Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 12 [1]December 2022 : 149-155
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Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
ORIGINAL ARTICLE **OPEN ACCESS**

An evaluation of the water quality of the Bandal River in the Dehradun region, Uttarakhand India

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ABSTRACT
Water is the primary life-sustaining resource and a critical component in a country's and human civilization's social, cultural, economic, and ecological growth. One of the key factors affecting water quality is temperature, which primarily affects how chemical and biological processes in aquatic creatures occur. It is crucial for determining a number of other properties, including PH, conductivity, gas saturation levels, alkalinity, etc. Global threats like water pollution differ in size and kind depending on the location. The objective of this research paper is to analyze the quality of water in Bandal River. The quality of water should be tested for contamination such as chemical and microbiological to assure that the water we are drinking is safe for us as well as for other people. The result of this study was that physical appearance is agreeable beside turbidity, and in chemical parameters the amount of calcium is more than limit; microbial contamination is also found in water. The conclusion drawn is that there is presence of calcium, turbidity and microbial contamination in the water.
Keywords: - *Water Quality, Dehradun, Biological, Chemical, River Water*

Received 19.10.2022 Revised 20.11.2022 Accepted 24.12.2022

INTRODUCTION

Water is one of the most vital resources required for survival in this planet. It is regarded as one of the most precious gifts by nature. It is a resource that supports survival. Water is the primary life-sustaining resource and a critical component in a country's and human civilization's social, cultural, economic, and ecological growth. Water is the most abundant resource present on earth. Nearly, one-third of the earth is covered is water. It holds the largest diversity of organisms and flora. Distribution of water is uneven on the terra firm as 97.5% of water is marine water and only 2.5% is freshwater which is fit to be consumed. Only 20% of the population of the globe has access to a reliable source of purified water. The remaining 80% of the water supply is sourced from contaminated wells, bore holes, and other unreliable sources [1].In the underdeveloped countries, contaminated water supplies and poor sanitation are at blame for almost 88 percent of all infections. More than 18 million children between the ages of 0 and 5 pass away every year as a result of inadequate, dependable water supplies and sanitary services[2]. According to estimates, 420 million more people than six years ago lack sanitary facilities, and 150 million more people now than in 1976 must drink tainted water. Over ten decades, it has been observed that water is a vulnerable site of pollution. Being a universal solves it holds the tendency to accumulate most of the inorganic and organic contaminants to it. As per EPA, water pollution refers to the accretion of harmful substances that alters the physiochemical characteristics of healthy water[3].

Point sources – point source sites involve effluents released from industries and household activities which are drained directly into water bodies without any treatment. Industries based on pesticides, chemicals and dye manufacturing are some major sectors contributing towards the accumulation and organic and inorganic waste. Sectors dealing in production of steel or those processes which release heavy metals as waste into water bodies severely affects the flowing water[4].

Non-point sources- non-point sources of water pollution, such as storm water and agricultural runoff, are major contributors to water contamination. Pesticides, fertilizers, animal dung, and dirt washed into streams during rains are non-point causes of pollution in farming regions. When livestock get access to stream banks, they may contaminate the water and hasten erosion[5-7].

One of the key factors affecting water quality is temperature, which primarily affects how chemical and biological processes in aquatic creatures occur. It is crucial for determining a number of other properties, including PH, conductivity, gas saturation levels, alkalinity, etc. Different aquatic organisms are more sensitive to heat than others. The term "Eurythmic" refers to creatures with a high tolerance for temperature changes, whereas the term "Stenothermic" refers to animals with a low tolerance[8-9].The hardness of water is caused by calcium and magnesium dissolved in it. In most cases, it is stated as the equal amount of calcium carbonate. Hardness is a characteristic of water that lowers the ability of soap to build a lather and raises the water's boiling point [10-12]. Although there are no known negative consequences of hardness on health, there is evidence of a strong inverse link between drinking water hardness and cardiovascular illnesses. No health-based standard for water may impact how it tastes or how much scale forms on the consumer's palate [13-15].
Water pollution is a global threat with varying sizes and kinds based on location. The eight groups of pollutants in water are sewage, pathogens, sedimentation, organic compounds, inorganic chemicals, radioactive substances, and thermal pollution. Rapid industrialization contributes significantly to environmental pollution and the extreme degradation of the pedosphere, hydrosphere, and atmosphere [16-18]. Since it introduces numerous pollutants, like heavy metals, into soil and water resources, water utilized in industry produces waste that might be hazardous to the ecosystem[19-22].
Furthermore, through the channel of drinking water, contaminants in water bodies, particularly trace elements, infiltrate marine environments and ultimately the human body. There are some metals that are toxic, non-biodegradable, and persistent, all of which may damage human health and the environment [23-26].

