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ORIGINAL ARTICLE **OPEN ACCESS**

Hydrochemical Investigation of Water Bodies from The Effluents of Sirgitti Industrial Area of Bilaspur (C.G.)

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ABSTRACT
The surface water bodies in the Sirgitti industrial zone of Bilaspur (Chhattisgarh) have been analyzed to determine the concentrations of a few key physicochemical parameters with metallic elements. In order to determine the physicochemical and heavy metal composition of the water, samples were taken from five different locations in 'May' 2021, during the pre-monsoon season, and analyzed using a standard technique in accordance with IS recommendations. More than seventy percent of these metrics were too high compared to the BIS 10500 and WHO drinking water standards. Increases in these metrics raise serious public health concerns. Several variables, including pH, colour, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total solids (TS), total suspended solids (TSS), nitrate, phosphate, calcium, magnesium, sodium, potassium, and heavy metals including copper, zinc, iron, aluminium, mercury, lead, cadmium, and WQI, were shown to alter.
KEYWORDS: *Physical and chemical factors, physical health, water quality, Industry-induced pollution.*

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INTRODUCTION

Water is necessary for human life, but it is in jeopardy of being depleted owing to human activities, e.g., mining, chopping down trees, and industrialization. Water is crucial to human survival. Even though water makes up 71% of the surface of the globe, humans are only able to utilize 1% of it. Both surface water and groundwater are utilized by humans, and each type of water possesses distinctive characteristics as a result of the dissolved minerals in the soil [1-3]. Because of human activities as well as the natural process of weathering, the quality of water throughout the cosmos has been deteriorating for a significant amount of time. This is due to the fact that people's actions have polluted water supplies with waste streams, pollutants from industries, and man-made chemicals, which has resulted in a decreased availability of water. It is for this reason that the availability of potable drinking water for all of the residents of the world is a global priority [4-7].

A number of different water systems have experienced deterioration in water quality as a direct result of an increase in the amount of contaminants entering those systems. These impurities include sewage, waste from industrial processes, and chemicals produced by humans. This is especially true in countries that have not yet reached their full potential. Chemicals produced by humans are also included in the category of pollutants. These pollutants consist of things such as human waste, rubbish from industrial processes, and chemical residues [8-12]. Both water that is absorbed from the surface of the earth and water that is absorbed from the subsurface do not employ the same processes to take up dissolved minerals. Both surface water and groundwater are governed by their own unique sets of processes. There are a few distinct applications for groundwater that are utilized by both surface water and groundwater. This priceless resource is always being replenished because of hydrological cycles, which can be found at or very close to the surface of the earth. Cycles like these can be found anywhere on or somewhat close to the surface of the earth. These cycles can be found in a wide variety of various areas all around the planet [13-17]. The factory dumps the insufficiently treated effluents all over the neighbourhood. Since pollutant mixing occurs when these industries, municipal sewage, and domestic effluents release their wastewater without proper treatment, determining how much pollution is already present in the water in this region is crucial. This research evaluates the quality of water in May 2021, just before the onset of the monsoon season, using a number of physicochemical indicators as well as a few selected metallic elements and the Water Quality Index (WQI).

MATERIAL AND METHODS

Bilaspur is the second-largest city in Chhattisgarh state and the district head zone of the Bilaspur district. The average annual rainfall is 1220 mm, and its coordinates are 21°47' to 23°08' North and 81°14' to 83°15' East. There is a lot of air, water, and soil pollution since so many companies operate factories or industrial equipment in the Sirgitti Bilaspur area. It is crucial to investigate the level of pollution in the water in this region [18-19]. This study evaluates the quality of the water in 'May' 2021 using physico-chemical parameters, just prior to the beginning of the monsoon season. It is of the utmost importance to determine the degree to which the water in this region has been polluted because of the discharge of wastewater from industries and municipalities that has not been treated or has only been treated in part.

