



**STUDY OF SURFACE WATER POLLUTION- CASE STUDY ON UTTRAKHAND AND
WEST U.P. (I. E. BIJNOR DISTRICT)**

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INTRODUCTION

The Ganga River has become polluted rivers in India as well as in the world because of the high-density population growth and speedy industrialization. The Ganga River is severely polluted and needs urgent revival. The Ganga River in Haridwar is polluted due to exceptional tourist activity, poor sewage facilities, and insufficient wastewater management amenities. The measurement of the quality can be done by water quality assessment. Due to historical, geographical, religious, political, and socio-cultural reasons, India has a unique place in the world (Agarwal et al., 2016). Pollution-causing activities have caused severe changes in aquatic environments over the last few decades. Serious questions have been raised in context to the safe use of river water for drinking and other purposes in recent times. Numerous contaminants are playing a major role in polluting the river water. It is one of the main concerns for most of the metropolitan cities of developing nations. Rivers play a vital role in shaping up the natural, cultural, and economic aspects of any country (Rafiq, 2016). Water is a vital resource for human life. According to the World Water Development Report 2021 published by UNESCO, the world's freshwater consumption has grown six-fold over the past century and is increasing at a rate of approximately 1% per annum since the 1980's. As water consumption increases, water quality challenges arise. Industrialization, agriculture, and urbanization have led to pollution and degradation of the environment, which affects the water bodies (rivers and oceans) essential for human life. This has a negative impact on human health and on sustainable social development. Around 80% of industrial or municipal wastewater is released into the environment without prior treatment, affecting human health and ecosystems alike. This percentage is higher in LDCs, where sanitation and sewage treatment facilities are significantly lacking.

Water pollution has several main sources. Industry is a key contributor, as various toxic chemicals and waste from activities like distilling, tanning, pulp and paper production, textiles, food processing, steel making, and nuclear power often enter waterways untreated. Heavy metals like arsenic, cadmium, and chromium in industrial wastewater are especially problematic (Chen et al., 2019; Chowdhary et al., 2020). Water pollution from industry tends to increase with urbanization and foreign direct investment in less developed nations (Jorgenson, 2009; Wu et al., 2020). Agriculture also causes significant water contamination through pesticides, fertilizers, organic wastes, sediments, and pathogens running off fields and farms. These pollutants introduce excess nutrients, toxins, and particulates into freshwater systems (Parris, 2011; RCEP, 1979). Overall, industry and agriculture have heavily polluted many natural waterways (Moss, 2008).

Pesticides have a negative impact on health through drinking water. According to Longitudinal Survey data, a 10% increase in pesticide use leads to a 1% increase in

the Medical Disability Index over 65 years of age (Lai, 2017). Water pollution is related to natural factors. Trace elements are found at elevated levels in water quality at Child Loess Plateau, which is caused by the environment and human activity. Poor river water quality is also linked with high sodium and salinity hazards, as well as hexavalent chromium pollution. Finally, water supply and sewage treatment facilities are important factors that affect drinking water quality globally.

This paper reviews the environmental science, health, and medical literature, with a particular focus on epidemiological studies linking water quality, water pollution. Health education is widely carried out. Introduce environmental education, educate residents on sanitary water through newspapers, magazines, television, Internet and other media, and enhance public health awareness. Train farmers to avoid overuse of agricultural chemicals that contaminate drinking water. The water samples were collected in areas with high pollution potential, the main pollutants near the collecting samples sites being Chandi Ghat (Haridwar),

Balawali (Binor) and Bairaj (Bijnor).

EXPERIMENTAL

Characterization of seasonal changes in surface water quality is an important aspect in evaluating temporal variations of river pollution due to natural or anthropogenic inputs of point and non-point sources. (11-13). Surface water quality data for 12 physical and chemical parameters collected from three main sampling sites/river (before, after and respectively, from a main pollution point along the river) during the springtime of years 2023 were analyzed.