MATERIAL AND METHODS

Study Area / Collection of water samples

River Bandal is a perennial river that rises in the TehriGarhwal Himalaya from spring-fed streams that start in the Surkanda hills. It is one of the most significant sources of drinking water for the city of Dehradun; the Bandal River contributes roughly 6.75 MLD of the city's total daily water availability of 30.8 MLD from water sources. For a laboratory investigation of the water quality, a water sample was obtained in a mineral water bottle and properly labelled. Every sample was taken in the morning between October and December. Five different Bandal River sites were chosen by us. (Fig.1 and Table1)

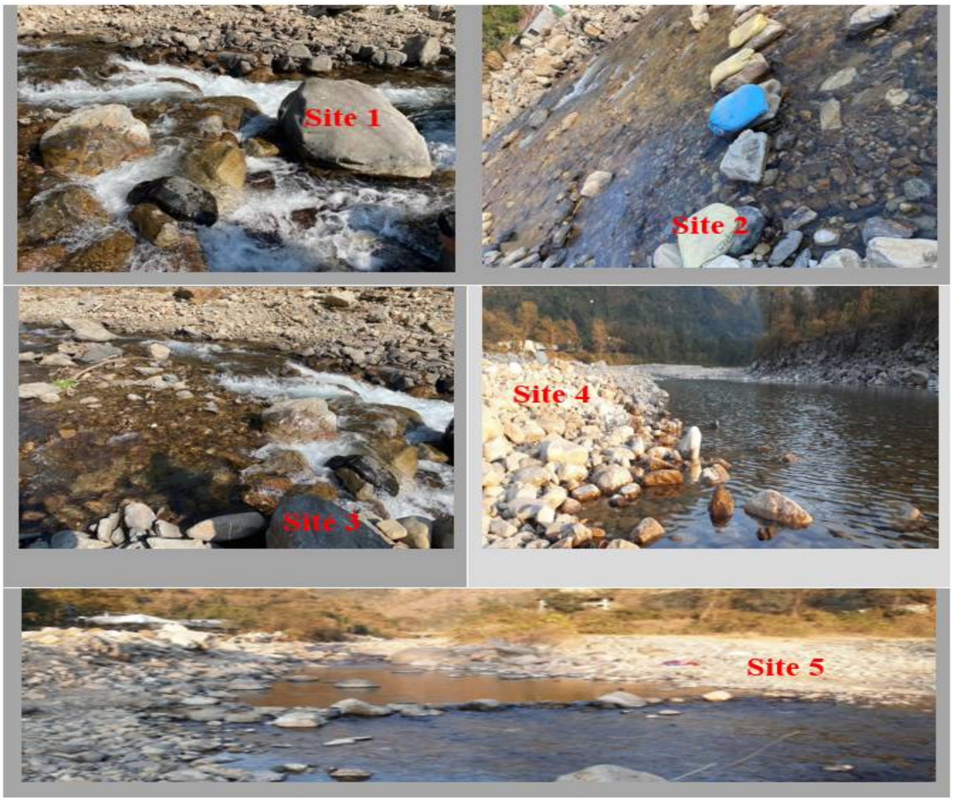

Fig1.Bandal Rao River Sampling Sites

Table 1. Latitude, Longitude and Altitude of BandalRiver Sampling Sites

#	Sampling Site	Latitude	Longitude	Altitude
Site1	Tachhila	30.38016^0	78.16075^0	868m (±9m)
Site2	Ghantusera	30.37593^0	78.15599^0	815m (±12m)
Site3	Sarkhet	30.36591^0	78.14271^0	764m (±11m)
Site4	Near PPCL	30.34557^0	78.13572^0	707m (±12m)
Site5	Before Merging song River	30.34553^0	78.13567^0	670m (±5m)

