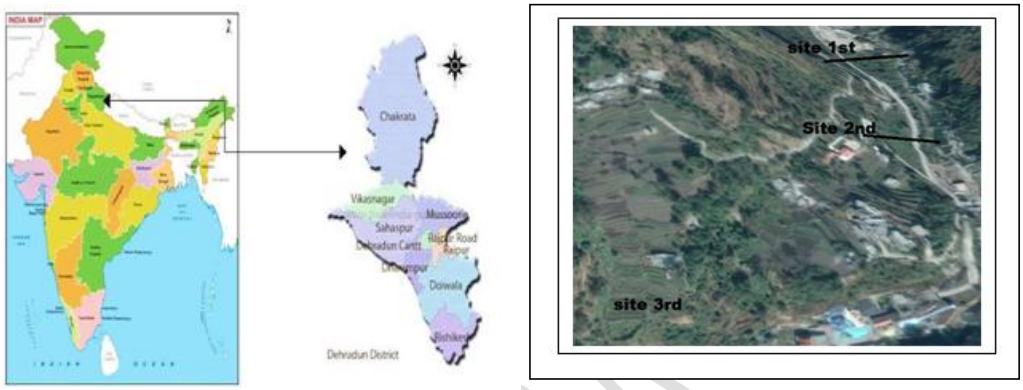
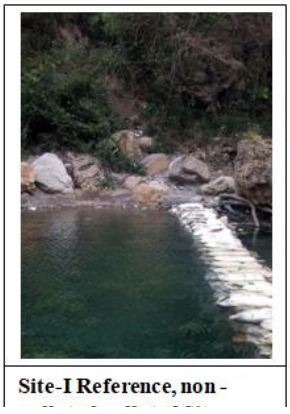


Plate-1 Map showing Sahastradhara stream in Dehradun region, India



Site-I Reference, non - polluted polluted Site

Site-II highly polluted Site

Site-III Moderately

Plate-2 Sampling Site of Sahastradhara stream in Dehradun region

Plate-3 Collection of samples from three different Site

Plate-4 Measurement of temperature

Plate-5 Measurement of transparency

Plate-6 Estimation of dissolved oxygen

Plate-7. Examine the collected samples in laboratory

4. RESULTS AND DISCUSSION

4.1- Observation of physical parameters of sampling water.

4.1.1- Observation of temperature: Among the physical parameters temperature is one of the most important environmental parameter feels the moment touches the water. Temperature is an important parameter which not only impacts the external behavior of living organisms, but also influences the internal physic- chemical processes. Some organisms, particularly aquatic animals flourish in warmer temperature. Temperature sets the pace of metabolism by controlling molecular dynamics (difusibility, solubility, ~~fluidity)and~~fluidity) and rate of biochemical reaction. Temperature partly determines in water. Oxygen solubility decreases with increased temperature, and so O_2 concentrations are usually lower in summer. The average value of temperature fluctuated between minimum and maximum ranges 25.9^{0}C and 27.3^{0}C at the Site Iand Site-II and moderate 26.6^{0}C at Site-III respectively. During the experiment the water quality variables of all the Sites were significantly different to each other at 5% level of significance.

Comment [L17]: This is not result, literature review.

Table-2 Observation of temperature during throughout the experimental period

Site area	Temperature (Ave)	Standard error (±)
Site-I	25.9	0.05
Site-II	27.3	0.08
Site-III	26.6	0.05

Comment [L18]: This Table format is not scientific. Also provide unit of measurement for the temperature.

Figure-1Forth nightly fluctuation in temperature of three different Site

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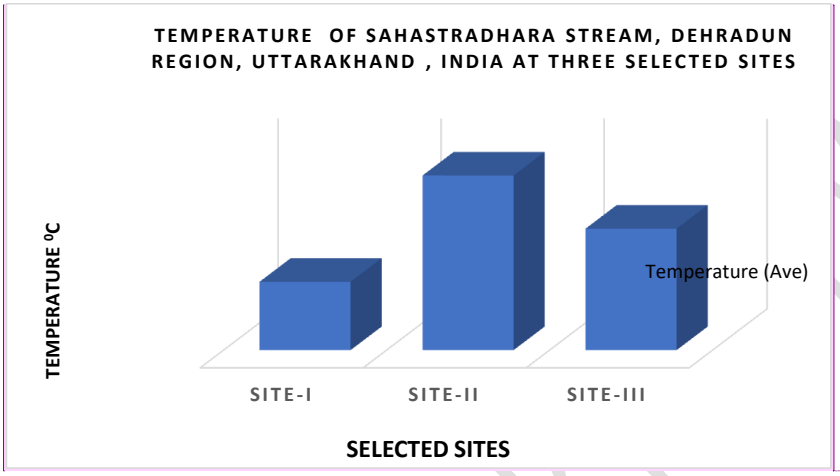