General procedure: During sampling, the weather reports and river aspects were different. At first sampling campaign, in April 2010, the outside temperature, in Haridwar and various cities of west Uttar Pradesh, was 21 °C and the sky partly clear. At our arrival to Roorkee, the next city from our sampling schedule, the wastewater, wastewater discharges from households, chemicals, etc., the most significant pollutant sources being from chemical industry and mining activities (Table-1).

Temperature: Water temperature is a critical parameter for aquatic life and has an impact on other water quality

parameters such as dissolved oxygen concentrations, pH, salts solubility in water and bacteria activity in water (Fig. 1). Temperature increased to 15 °C, the sky being clear with the sun up. In Haridwar, the weather conditions were the same as Balawali and other cities of West U.P. On the other hand, at the second sampling campaign, in mid of May 2023, despite of the rainy weather of that month, that day was sunny, with unexpected temperature for that period of the year, between 25 and 32.

The samples were collected in polyethylene bottle at depth between 0.20 to 0.50 meters. The experimental part being made at N.I.H., Roorkee and Research Division, Sahu Jain College, Najibabad. These results are just a first part of a monitoring programme, the maiden work continuing with seasonal collected data in order to have significant patterns of change through the day and through the seasons for investigated different places of the river. The main water quality parameters were determined by potentiometric methods and the particulate matter was determined by gravimetric method and the heavy metals by inductively coupled plasma mass spectrometry measurements.

TABLE-1: WATER QUALITY PARAMETERS FOR STUDIED SITES

Quality indicators	Ganga river						Ganga Canal river						Upper Ganga canal river					
	1		2		3		4		5		6		7		8		9	
	Apr	May	Apr	May	Apr	May	Apr	May	Apr	May	Apr	May	Apr	May	Apr	May	Apr	May
Temp. [°C]	19.2	21.5	19.0	22	20	23.2	21.0	23.0	20.5	22.5	19.5	22.7	20.0	23.3	20.9	23.5	21.0	23.0
pH [upH]	7.07	8.18	7.25	7.83	7.18	8.5	7.23	7.92	7.59	7.82	7.19	7.83	7.28	7.86	7.49	8.05	7.44	8.08
Conductivity [µS/cm]	372	237	362	290	400	289	457	324	499	342	960	783	497	277	556	295	602	315
Turbidity [NTU]	1.5	3.76	5.0	4.51	3.5	6.21	11.7	12.2	9.3	5.67	10.9	7.18	25.3	43.8	30.5	49.0	27.7	33.5
Particulate matter [mg/L]	119	98.0	90.5	77.4	62.2	39.9	40.0	25.0	323	454	41.5	58.8	75.0	60.1	94.0	72.6	585	383
DO [mg/L]	7.0	8.3	8.6	8.6	6.7	7.2	8.6	9.1	8.3	9.1	9.0	6.7	7.7	7.0	8.3	8.3	9.2	9.2
Cl ⁻ [mg/L]	33.3	61.9	27.4	41.7	25.8	48.2	152	124	265	177	249	219	44.1	42.6	26.9	30.5	55.2	56.8
Ca ²⁺ [mg/L]	72.1	54.5	37.7	48.9	39.2	55.3	170	52.9	94.4	54	109	83.4	23.3	60.2	15.9	46.4	25.6	56.1
NO ₃ ⁻ [mg/L]	17.5	21.7	15.4	17.8	15.3	18.02	13.9	17.1	19.27	16.8	11.9	14.53	16.0	19.2	12.4	10.2	20.9	19.2
NH ₄ ⁺ [mg/L]	0.26	0.18	0.38	0.09	0.18	0.10	0.27	0.62	0.72	0.26	0.23	0.26	0.2	0.4	1.2	0.9	0.95	1.6
F ⁻ [mg/L]	0.26	0.25	0.31	0.18	0.32	0.19	0.35	0.62	0.37	0.15	0.5	0.9	0.5	0.4	0.10	0.25	0.77	1.1
TOC [ppm]	3.34	2.41	3.0	2.02	3.0	2.43	1.9	2.40	1.7	2.69	1.9	2.48	1.1	0.9	2.2	1.72	2.9	1.6
Ni [µg/L]	0.4	4.3	0.4	4.2	0.4	4.4	1.6	4.1	0.96	4.5	4.1	8.3	0.4	4.1	0.4	5.1	0.4	4.2
Cd [µg/L]	0.04	0.23	0.04	0.26	0.04	0.22	0.04	0.2	0.04	0.21	0.04	0.18	0.04	0.22	0.04	0.22	0.04	0.24
Pb [µg/L]	1.64	1.64	2.3	1.8	1.94	1.95	1.97	1.79	1.02	1.84	3.62	2.08	1.67	2.04	2.59	2.72	3.58	3.2
Zn [µg/L]	15.3	12.15	4.61	5.15	4.83	6.37	5.07	6.92	7.34	7.8	11.36	11.0	8.8	8.6	14.6	10.46	14.5	11.7
Cu [µg/L]	49.6	113.6	13.2	27.3	25.01	22.8	40.1	18.1	12.2	33.8	32.3	105.3	19.8	104	18.4	157.6	35.6	113