Physical appearance

For identifying the physical appearance of a water sample in terms of its temperature at the sampling point. Color (determined using the chloroplatinate procedure), pH (100 ml of water sample in a flask and pH measurement using a pH meter), and odour (half-fill a bottle with water sample and secure stopper) are the other tests that may be performed on water samples. Shake the vial for 2–3 seconds and notice the odour, taste (tested from pleasing to objectionable), TDS (measured with a Hach HQ430d meter), and turbidity (measured with a Systronics C Turbidity meter 135) at room temperature (APH 23rd edition 2017).

Total hardness estimation in water samples

In a nutshell, 1 to 2 ml of ammonium chloride-ammonium hydroxide solution were added to 50 ml of water sample, bringing the pH of the final solution to 10.0, and 2-4 drops of the Eriochrome Black T indicator were added. The solution was then carefully shaken and titrated with standard EDTA solution. Mark the endpoint after shaking it till the colour changes from wine red to blue.

Estimation of Calciumin water samples

Take 50 ml of water sample, 2 ml of sodium hydroxide buffer, and 0.1 to 0.2 gm of murexide indicator to the solution, then titrate with EDTA solution and mark the end point for the determination of calcium in water samples. Total Hardness calculation is nearly identical to that above. Magnesium hardness is further measured in mg/L or in ppm.

Estimation of Alkanityin water samples

Put a 25 ml sample of water in a titration flask. Titrate the solution against a solution of stranded hydrochloric acid after adding a few drops of methyl-orange indicator and thoroughly shaking the mixture. APH 23rd edition, 2017; colour shift from yellow to orange.

Most Probability Numbers (MPN/100 ml)

Presumptive Coliform Test

Make three sets of five test tubes each out of the 15 test tubes. Make five double-strength MacConkey broth vials and add 10 ml of broth into each one. 10 single-strength MacConkey broth tubes should be prepared, with 10 ml of broth placed in each. Without causing any bubbles to develop in the soup, insert Durham's tube into the test tube's wall. Use a 15 lb pressure autoclave at 121°C for 15 minutes to cook this broth. After autoclaving, let them cool to ambient temperature before adding 10 ml of water samples to each double-strength tube, 1 ml to each of 5 single-strength tubes, and 0.1 ml to each of an additional 5 single-strength tubes. They should be kept at 37 °C for 48 hours. Perform a confirmative test if acids and gases are forming.

Confirmative Coliform Test

Transfer loopful cultures from the presumptive test to bright green agar broth. Incubate for 24 to 48 hours. Then, using the MPN chart, compute the MPN values for total coliform based on the number of positive results.

Faecal Coliform

Autoclave the EC broth tubes after preparing them. Loopful culture should be taken from the presumptive test and transferred to EC broth tubes. For 30 minutes, let the infected EC broth vial sit at 44.5 °C. After that, let it grow for 24 hours. Use the MPN chart to calculate. (APH 23rd edition 2017).

RESULT

Physical Appearance

The pH of the tested water sample resulted within acceptable range in all 5 sites. The temperature varied from 18.7° C to 23.8° C in water samples. As per visual observation, it was found that in all 5 sites color of water was fine. As per the observation of odor in water samples, all samples were agreeable. The TDS range of water samples is within limit of 500. The turbidity of water samples is high than the limit which is 1 NTU. The range in water samples lies between 0.1-3.6 NTU **(Table3 and Graph 1-4).**

Total Hardness, Calcium, Magnesium, and alkalinity

The total hardness, magnesium and alkalinity of the tested water samples was under the limit.