In 'May' 2021, before the beginning of the monsoon season, five samples of water from the surface were collected and placed in high-quality polyethylene Jerry cans with a capacity of two litres each. The cans had previously been washed in 8M HNO_3, rinsed with detergent, and rinsed in double-distilled water in order to determine if the chemicals in the water functioned. Surface water samples were taken in the Bilaspur-Sirgitti industrial zone (Figure 1), namely at Sirgitti Gokhane Nala Railway Bridge (SS1), Sirgitt Stock Dam (SS2), Sirgitti Nala near Narmada Coldrinks (SS3), Sirgitti Nala near Bannakdih Chowk (SS4), and Sirgitti Nala near New India Industries (SS5). The collected water sample was kept frozen and dark [20-21]. Using the usual methodology [20-30], the analysis was completed rapidly to produce more consistent and great results. A water tester kit was used to take readings on the spot, including pH, temperature, electrical conductivity (EC), turbidity, and total dissolved solids (TDS). Comparisons of colours were made visually. Gravimetric analysis was used to calculate TSS and TS. Cl^-, TH, and TA concentrations were measured using titrimetric analysis; dissolved oxygen (DO) was measured using a DO meter; COD was measured using the digestion method; and BOD was measured using an incubator. The anions (F^-, NO_3^-, PO_4^{3-}, and SO_4^{2-}) were analyzed using spectrophotometry. A flame photometer was used to identify the dominant cations. Using atomic absorption spectroscopy, trace elements such as iron, zinc, manganese, aluminium, mercury, lead, and cadmium were investigated, and WQI was explored statistically.