Sample Places: 1. Chandhi Ghat 2. Balawali. 3. Bairaj, 4. Roorkee, 5. Purkaji, 6. Jansath, 7. Sardhana 8. Tikri & 9. Muradnagar.

Detection method: The studied parameters were: temperature, pH, turbidity, particulate matters, electrical conductivity, dissolved oxygen, Cl⁻, Ca²⁺, NO₃⁻, F⁻, NH₄⁺ and organic carbon. The main water quality parameters were determined by potentiometric methods and the particulate matter was determined by gravimetric

method and the heavy metals by inductively coupled plasma mass spectrometry measurements.

RESULT AND DISCUSSION

The water quality in Haridwar and Various cities of west U.P. around Ganga river are most influenced by the

specific anthropogenic factor through activities developed through the study area, such as extracting underground resources (minerals, salt), processes the resulting wastewater, wastewater discharges from households, chemicals, etc., the most significant pollutant sources being from chemical industry and mining activities (Table-1).

Temperature: Water temperature is a critical parameter for aquatic life and has an impact on other water quality parameters such as dissolved oxygen concentrations, pH, salts dissolubility in water and bacteria activity in water (Fig. 1). Factors that can have an impact on water temperature could be the quantity and maturity of riparian vegetation, the rate of flow, the precipitations, thermal discharges, impoundments and groundwater.

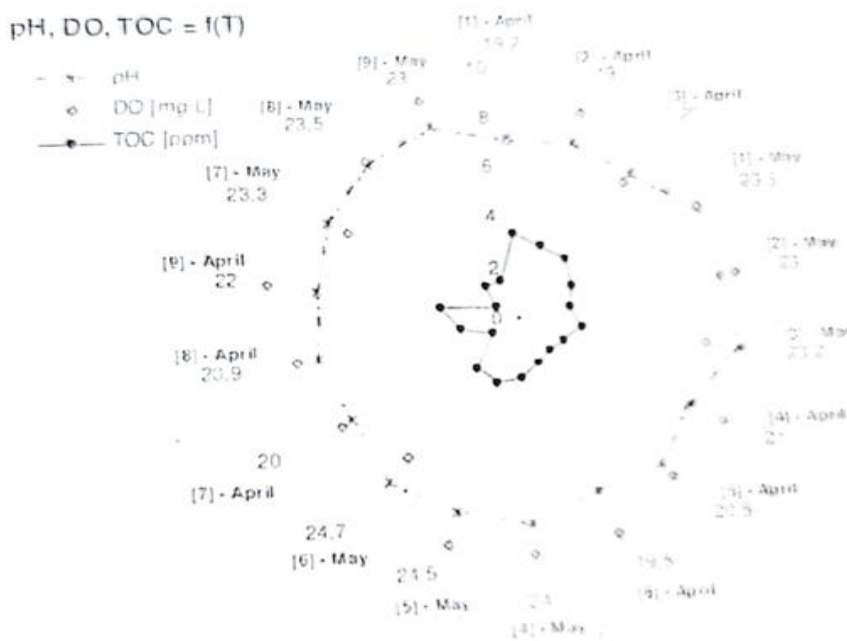


Fig. 1: PH, DO, TOC variation with temperature, on sample sites 1-9.