Comment [L19]: You cannot repeat same data in different format. You have already presented this in the previous Table, no need for this graph. Also, the graph is not calibrated, no figures.

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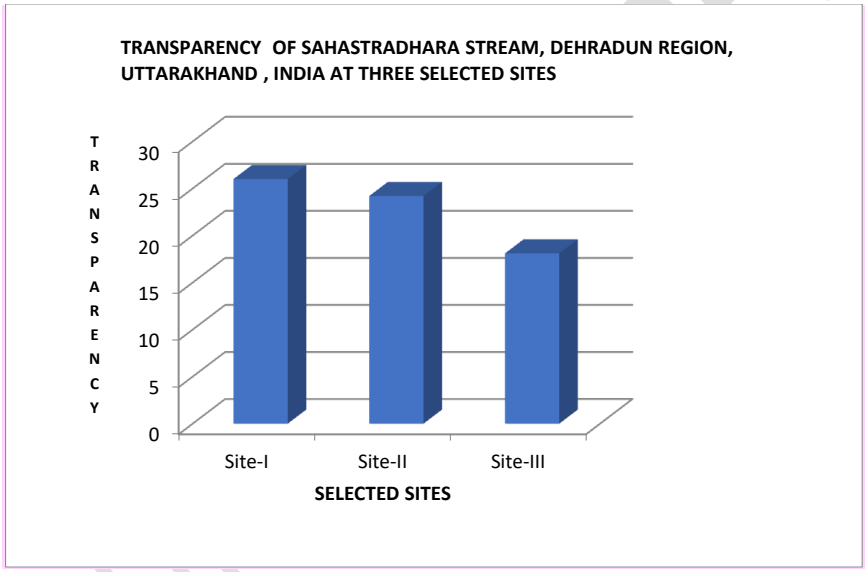
Table-3 observation of transparency during throughout the experimental period

Site area	Transparency (Ave)	Standard error(±)
Site-I	26.0	0.5
Site-II	24.2	0.8
Site-III	18.1	0.1

Figure-2 Fourth nightly fluctuation in transparency of the different Site



4.1.2- observation of pH-It is a measure of hydrogen ion concentration in water and indicates how much acidic or basic the water is. The pH scale ranges from 0-14 with 7 as neutral. When there are more

hydrogen ions (H^+) present the pH will be lower than 7 and the water will be acidic. Water is basic (alkaline) when there are more hydroxyl ions (OH^-). Water pH affects metabolism and physiological process of aquatic organisms. During the present study the overall maximum and minimum value of pH were observed 7.2 and 6.3 in the month of March to April at the Site-III, Site-II and moderate at Site III respectively. All the water quality variables were significantly different to each other during the experimental period. @ 5% level of significance.

Table-4 Observation of pH during throughout the experimental period.

Site area	pH (Ave)	Standard error(±)
Site-I	7.1	0.5
Site-II	6.3	0.5
Site-III	7.1	0.5