The calcium limit is high in many sites, it ranges between 40-164. (Table3 and Graph 4-8).

MPN

There is a presence of Coliform and Faceal Coliformin the river water. (Table 4).

DISCUSSION

Temperature of the water sample, for example, ranged from 18.7° C to 23.8°. The color,and odor of water samples were agreeable. Water has a pH of 6.5-8.5. The minimum pH was 6.96 in Site 3, and maximum was 8.32 in Site 2. Water's pH balance is crucial since it controls our bodies' metabolic activities. It is not beneficial for our health if the pH is alkaline or acidic. Water with a pH over 8.5 may taste harsher. Alkaline pH may result in calcium and magnesium carbonate buildup in your pipes. Although it is not harmful, it might cause skin irritation, dryness, and itching. Either an excessively high or an excessively low pH will kill marine life. The pH of water can also affect how poisonous and soluble compounds and heavy metals are in it.The turbidity of water samples was high in several sites like 2.3 in Site 1, 2.6 in Site 2, 2.5 in Site 3, 2.6 in Site 4, and 3.9 in Site 5 which is very high. Water that has a high turbidity level may contain microbiological infections. High turbidity can degrade the scenic quality of ponds and rivers, reducing recreational and tourist opportunities. It has the potential to raise the cost of water treatment for drinking and food processing. The TDS in all Sites was in range as in Site 1 it was 180.4-202.4, Site 2 it was 189.2-222.3, Site 3 it was 172.1-185.3, Site 4 it was 203.1-212.9, and Site 5 it was 222.9-215.23. All samples of water's TDS range fall below the permissible range of 500 mg/L. Salty, bitter, or metallic flavors are associated with water that has a high TDS level. TDS levels above a certain level also indicate the presence of poisonous minerals that are health-hazardous. A high TDS value can be a sign of more caustic chemicals present. These substances may not be harmful to human health, but they can technically harm the surfaces and plumbing in your house.

The range of hardness of water in Site 1 is 128.10-180.14, in Site 2 is 120.10-200.16, in Site 3 128.10-180.14, in Site 4 160.13-224.18 and in Site 5 152.12-216.17. According to the WHO's Geneva Conference, hard water has no known detrimental effects on health. Additionally, extremely hard water in particular might provide a significant additional contribution to the overall intake of calcium and magnesium. The major drawbacks of hard water include increased soap usage, boiler scaling, pipe erosion and incrustation, and bland food.The hardness of the water prevents soap from lathering and elevates the boiling point of the liquid. The hardness of the water is based on the amount of calcium or magnesium salts present. There are many resorts around the banks of Bandal River and the sever waste of these resorts maybe drains to the river. It can be a reason of the presence of the fecal coliforms in the river.

#	Characteristic	Requirement (Acceptable Limit)	Permissible Limit in the Absence of Alternate Source
1	Odour	Agreeable	Agreeable
2	pH	6.5-8.5	No relaxation
3	Turbidity, NTU	1	5
4	Total dissolved solids, mg/l	500	2000
5	Colour, Hazen units, Max	5	15
6	Total hardness (CaCO3), mg/l	200	600
7	Magnesium (Mg), mg/l	30	100
8	Calcium (Ca), mg/l	75	200
9	Total alkalinity mg/l	200	600
10	MPN 100ML	Non-detectable	Non-detectable
11	Faceal Coliform	Non-detectable	Non-detectable