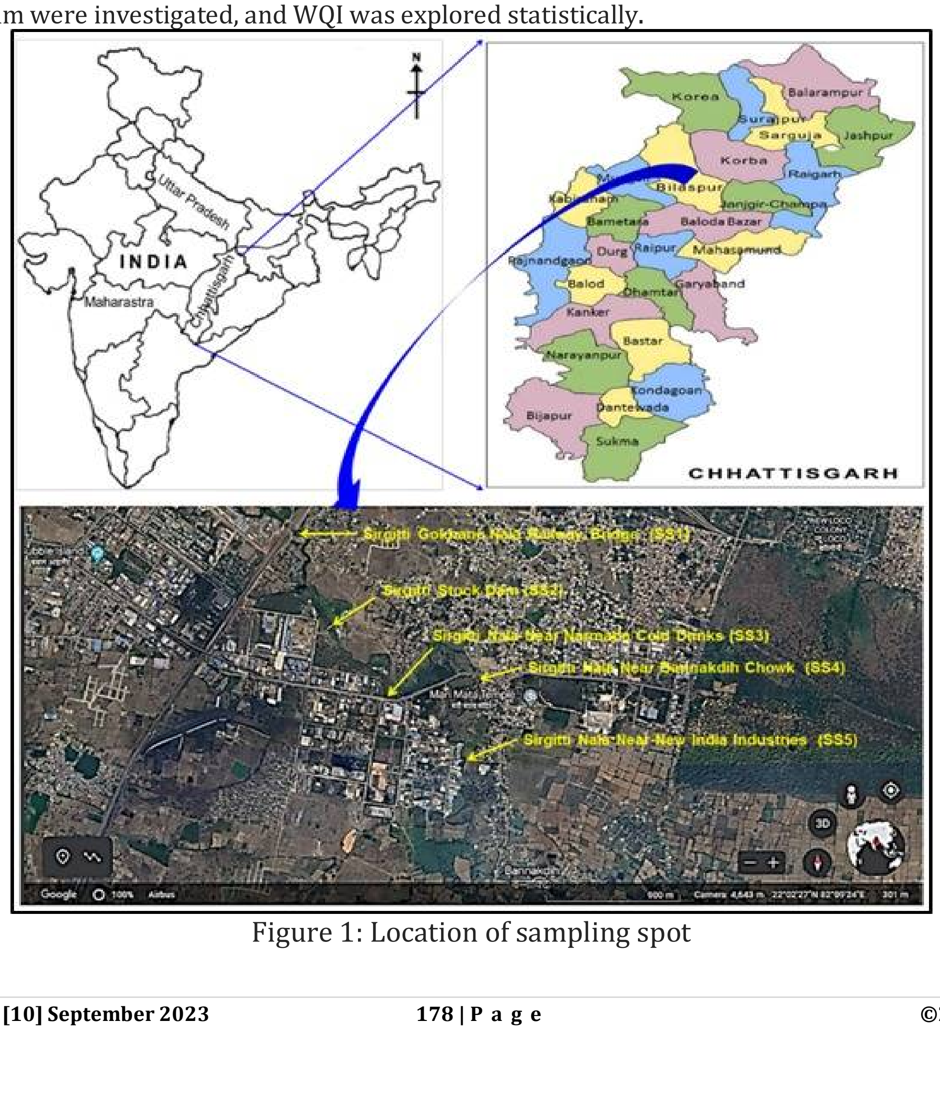

Figure 1: Location of sampling spot

Table 1: Physicochemical properties of surface waters of Sirgitti Industrial area

S.N.	Parameter	Sampling Spot				
		SS1	SS2	SS3	SS4	SS5
1	Temperature	30.2	30.4	29.8	30.3	30.5
2	pH	6.93	7.85	7.6	7.53	7.64
3	Conductivity	992.3	1238.3	1125.7	1388.55	1424.61
4	Turbidity	16	17	24	22.4	25.8
5	TS	1044	1053	1204	1421	1512
6	TDS	925	899	904	1083	1119
7	TSS	120	155	301	339	394
8	Alkalinity	523.4	554.67	543	498.58	486.6
9	Total Hardness	567	451	643.6	511.8	503.4
10	Chloride	324.7	465.66	388.46	376.4	388.52
11	Fluoride	1.09	0.87	1.41	0.94	0.99
12	Sulphate	286.62	234.02	352.54	421.7	409.7
13	D.O	3.5	3.16	4.15	3.9	4
14	BOD	2.7	3.55	2.5	3.99	4.3
15	COD	39	45.4	47.6	48	43.6
16	Nitrate	24.4	32.66	38.9	35.64	46.32
17	Phosphate	0.05	0.06	0.08	0.1	0.17
18	Sodium	55	78	136.4	195.6	205.2
19	Potassium	4.5	5.9	5.38	6.36	7.7
20	Calcium	268.3	286.76	199.76	206.7	213.96
21	Magnesium	34.22	28.88	45.7	34.9	40.52
22	Iron	0.99	1.39	1.24	1.07	1.13
23	Copper	0.03	1.5	0.04	0.07	0.06
24	Zinc	1.02	3.2	2.89	1.56	2.49
25	Magnese	0.2	0.43	0.41	0.03	0.02
26	Aluminium	0.12	0.14	0.13	0.22	0.26
27	Mercury	0.001	0.0089	0.0026	0.0012	0.0013
28	Lead	0.01	0.07	0.05	0.06	0.04
29	Cadmium	0.002	0.003	0.005	0.004	0.006
30	WQI	120.8	121.6	119.2	121.2	122

* All parameter in mg/L except Conductivity (μ mhos/cm), Turbidity (NTU) and pH
SS1= Sirgitti Gokhane Nala Railway Bridge, SS2= Sirgitt Stock Dam, SS3= Sirgitti Nala near Narmada Coldrinks, SS4=Sirgitti Nala near Bannakdihi Chowk and SS5= Sirgitti Nala near New India Industries.

RESULTS AND DISCUSSION

Table 1 shows the findings, while Tables 2–3 show the statistical data (mean, standard deviation, standard error, percent coefficient of variation, and water quality index).