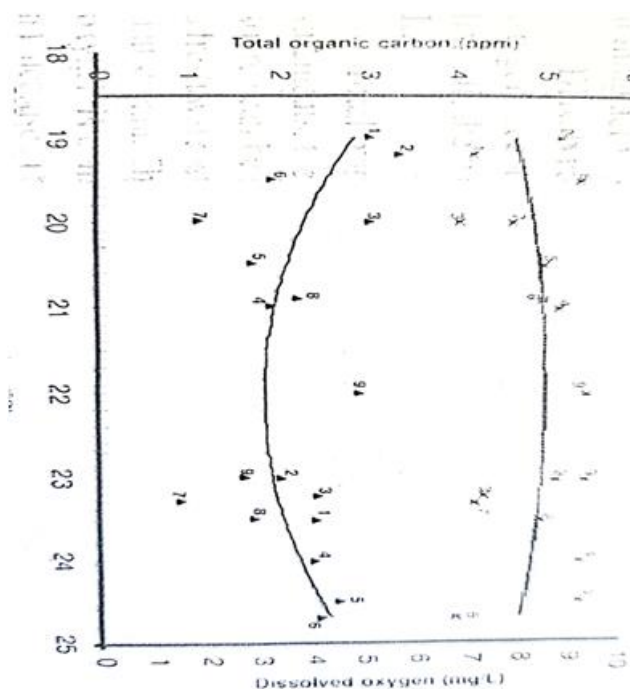


Fig. 2: Correlation between dissolved oxygen (DO) and total organic carbon (TOC) function on temperature.

Table 3: Table for Calcium and Chloride Ion Concentration.

Sample Site No.	Calcium Ion Concentration (mg/L)		Chloride Ion Concentration (mg/L)	
	April 2023	May 2023	April 2023	May 2023
Site 1	50	49	48	52
Site 2	46	48	46	48
Site 3	46	49	46	48
Site 4	150	49	150	137
Site 5	94	49	252	154
Site 6	98	95	250	200
Site 7	43	48	50	50
Site 8	40	49	46	45
Site 9	44	49	53	52

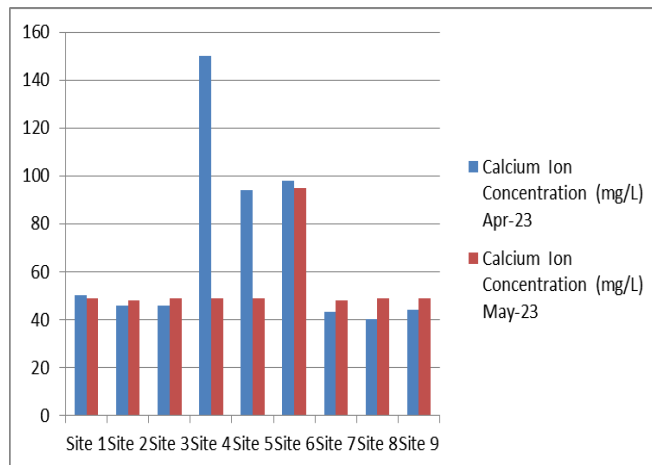


Fig. 3a: Calcium Ion Concentration (mg/L).

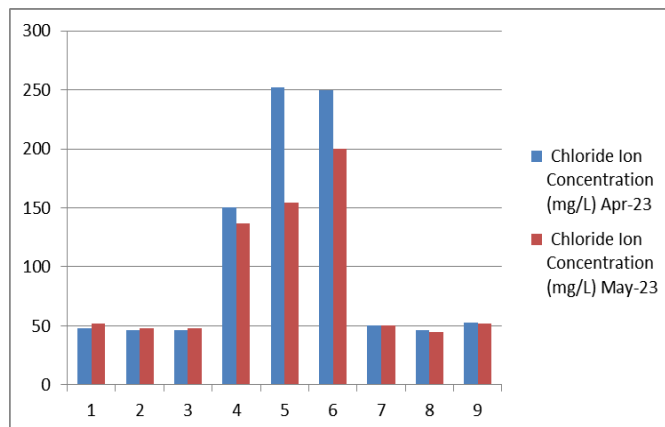


Fig. 3b: Chloride Ion Concentration (mg/L).