Table 2.Indian Standard Drinking Water Specification- IS 10500: 2012

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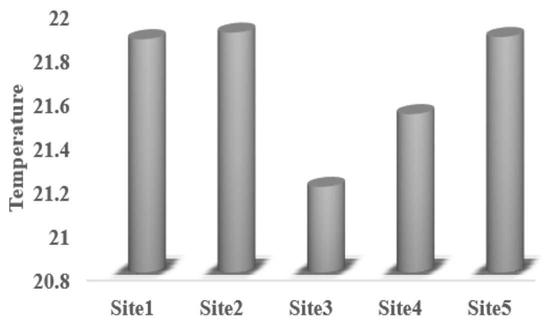
Parameters	Site1				Site2				Site3				Site4				Site5			
	Min	Max	Avg.	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD
Temperature ^{0}c	18.7	23.8	21.9	1.41	20.1	23.4	21.9	1.0	19.3	22.9	21.19	1.01	19.7	23.7	21.52	1.12	20.2	23.7	21.87	1.06
Colour, Hazen	5 H	5 H	5 H	0	5 H	5 H	5 H	0	5 H	5 H	5 H	0	5 H	5 H	5 H	0	5 H	5 H	5 H	0
pH	7.12	8.16	7.64	0.38	7.3	8.32	7.9	0.3	6.96	8.1	8	0.37	7.05	7.59	7	0.15	7.1	8.19	8	0.33
Odor	Agreeable			0	Agreeable				Agreeable			0	Agreeable			0	Agreeable			0
TDS, mg/l	180.4	202.4	191.1	6.3	189.2	222.3	199.0	11.9	172.1	185.3	179	3.47	203.1	212.9	209.07	2.63	197.3	222.9	215.23	7.15
Turbidity, NTU	0.1	2.3	1.2	0.6	0.5	2.6	1.7	0.6	0.3	2.5	1.37	0.62	0.3	2.6	1.38	0.67	0.3	3.9	1.67	1.08
Hardness, mg/l	128.10	180.14	151.65	15.07	120.10	200.16	166.95	20.07	128.10	180.14	151.23	15.07	160.13	224.18	193.64	14.82	152.12	216.17	181.33	16.01
Calcium, mg/l	40.03	120.10	77.54	19.71	64.05	156.12	110.01	28.23	44.04	152.12	88.07	30.67	88.07	160.13	125.43	19.52	100.08	164.13	132.25	17.146
Magnesium, mg/l	3.89	28.21	18.01	6.69	3.89	28.21	13.84	6.24	0.97	28.21	15.35	7.34	2.92	26.26	16.57	5.53	1.95	24.32	11.93	5.69
Alkalinity, mg/l	42	68	56.37	6.88	22	68	49.19	11.59	24	84	54.74	18.08	26	88	56.07	13.96	30	86	62.52	14.95

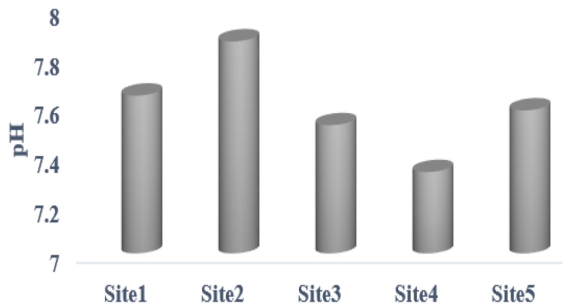
Table 3. Physicochemical analysis of Bandal River of October to December -2022

Location Dehradun	Combination of Positive Samples			MPN Index /100 ml (MPN)	Combination of Positive Samples			MPN Index /100 ml (Faceal Coliform)
	10 ml	1 ml	0.1 ml		10 ml	1 ml	0.1 ml	
Site1	4	2	3	100	4	0	2	40
Site2	4	4	2	120	2	2	1	26
Site3	5	1	2	150	3	5	0	70
Site4	5	2	1	170	4	1	1	42
Site5	5	0	2	100	4	2	0	50

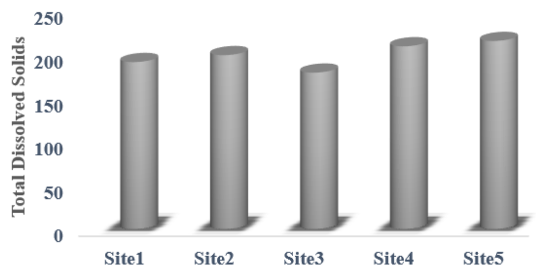
Table 4. MPN and Faceal Coliform of Bandal River Different Sites



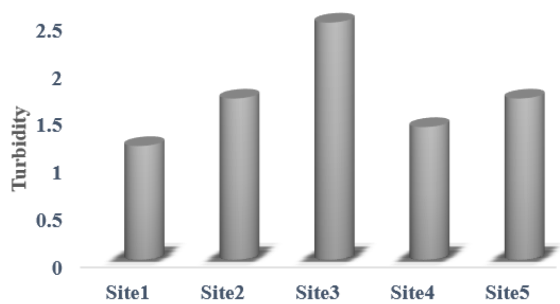
Graph 1: Variation of Temp. during study period.