Figure-3: Forth nightly fluctuation in pH of three different Site

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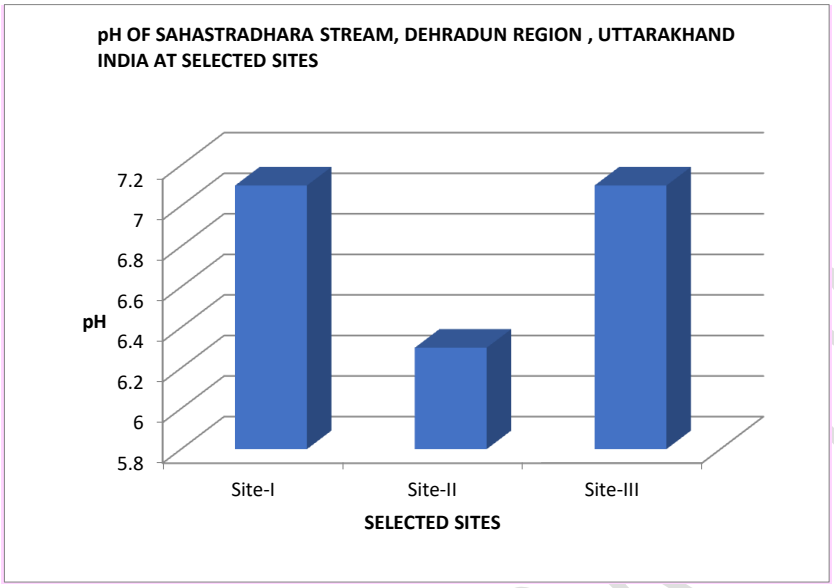

4.1.4-Obervation of turbidity. It is a very general term that describes cloudiness or muddiness of water. The Turbidity of any water sample is the reduction of transparency due to the presence of particulate matter such as lay or slit, finely divided organic matter, plankton and other microscopic organisms. During the present study the maximum and minimum value of turbidity were observed 80.16 NTU and 58.1 NTU in the Site-I and Site-II, respectively and moderate at Site-III (79.8) All the water quality variables were significantly different to each other during the experimental period.@ 5% level of significance.

Table-5 Observation of turbidity during throughout the experimental period.

Site area	Turbidity (Ave)	Standard error(±)
Site-I	64.3	0.01
Site-II	58.9	0.02
Site-III	79.8	0.01

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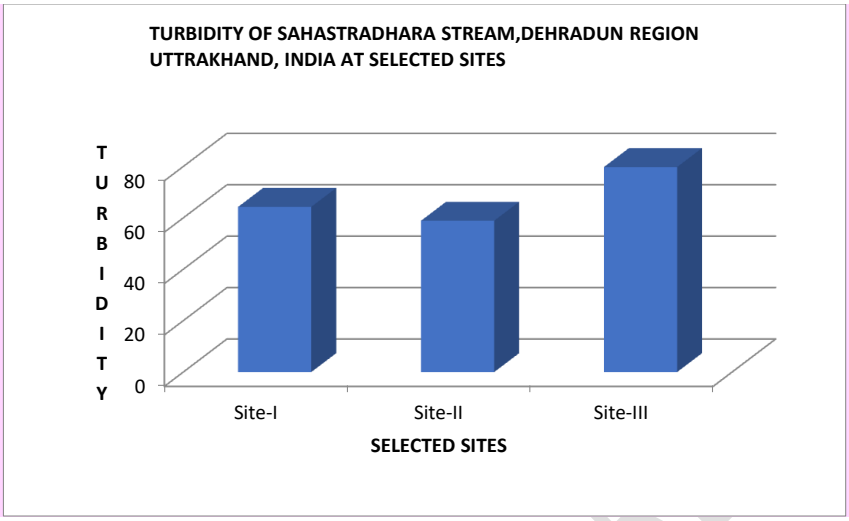
Fig: 4- Fortnightly fluctuation in turbidity 0f the different Site



4.2- observation of chemical parameters of sample water-

4.2.1- observation of dissolved oxygen (DO). Dissolved oxygen refers to microscopic bubbles of gaseous oxygen (o_2) that are mixed in water and available to aquatic organisms for respiration. It is a critical process for almost all organisms. Oxygen enters water through photosynthesis by aquatic plants, principally phytoplankton, and by diffusion at the air-water interface. In the present study the lowest and highest mean value of dissolved oxygen were observed 7.2mg/l and 8.5mg/l at the Site-II and Site-I and respectively. While moderate at Site-III (7.3) DO show negative correlation with temperature. All the water quality variables were significantly different to each other during the experimental period.@ 5% level of significance.