Table 2: Qualitative and Quantitative Measures of Water Quality

Parameters	N	Range	Mean	SD	SE	%CV	Indian Drinking water Std. IS 10500: 2012	WHO Rec. 2011
Temperature	5	29.8-30.5	30.24	0.27	0.121	0.89	***	27-28
pH	5	6.93-7.85	7.51	0.35	0.157	4.66	6.5-8.5	6.5-8.5
Conductivity	5	992.3-1424.61	1233.89	180.54	80.74	14.632	***	1000.000
Turbidity	5	16-25.8	21.04	4.33	1.936	20.58	5-8 NTU	5 NTU
TS	5	1044-1512	1246.8	212.83	95.18	17.07	520-2050	***
TDS	5	899-1119	986	106.2	47.494	10.8	500-2000	1000.000
TSS	5	120-394	261.8	118.83	53.142	45.39	20-50	***
Alkalinity	5	486.6-554.67	521.25	28.76	12.862	5.52	300-600	***
Total Hardness	5	451-643.6	535.36	73.16	32.718	13.67	300-600	500.000
Chloride	5	324.7-465.66	388.748	50.42	22.549	12.97	200-1000	200-1000
Fluoride	5	0.87-1.41	1.06	0.21	0.094	19.81	1-1.2	1.500
Sulphate	5	234.02-421.7	340.916	80.26	35.893	23.54	200-400	250.000
D.O	5	3.16-4.15	3.742	0.4	0.179	10.69	5.000	***
BOD	5	2.5-4.3	3.408	0.79	0.353	23.18	5.000	***
COD	5	39-48	44.72	3.66	1.637	8.18	10.000	***
Nitrate	5	24.4-46.32	35.584	8.06	3.605	22.65	45	50
Phosphate	5	0.05-0.17	0.092	0.05	0.022	54.35	0.01	0.01
Sodium	5	55-205.2	134.04	67.54	30.205	50.39	75-200	200

Potassium	5	4.5-7.7	5.968	1.19	0.532	19.94	10	25
Calcium	5	199.76-286.76	235.096	39.6	17.71	16.84	75-200	200
Magnesium	5	28.88-45.7	36.844	6.44	2.88	17.48	30	***
Iron	5	0.99-1.39	1.164	0.16	0.072	13.75	0.3-1.0	0.3-1.0
Copper	5	0.03-1.5	0.34	0.65	0.291	191.18	0.05	2
Zinc	5	1.02-3.2	2.232	0.92	0.411	41.22	5	5
Magnese	5	0.02-0.43	0.218	0.2	0.089	91.74	0.1	0.5
Aluminium	5	0.12-0.26	0.174	0.06	0.027	34.48	0.03 - 0.2	0.2
Mercury	5	0.001-0.0089	0.003	0.003	0.001	100	0.001	0.006
Lead	5	0.01-0.07	0.046	0.02	0.009	43.48	0.01	0.01
Cadmium	5	0.002-0.006	0.004	0.002	0.001	50	0.003	0.003
WQI	5	119.2-121.6	120.7	1.05	0.525	0.87	50-75	-

Table 3: Index of Water Quality

Sampling Spot	ΣQiWi	Σwi	WQI=ΣQiWi/Σwi
SS1	23.677	0.196	120.8
SS2	23.834	0.196	121.6
SS3	23.363	0.196	119.2
SS4	23.755	0.196	121.2
SS5	23.912	0.196	122

pH

Our study found a pH range from 6.93 at the SS1 sample site to 7.85 at the SS2 site. The water slightly acidic to slightly basic pH is within the safe range recommended by the World Health Organization and the Bureau of Indian Standards.

Electrical Conductivity

The ideal range of conductivity for aquatic life is between 150 and 500 Scm^{-1}. Conductivity readings showed a range from 992.3 mhos/cm at the SS1 site to 1424.61 mhos/cm at the SS5 location, both of which are beyond the maximum allowable level set by the WHO, 2011 [25]. The high EC value indicates that the water sample had a significant quantity of dissolved inorganic and organic salts [9].