Table 4: Table for Nitrates and Ammonium Ion Concentration (mg/L).

Sample Site No.	Temp (°C)		pH		NO ₃ ⁻ (mg/L)		NH ₄ ⁺ (mg/L)	
	April 2023	May 2023	April 2023	May 2023	April 2023	May 2023	April 2023	May 2023
Site 1	18.5	21.1	6.5	7.3	0.7	0.1	17.5	21.7
Site 2	17.5	21.8	6.7	7.6	0.5	0.2	15.3	17.4
Site 3	21.3	22.3	6.7	7.9	0.1	0.1	21.6	17.4
Site 4	22.0	23.0	7.8	7.1	0.1	0.3	13.7	12.0
Site 5	21.5	23.2	7.6	7.3	0.3	0.1	19.2	13.4
Site 6	22.6	23.4	7.4	7.4	0.1	0.2	12.3	12.8
Site 7	20.5	22.7	7.3	7.3	0.1	0.1	18.4	18.2
Site 8	21.4	22.9	7.1	7.2	0.5	0.3	13.6	12.8
Site 9	22.1	21.6	7.1	7.1	0.4	0.4	19.4	18.6

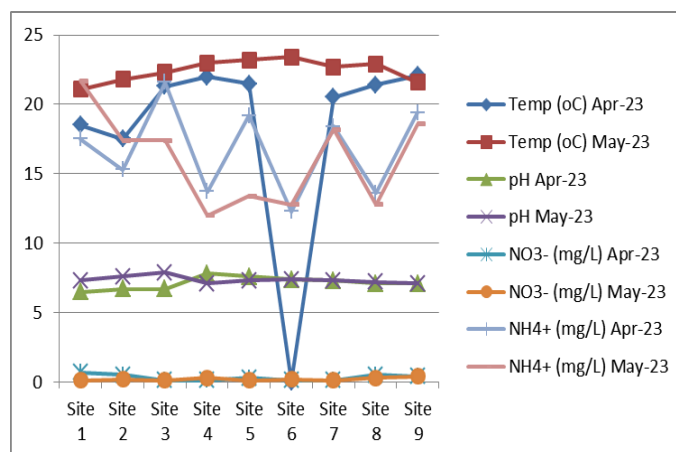


Fig. 4b: Graphical representation for Nitrates and Ammonium Ion Concentration (mg/L).

PH: For the analysed samples, the average pH values of water were in the range of 7.07 and 8.5 didn't exceeding the limits, according with the survey report of NIH, Roorkee, (6.5-8.5). These values are typical for natural surface water, being optimum for most organisms. The increase of pH from April to May, 2023, was caused also by the natural and anthropogenic factors.

Conductivity: The measured values for present samples were in the range of 237 $\mu\text{S}/\text{cm}$ (on Ganga river - site 1) and 960 $\mu\text{S}/\text{cm}$ (on Ganga river - site 5), didn't exceeding the limit value for drinking water.

Turbidity: There is an increase of suspension particulate matter on Ganga river (site 5 and site 9), at the interaction with the chemical industry and mining activity, in the studied area.

Dissolved oxygen- The measured value for dissolved oxygen, according with the water quality by Central Government of India, fit the water quality in the studied area in classes I and II.

Total organic carbon: Using total organic carbon measurements, the number of carbon-containing compounds in a source can be determined. Knowing the amount of carbon in a fresh water stream is an indicator of the organic character of that stream. The larger the carbon or organic content, the more oxygen is consumed (Fig. 2). A high organic content means an increase in the growth of microorganisms which contribute to the depletion of oxygen supplies. Industrial waste effluents may contain carbon-containing compounds with various toxicity levels. These situations can create unfavourable conditions for aquatic life, such as the depletion of oxygen and the presence of toxic substances.