Table-6 Observation of DO during throughout the experimental period

Site area	Dissolved oxygen(Ave)	Standard error(±)
Site-I	8.4	0.08
Site-II	7.3	0.02
Site-III	7.8	0.08

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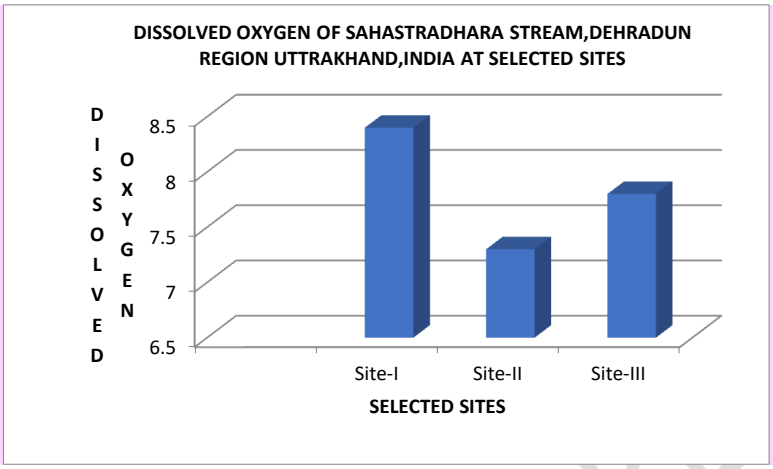
Figure-5 Fortnight fluctuation of DO of the different Site



4.2.2- observation of dissolved carbon dioxide. Carbon dioxide is present in water in the form of a dissolved gas. Surface waters normally contain less than 10 ppm free carbon dioxide, while some ground waters may easily exceed that concentration. Carbon dioxide is readily soluble in water. In the present study the lowest and highest mean values of dissolved carbon dioxide were observed 1.83mg/l and 1.53mg/l at the Site-II (1.82) and Site-I (1.58), respectively. While moderate at Site-III The value of all Sites were significantly different to each other. During the experimental period. @ 5% level of significance.

Table-7 observation of CO_2 during throughout the experimental period.

Study area	CO_2(Ave)	Standard error(±)
Site-I	1.58	0.01
Site-II	1.82	0.02
Site-III	1.76	0.01

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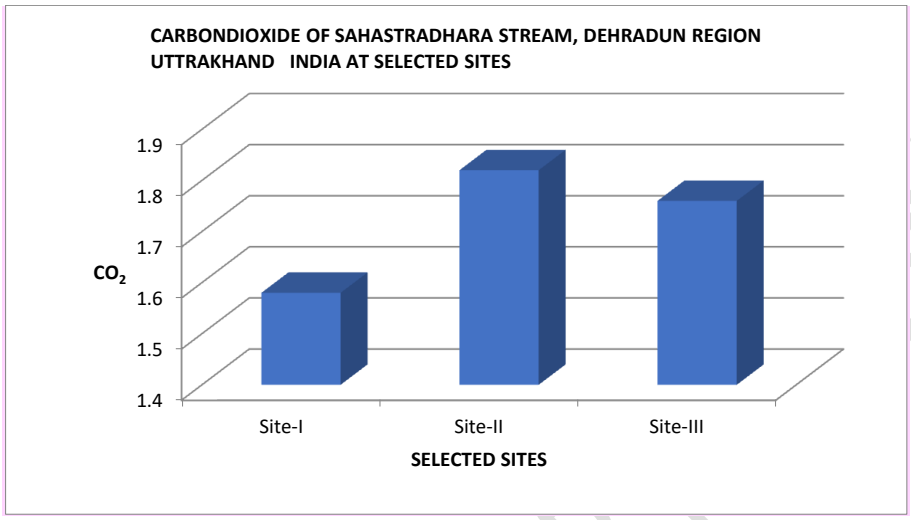
Figure-6 fourth night fluctuation in CO_2 of different Site



4.2.3- observation of BOD. Biological oxygen demand (BOD) refers to the amount of dissolved oxygen (DO) that aerobic organisms need in order to break down organic material in water over time. During the present study the overall lowest and highest mean value of bio-chemical oxygen demand were observed 1.5mg/l and 2.6 mg/l at the Site-I and Site-II, while moderate at Site-III (2.2) respectively. All the water quality variables were significantly different to each other during the experimental period.@ 5% level of significance.