Turbidity

At the SS1 sampling location, the reading was 16 NTU; however, at the SS5 sample site, the reading was 25.8 NTU. All the readings were too high instead of the 5–8 NTU allowed by WHO (2011) and BIS (2012) [24-25].

Suspended and Dissolved Solid

At sampling locations SS1 and SS5, TS concentrations of 1044 to 1512 mg/L were found. Samples of the filtrate water were tested for total dissolved solids (TDS) and found to have 899 mg/L at the SS2 site and 1119 mg/L at the SS5 site. TSS levels at sample sites SS1 and SS5 were recorded between 120 and 394 mg/L. Both the TS and TDS levels were well below the permitted range; however, in all sampling locations, the TSS values were too high [24-25].

Alkalinity

Dissolved ions like hydroxyl (OH^-), bicarbonate (HCO_3^-), phosphate (PO_4^{3-}), borate (BO_3^{2-}), and others are responsible for the water's alkalinity. Different water monitoring authorities, including WHO (2011) and BIS (2012), recommend a range of 300 mg/L to 600 mg/L as the optimal and maximum allowable units. We found a low alkalinity concentration of 486.6 mg/L at sampling site SS5 and a maximum alkalinity concentration of 554.67 mg/L at site SS2.

Total Hardness

When calculating overall hardness, both the temporary and permanent hardness values are added together. The dissolved ions of hydroxyl (OH^-), hydrogen carbonate (HCO_3^-), chloride (Cl^-), and sulfate (SO_4^{2-}) contribute significantly to the hardness of water. The study area included a range of 451 mg/L to 643.6 mg/L, with values obtained at SS2 and SS3. The highest amount exceeded the 500 mg/L threshold set by the WHO's drinking water quality guidelines in 2011 [16].

DO

The level of dissolved oxygen in the water is a key indicator of the degree of organic water pollution. Several organizations that keep tabs on water quality say that a level of 5 mg/L is ideal. The low and high values we observed in our research ranged from 3.16 mg/L to 4.15 mg/L in the SS2 and SS3 sample locations, respectively.

BOD

At SS3, the BOD concentration was 2.5 mg/L, but at SS5, it reached 4.3 mg/L. The contents of many water samples were determined to be below the 5 mg/L threshold set by BIS (2012) [10].

COD

Results varied between 39 and 48 mg/L (SS1 and SS4, respectively). This amount is higher than the 10 mg/L set by the BIS in 1991, the standard drinking water agency. There may be more carbonaceous and suspended particles in the water due to the high value [31].

Chloride

Cl^- has a laxative impact on people who aren't used to it, and its microbial killing capacity is pH-dependent. Our preliminary investigation reveals that the concentrations in SS1 and SS2 are below the target range, ranging from 324.7 to 465.66 mg/L.

Fluoride

Humans may make use of fluoride concentrations between 1.0 and 1.5 mg/L. When its concentration exceeds the safe range of 1.1 to 1.5 mg/L (WHO, 2011), it becomes harmful to human health. The concentrations of SS2 and SS3 found in this study ranged from 0.87 to 1.41 mg/L. The measured value was within the typical margin of the permissible level [32].

Sulphate

The lowest value of sulphate was found 234.02 mg/L at SS2, while the highest was 421.7 mg/L at SS4. The measured value was within the typical margin of the permissible level [24-25].

Nitrate

At the SS1 sampling site, nitrate levels were found to be as low as 24.4 mg/L and as high as 46.32 mg/L at the SS5 sampling site. The measured value was within the typical margin of the permissible level [24-25].

Phosphate

Phosphate in water often comes from two places: human waste and artificial fertilizer. This research found phosphate concentrations that exceeded both the World Health Organization's (2011) and the BSI's (2012) recommendations, with values as high as 0.17 mg/L at the SS5 sample location [24-25].