Hardness: The main reason for abundance of Ca^{2+} in water is its natural occurrence in the earth's crust. Rivers contain 1-2 mg/L calcium, but in lime rivers area they may have calcium concentrations as high as 100 mg/L. In present study, an increase in calcium by the Ganga River (Fig. 3) can be observed, as an influence of Industrial activities.

Chlorides: The chloride ion (Cl^-) is found naturally in some surface waters and groundwater. Higher-than normal chloride concentrations in freshwater is detrimental to water quality. Depending upon the end-user, there are maximum concentration limits recommended. The surface waters with chloride concentration below 25 mg/L belong to the first class of quality and waters with chloride concentration of 25 - 50 mg/L belong to the second class of quality. From Fig. 4, a higher amount of chloride ions can be observed on Ganga River, as a consequence of Industrial chemical plant activities in the monitored area.

Fluoride: The amount of F^- concentrations in investigated area didn't exceed the central govt of India maximum admissible value, of 5 mg/L, being in the range of 0.1 to 1.1 mg/L.

Nutrients: A high amount of nitrates in rivers water (Fig. 3) can be observed along the investigated route as a consequence of urban settlements, agricultural emissions and/or industry and traffic.

Ammonium is a nutrient for plants, but can also have toxic effect, especially on fish, when its concentration is higher than 0.2 mg/L. The toxicity of ammonia is dependent on pH and temperature and added the buffering effect which masks any additional toxicity over pH = 8. To avoid ecological damage .we has to consider the pH fluctuation caused by photosynthesis, which is difficult in the case of ammonia as a wide range of parameters such as concentration, pH and temperature. The surface water with a concentration of NH_4^+ over 1.5 mg/L belongs to the 5th class quality. In all the determinations, especially on Cities located on Upper Ganga Canal River, a high level of ammonium can be observed, probably due to the organic matter dissolved in water. The consequence of high ammonium concentrations may be an increasing amount of algae.

Metals: The heavy metals analysis has been performed with an ICP-MS, the amounts of micro-contaminants in investigated river waters being in normal limits, with few exceptions (Fig. 6).

In terms of water quality, the Ganga river waters are classified by classes. For the investigated elements, the limits classes are given in Table-2. An increase of Ni and Cu can be observed on various cities of Ganga River, as a consequence of mining activities in the area. Also, on river - site (2) and river - site (4), there is a much higher Ni concentration than the permissible limit of the Indian Standards, possible as a part of wastewater streams. Water can also be polluted with zinc, due to the presence

of large quantities of zinc in the wastewater of industrial plants. This wastewater is not purified satisfactory, one of the consequences being that rivers are depositing zinc-polluted sludge on their banks. There is a high concentration of Zn on A site 1, site 6 and site 8 and 9. As regard of Cd and Pb concentrations, the investigated waters rivers are almost all included in class II and III, according with the Indian standards.

Table-2: Standardized Limits by Water Quality Classes for the Investigated Heavy Metals Concentration in Rivers Water (India).

Metals [$\mu\text{g/L}$]	Values regulated by the Indian standards				
	Class I (very good)	Class II (good)	Class III (moderate)	Class IV (satisfactory)	Class V (low)
$\text{Ni}^{2+} + \text{Cd}^{2+} + \text{Pb}^{2+}$	Natural background	1.0	2.0	5.0	> 5.0
Zn^{2+}	Natural background	0.1	0.2	0.5	> 0.5
Cu^{2+}	Natural background	1.0	2.0	5.0	> 5.0
	Natural background	5.0	10.0	25.0	> 25.0
	Natural background	20.0	40.0	100	> 100

Table 5a: Table for Heavy metals (Ni, Cd & Pb) Concentration ($\mu\text{g/L}$)