Table-8 Observation of BOD during throughout the experimental period

Site area	BOD(Ave)	Standard error(±)
Site-I	1.52	0.5
Site-II	2.37	0.5
Site-III	2.2	0.5

Figure-7 Fortnightly fluctuation in BOD of different Site

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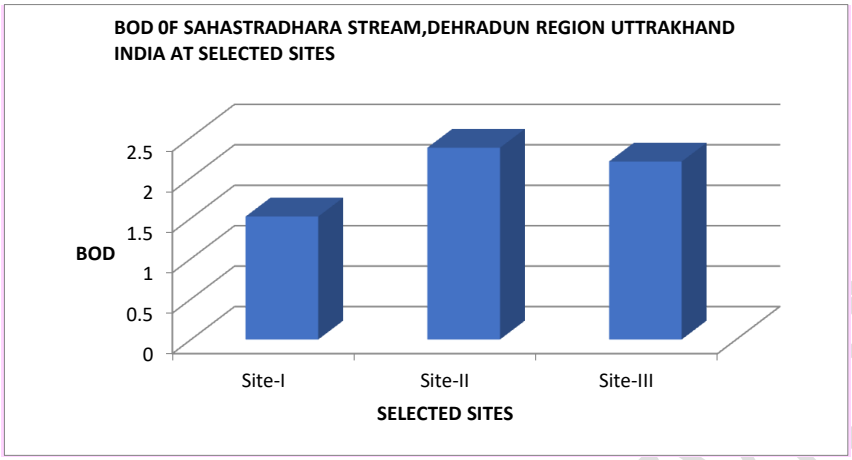

4.2.4- observation of alkalinity. Alkalinity is the capacity of water to resist changes in pH that would make the water more acidic (It should not be confused with basicity which is an absolute measurement on the pH scale.) Alkalinity is the strength of a buffer solution composed of weak acids and their conjugate bases conjugate basesit is measured by titrating the solution with a monoprotic acid such as HCL until its pH changes abruptly, or it reaches a known endpoint where that happens. Alkalinity is expressed in units of meq/L (mili equivalents per liter) which corresponds to the amount of monoprotic acid added as a titrant in millimoles per liter. During the present study the overall lowest and highest mean value of pH were observed 250mg/l and 308.1 mg/l at the Site-I and Site-II while moderate at Site-III (260.0) respectively .All the water quality variables were significantly different to each other during the experimental period.@ 5% level of significance.

Table-9 Observation of alkalinity during throughout the study period

Site area	Alkalinity(Ave)	Standard error(±)
Site-I	250.7	0.1
Site-II	302.9	0.05
Site-III	260.0	0.3

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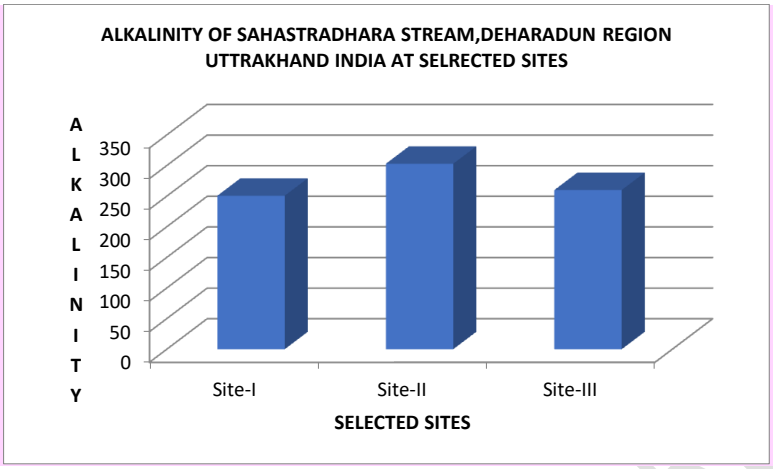
Figure-8 fourth night fluctuation of alkalinity of the different Site



4.2.5- observation of chloride. Chlorine is a highly efficient disinfectant, and is added to public water supplies to kill disease-causing pathogens, such as bacteria, viruses, and protozoans, that commonly grow in water supply reservoirs, on the walls of water mains and in storage tanks. Chlorides concentration is an important ion required by photosynthesizing cells. The water from human excreta is rich in chlorides. Human body discharge about 8.0gm to 15.0gm chloride per day. Therefore chlorides concentration serves as an indicator of pollution. During the present study the overall lowest and highest mean value of chlorides were observed 30.2mg/l at the Site-I Site-II and moderate at Site-III(32.0), respectively .All the water quality variables were significantly different to each other during the experimental period.@ 5% level of significance.

Table-10-observation of chloride during throughout the experimental period.