Sodium

The majority of the sodium in our water supply comes from human waste. Our study found that the concentrations of sodium in SS1 and SS5 were 55 mg/L and 205.2 mg/L, respectively (the sodium concentration in SS5 was above the permissible limits) [24-25].

Potassium

BIS, WHO, and ICMR all agree that 10 mg/L is the maximum allowable concentration in potable water. The lowest potassium concentration, 4.5 mg/L at sampling site SS1 and the highest concentration, 7.7 mg/L at site SS5, are well below permissible limits [24-25].

Calcium

The significant dissociation of its components in water gives rise to hard water. Our studies showed that calcium concentrations in SS3 and SS2 varied from 199.76 mg/L to 286.76 mg/L. Nearly every sampling site had levels above the normative upper limit [17].

Magnesium

The significant dissociation of its components in water gives rise to hard water. Our studies showed that magnesium concentrations in SS2 and SS3 varied from 28.88 mg/L to 45.7 mg/L. Nearly every location we checked out had readings that were the maximum we'd expected [14].

Copper

We found that the copper concentrations ranged from 0.03 to 1.5 mg/L. At the sampling location SS1, it was found to have a minimum value of 0.03 mg/L and a maximum value of 1.15 mg/L at the location SS5. At a few locations, the levels of copper were far higher than what is considered safe for use in drinking water.

Zinc

Our results showed a range of zinc concentrations, from 1.02 mg/L (the minimum value at SS1) to 3.2 mg/L (the maximum value at SS2). Zinc concentrations in all areas were below the maximum allowed by the norm for potable water.

Manganese

Our data showed that manganese concentrations ranged from 0.02 to 0.43 mg/L (at SS5 and SS2, respectively). A small percentage of the sample locations had manganese concentrations that were below the standards for safe drinking water [25].

Mercury
Our results showed a range of SS2 concentrations from 0.001 to 0.0089 mg/L (at SS1 and SS2, respectively). Several locations (especially at SS2) have mercury concentrations that are too high to be considered safe for human consumption [17].

Lead
Our results showed lead concentration levels ranging from 0.01 mg/L (at SS1) to 0.07 mg/L (at SS2). In a few locations, lead concentrations were found to be far higher than what is considered safe for use in drinking water.

Cadmium
Cadmium is too much toxic element in nature. The concentrations of cadmium in our investigation ranged from 0.002 mg/L to 0.006 mg/L at SS1 and SS5, respectively. Some locations had cadmium concentrations that were too high to be considered safe for human consumption.

Water Quality Index
The water quality index was computed, and the findings varied from 120.8 at the SS1 sample site to 122 at the SS5 measurement point. The water quality index may be seen to have a wide variation. When this statistical characteristic was high, it meant that a lot of pollutants were being dumped into the environment. All the sampling locations had water quality indicators (WQIs) over the maximum value of 100, indicating very poor water quality and the possible introduction of contaminants into the water supply from nearby landfills and sewage treatment plants [10, 31].

CONCLUSION
Water is the elixir of any form of life. The purpose of this research was to assess the degree of pollution in the Sirgitti industrial area's open water systems. The above findings and accompanying analysis and discussion make it clear that almost 70% of water quality parameters were higher than the recommended limit, which is an indication of pollution hazards and is also confirmed by WQI values. Surface water bodies are polluted by the contamination of commercial effluents, which may impede public health. There is evidence that toxins from causes including municipal garbage and industrial effluent have made their way into the water supplies, suggesting that the quality of the water is quite bad because it is above the permissible threshold. Water sources in the present research region have become highly contaminated, which is not acceptable by established norms. The water sources are not fit for agricultural or industrial purposes.

Conflict of Interest
There is no conflict of interest between authors regarding academic, commercial, financial, personal and professionally relevant to the work.

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