Sample Site No.	Ni metal Concentration ($\mu\text{g/L}$)		Cd metal Concentration ($\mu\text{g/L}$)		Pb metal Concentration ($\mu\text{g/L}$)	
	April 2023	May 2023	April 2023	May 2023	April 2023	May 2023
Site 1	0.3	4.2	0.1	0.3	1.7	1.7
Site 2	0.4	4.0	0.1	0.4	1.9	2.1
Site 3	0.4	4.1	0.1	0.4	2.0	2.0
Site 4	1.8	3.9	0.2	0.5	1.8	1.9
Site 5	1.1	4.3	0.1	0.3	1.4	1.7
Site 6	3.2	7.9	0.1	0.3	3.1	2.6
Site 7	0.2	3.6	0.2	0.4	1.9	2.1
Site 8	0.2	4.1	0.1	0.3	2.4	2.5
Site 9	0.3	4.0	0.1	0.4	2.6	2.4

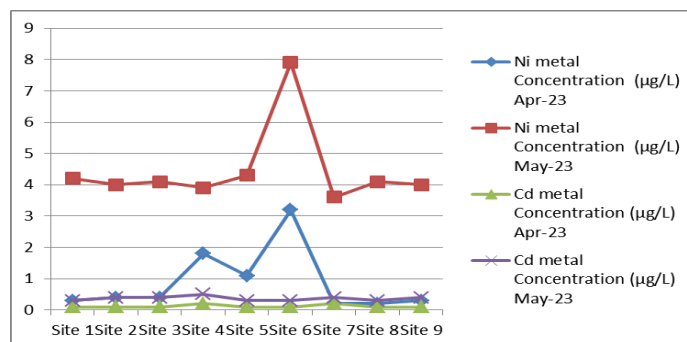


Fig 5a: Graphical representation of Heavy metals (Ni, Cd & Pb) Concentration ($\mu\text{g/L}$).

Table 5b: Table for Heavy metals (Zn & Cu) Concentration ($\mu\text{g/L}$).

Sample Site No.	Zn metal Concentration ($\mu\text{g/L}$)		Cu metal Concentration ($\mu\text{g/L}$)	
	April 2023	May 2023	April 2023	May 2023
Site 1	18.4	17.2	18.4	117.2
Site 2	16.2	16.2	15.2	30.2
Site 3	16.4	16.4	24.6	37.0
Site 4	16.7	17.2	40.0	21.3
Site 5	17.1	17.3	17.4	36.2
Site 6	18.7	18.1	33.2	111.6
Site 7	18.3	18.1	30.1	111.6
Site 8	19.1	19.2	27.4	144.2
Site 9	19.7	20.3	37.1	111.3

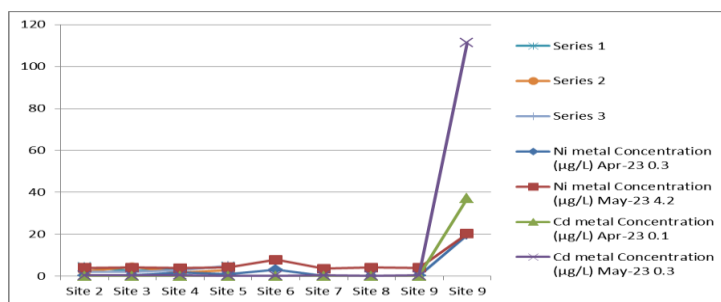


Fig 5b: Graphical representation of Heavy metals (Zn & Cu) Concentration (µg/L).
Fig. 5b Heavy Metal (Zn & Cu) Concentration in (µg/L).

CONCLUSION

The water quality for all three rivers is affected by both natural and anthropogenic factors. The river pollution indicators, such as ammonium, nitrogen, organic carbon, dissolved oxygen and heavy metals exceed the admissible limits for various classes of quality if in environmental area is evolve communal economy activities, chemical industry and agriculture activities followed by the economic units within the ore mining and metal processing. The presence of nutrients in water, like nitrogen and ammonium ions, can be associated with the biogeochemical cycles, but also with the industrial (chemical industry and mining) and agricultural activities. The concentration of NH_4^+ in water can also be correlated with the water temperature, concentration of dissolved oxygen and pH.

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