Study area	Chloride(Ave)	Standard error(±)
Site-I	30.2	0.1
Site-II	30.6	0.05
Site-III	32.0	0.05

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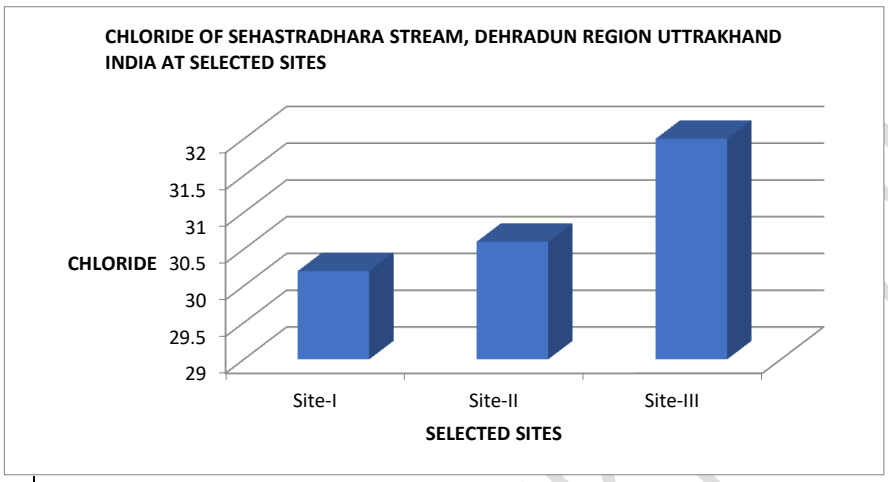

Figure-9 Fourth night fluctuation of chlorine of the experimental period.

Comment [L20]: The data in this article can be presented In a single Table. But where you feel it will make your work too scanty, you can present them in appropriate figures, with those parameters with same measuring units in one figure while others can appear separately.

The pollutants ~~in~~to an aquatic system can set off a complicated series of biological and chemical reactions. In order to understand how and why these reactions occur and to successfully manage any ecosystem, a sound knowledge of the structure and basic functioning of that system is vital. The results obtained for this study made from March 2018 to April, 2018, at three selected Sites namely, Site-I, Site-II and Site-III on Sahastradhara ~~river~~ River Dehradun. A total of nine physico-chemical parameters were examined to findings of water quality assessment are represented in table-1-table-10 respectively

.In the present study water temperature fluctuated between the minimum25.6^{0}c and maximum 27.6^{0}c.Minimumtemperature was recorded 25.6^{0}c at Site-I whereas the maximum temperature recorded was 27.6^{0}c in at Site-2nd. Among the three selected Sites the Site-II, has been treated as reference Site, recorded that normally there are no touristic activities but where 98% of tourists come at Site- II this Site is the point of main action. This may be due to change in air temperature, which naturally affects the water tempera-ture and cause thermal variations in water [9]. reported minimum air temperature was recorded in the month of January, with the lowest recorded temperature as (2.12oC) at Site A, while as the maximum in the month of July, with the highest 35.42oC at Site C. Overall the temperature was high in summer and low in winter on an average. There was a moderate increase in temperature while moving downstream of the Sahastradhara river.

Transparency has direct bearing on the light penetration of water and depends upon suspended matter and dissolved colored substances including sewage. In the present study the transparency ranged between 14.6 cm to 27.5 cm. The minimum transparency was recorded 14.6 cm in at Site-II and maximum transparency was recorded 27.5cm at Site-III in river Dehradun. Considerable Fluctuations in transparency

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were found throughout the study period, transparency relatively low due to the touristic activities at Site-II and transparency of Site-I and Site-II is moderate, because there was no pollution in these two Sites at Sahastradhara stream. Approximately similar result for transparency [10]. observed minimum 14.9 whereas maximum was 27.5 cm in April 2018 at Site-II and Site-I respectively at Bariaghat in river Chambal.

pH plays a critical role in the chemistry of rivers. The pH of water affects the solubility of many toxic and nutritive chemicals; therefore, the availability of these substances to aquatic organisms is affected. As acidity increases, most metals become more water soluble and more toxic. During the present study gradual increase (7.5-7.6) in pH from Site (I-III) was related to increasing pollution pressure resulting, because of tourist activities in the catchment of Sahastradhara stream at Dehradun valley. A similar result for pH (7.5-7.8) at down streams SII and SIII, was recorded by [11]. in the water of s River Ganga at Kanpur (India) at intervals of one month for the year 1977 due to the effect of touristic activity.