Graph 2: Variation of pH during study period.



Graph 3: Variation of TDS during study period



Graph 4: Variation of Turbidity during study period

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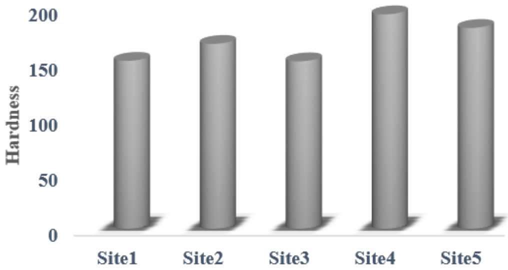
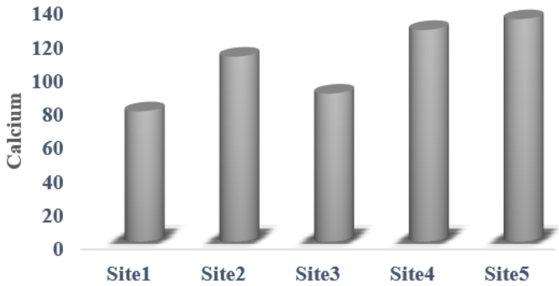
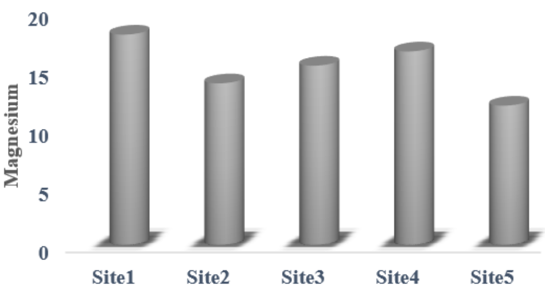


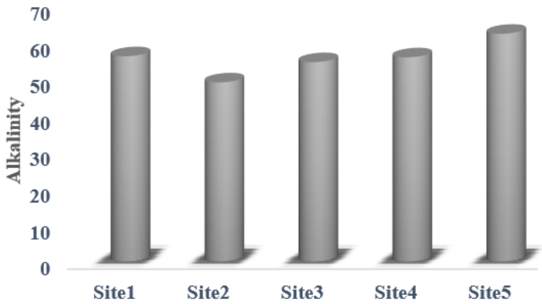
Graph 5: Variation of Hardness during study period



Graph 6: Variation of Calcium during study period



Graph 7: Variation of Magnesium during study period



Graph 8: Variation of Alkalinity during study period

CONCLUSION

We may take a variety of actions to improve the water quality of our streams, such as reducing farm run-off by planting trees along streams and on hills to control farm pollution. If potential limiting factors, such as point source discharges or agricultural effluents, are stopping long-term natural recovery, they should be eliminated or reduced. Improve the efficiency of stock management by, for example, fencing off streams and rivers to prevent direct water pollution and exercising caution while applying fertilizers and pesticides. Keep an eye on the depth of the water table and limit your water use during dry seasons. Retire land from inappropriate usage or modify their uses, and carefully plan developments and urban expansion to have as little influence as possible on nearby waterways.

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CITATION OF THIS ARTICLE

R Pant, K Tiwari, A Gupta, N Pandey, N Patrick. An evaluation of the water quality of the Bandal River in the Dehradun region, Uttarakhand India. Bull. Env. Pharmacol. Life Sci., Vol 12 [1] December 2022: 149-155