Comment [L21]: How do the tourists introduce pollutants into the water body?

Comment [L22]: Too old.

The Turbidity of any water sample is the reduction of transparency due to the presence of particulate matter such as lay or slit, finely divided organic matter, plankton and other microscopic organisms. During the present study the overall lowest and highest mean value of turbidity was observed 58.1NTU and 81.1 NTU at the Site-II and Site-III, respectively. The maximum relative difference (200%) was found in turbidity at Site-II because of touristic activities on Sahastradhara river Similarly, [12]. reported high turbidity at the downstream (SITE-II and SITE-III) in the Ganga River due to anthropogenic activities which may lead to serious water quality pollution earlier described by the number of patient were raised due to water borne diseases at touristic place due to touristic activities. Oxygen is the regulator of metabolic processes of plant and animal communities and indicator of water condition. The oxygen is most important gas, produced during photo-synthesis by the phytoplankton in aquatic environment. During the present study minimum mean DO value (7.2 mg/L) was recorded at Site- II, while as maximum mean DO value (8.5 mg/L) was recorded at Site I. In the present study DO reduces in SII because of anthropogenic activities. In Site-II it may be due to huge amount of organic matter being released by the touristic activities in river in the form of polythene plastic bottles, rappers of synthetic items in Sahastradhara stream ,as compared to Site-I and SIII, were there is no pollution in Site-I and Site-III respectively, because there was no anthropogenic activities on these two Sites. Similarly [13]. reported the value of (DO 8.05 mg/1) at Site-B during the month of January for river Yamuna.

Carbon dioxide (CO_2) enters in water from the atmosphere at the air-water interface and is naturally present in solution as a by-product of metabolism in the present study the free carbon dioxide values ranged between 1.55 to 1.83 mgl^{-1}. The minimum carbon dioxide was recorded 1.55 mgl^{-1}in at Site-I, whereas the maximum of 1.83 mgl^{-1} at Site-II. The free Carbon dioxide of water increased along downstream of the Sahastradhara river, Considerable fluctuations were found throughout the study period, because of anthropogenic activities of Sahastradhara stream Similarly [14]. Reported the value of (CO_2 1.87-1.95 MG/L^{-1}) at Site-III and Site-II on the river Ram Ganga

Biochemical oxygen demand (BOD) is used to measure the amount of organic material of an aquatic system which supports the growth of microorganism. In fact, BOD is indirect assessment of biodegradable material present in the water. Biochemical oxygen demand (BOD) determination is still the best available test for assessing organic pollution. In the present study a Site-I, the minimum mean value of BOD (1.5 mg/L) was recorded, whereas maximum mean value of (2.6 mg/L) was recorded at Site-II during study period at Sahastradhara stream, considerable fluctuations were found throughout the study period, because of touristic activities in Sahastradhara stream. Similarly [15]. reported the value of BOD (2.8-3.5 mg/l) during the month of January along the down streams (SITE-III and SITE-IV)of Narmada River.

Alkalinity is an important parameter in determining the quality of water which ultimately determines the biotic composition of the systems Alkalinity is the capacity to neutralize acids, and the alkalinity of natural water is

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derived principally from the salts of weak acids. Hydroxide carbonates, and bicarbonates are the dominant source of natural alkalinity. Reactions of carbon dioxide with calcium or magnesium carbonate in the soil create considerable amounts of bicarbonates in the soil. Organic acids such as humic acid also form salts that increase alkalinity. In the present study the alkalinity ranged between 245 to 308.2 mgl-1, minimum alkalinity values was recorded 245 mgl^{-1}in at Site-I whereas the maximum of 308.2 mgl^{-1} at Site-2. Considerable fluctuations were found throughout the study period because of anthropogenic activities in Sahastradhara stream Dehradun. Similarly [16] reported the value of alkalinity (98-248mg/$l^{-1)}$at Site-I and Site-II respectively, in water quality of river Ganga at Kanpur city during July 2002 and June 2004.

Chloride is one of the major inorganic anions in water. The chloride content in river water comes at Site mainly from the sediments and from sewage drains, trade and industrial effluents, if present unpolluted rivers in the present study the chloride ranged between 30.2 to 37.2mgl-1. The minimum chloride value recorded 32.2 mgl-1 in at Site-I whereas maximum of 37.2 mgl-1 at Site-II. Considerable fluctuations were found throughout the study period, because of touristic activities of Sahastradhara river Similarly [17] reported the value of chloride (32-38.5 mgl^{-1}) at SITE-IV and SITE-III of Lumding Town of Assam

4- Summary and Conclusion:

The present study concluded that touristic activities in the catchment of Sahastradhara stream Dehradun have deteriorated the water quality. From the analysis and discussion of the results, it is concluded that the main reasons for the deterioration of the water quality of Sahastradhara stream are increase in tourist flow, which increases the concentration of pollutants, due to sewage disposal, bathing and washing in the vicinity of the stream. This information has been depicted by the Physico-chemical characteristics of the stream. All the findings of the present work are summarized below:

Comment [L23]: Really? How does increase in tourists flow impact the water? Do the tourist urinate, defaecate or introduce some pollutants into the water?

- Temperature was recorded minimum at Site-I (25.6), because this Site was a reference Site and it was recorded as non-polluted Site and maximum at Site-II (27.6), because this Site was more polluted, due to touristic activities whereas, Site-III was recorded moderately polluted than Site-II and the pollutants of Site-II may be transferred to Site-III during study period.
- pH was recorded normal at Site-I (7.0), acidic in Site-II(6.3), because of pollution due anthropogenic activities, whereas in Site-II I(6.4) pH was slightly acidic, due to presence of pollutants in least concentration.
- The data was present study reflect that a relative comparison in transparency showed wide variation in water quality, during the present study the lowest and highest mean value of transparency observed (22.5),(25.4) and (15.36) at the Site-II, Site-III and Site-I respectively, during the present study the transparency was low range in Site-II, due to touristic activities, and transparency was normal range in Site-I and Site-II, were there is no pollution at Site-I and moderate pollution at Site-III respectively.
- During the study period, turbidity was less found at Site-I(64.3),while as maximum turbidity was found at Site-I I(79.8), while moderate at Site-III(58.3)
- DO was recorded normal at Site- I(8.5), while DO was decreased at Site-II (7.5) and moderate at Site-III (8.2),during study period
- CO_2 was recorded minimum at Site-I (1.55), because this Site was a non- polluted Site, and maximum at Site-II(1.82), because this Site was more polluted, due to touristic activities and moderate at sit-II I(1.62), during study period.
- During the study period, alkalinity was moderate at Site- I(250.7) and Site-III 260.5, because there was no pollution in these two Site, while , alkalinity was maximum at Site-II(302.9), due to high pollution.

- BOD was recorded normal at Site-I (1.52) and showed wide variation at Site-II (2.37), because of touristic activities while moderate at Site-III (2.2, during the study period.
- During the study period, chlorine was recorded at normal at Site-I (30.2), because this Site was a reference Site, and it was recorded as non-polluted, and maximum at Site-II (36.6) –because this Site was more polluted due to touristic activities, while moderate at Site-III (32.0).

Comment [L24]: This summary may not be necessary in journal article, conclusion captures everything.

The Physico-chemical analysis shows variations in most of the water quality parameters such as pH changes gradually where-as CO2, BOD, Cl- increased, while DO decreased. Due to the increased concentrations of pollutants because of anthropogenic factors mainly touristic activities and catchments runoff may influence the water quality index of stream. During the study period the Site-I was seemed to be unpolluted, because of no interference of any human activity, while Site-II was more polluted, because of pollution load due to tourism increased day by day and about Site-III which was being moderately polluted may be by the flow of water from Site-II respectively Low water quality index of the stream is altering and negatively deteriorating the distribution of aquatic flora and fauna therein. The direct disposal of sewage from the nearby areas into the Sahastradhara stream has increased the nutrient load. Due to higher nutrient enhancement, reduction in the DO content has been observed. The water of Sahastradhara stream serves domestic, irrigation and other commercial sectors (including hotels at Sahastradhara) which have a directly impact on the water quality of Sahastradhara stream. It is contingent from the present study that pollution load due to tourism increased. Therefore, there should be appropriate management and disposal of wastes emerging from tourism sector. It is suggested that suitable mechanism should be adopted for continuous monitoring of the Sahastradhara stream for the conservation of this important stream.

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