ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 9, Issue 11 , November 2022

Effect of Steel Industry effluent on surface water and ground water quality

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ABSTRACT: Industrialization exploited the water resources both by making huge amount of water for process continuation and releasing the effluents to the water-bodies. An attempt has made to study the impact of release of steel plant effluents on nearby surface and ground water. The investigation of samples showed the pH value is within the BIS recommended value. EC in all the water samples varied widely from 103 to 1480 µS/cm. The TDS found in range from 62 –888 mg/l. TDS in the samples RWS5 (828 mg/l) and BWS9 (888 mg/l) are above the permissible limit. The values of alkalinity varied from a minimum of 40 mg/l and maximum of 170 mg/l. The chloride values ranged from 45 to 100 mg/l and are within the permissible limit of BIS. The iron ranged from 0.036 to 0.265 mg/l. The lead ranged from 0.033 – 0.400 mg/l. The lead investigated were above the values of BIS and WHO standard with the exception of sample DWS3 (BDL), BWS7 (0.041mg/l) and TWS8 (0.033 mg/l). The highest value was observed for BWS9 (0.400 mg/l) and lowest for TWS8 (0.033 mg/l). The value of chromium in some of the samples tasted below the permissible level, that ranged from 0.027 to 0.058 mg/l with the exception of samples FWS4 (0.163 mg/l), RWS5 (0.113 mg/l) and PWS6 (0.058 mg/l). It can be concluded that the quality of waste water and surface water is deteriorating in Bhilai Industrial area with high concentration of undesirable quality of TDS, EC, lead and chromium.

KEY WORDS: Physicochemical, heavy metals, industrial effluent, surface water, groundwater

I. INTRODUCTION

Industrial and sewage effluents from Steel Plant in Bhilai and Chhattisgarh situated in the catchment of the river Seonath and its tributary - Kharoon, are discharged into them making them highly polluted and also polluting the ground water regime in the heart of the city. The major industries discharging wastes into the river include Bhilai Steel plant (BSP), HEG Borai, steel industries near Siltara Raipur apart from other non steel industries like Kedia Distilleries Plant in Bhilai Rice mills at Durg, Kedia Distillery in Raipur Dist. The Municipal Corporation of Bhilai, Durg and Raipur also discharge partly treated or untreated effluents into the river Seonath through several drains at Bhilai, Durg and through Chhokranala main drain into Kharoon River [1].
The effluents discharged from different units of steel plants from time to time are released into the nearby water body and cause water pollution. The effluents of blast furnace emanate from operation in the form of wash water containing suspended solids, oxygen demanding substances, cynide, oil and other heavy metals Unit of pig casting releases solid particles in its effluent and is alkaline in nature The major source of waste water during steel making is the cooling water that contains hexavalent chromium Hexavalent form of chromium is more hazardous to biological activities [2, 3]. Hence the regulation of quality of industrial effluents is of almost necessity in order to protect the aquatic environment from adverse effects caused by effluent discharge [4]. The extent of discharge of domestic and industrial waste is such that rivers receiving untreated effluents cannot give dilution necessary for their survival as good quality water sources [5]. Not only it brings about several chemical changes and high degree of variation in metal concentration but also affects the entire ecosystem including the bacterial population [6, 7]. The effluents contain various inorganic and organic substances in different concentrations that may also affect the growth and germination of crop plants [8]. Heavy metals are present in waste water from industries and municipal sewage and form one of the chief polluting sources widespread in environment [9, 10]. When these metals enter the human body in more than the prescribed limits, start causing harm [11]. These are extremely persistent in the environment, as these are non-biodegradable and non thermo-degradable and thus, readily accumulate to toxic levels [12, 13].

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II. SITE OF STUDY

Bhilai city is located in the Durg district of Chhattisgarh is about 22 kilometers west to Raipur, the capital of Chhattisgarh on the main Howrah–Mumbai rail line and National Highway 6. It coordinates at 21.21°N 81.38°E and is spread over an area of about 269.45km^2. Bhilai Steel Plant (BSP) is India's first and main producer of steel rails, as well as a major producer of wide steel plates and other steel products. It is popularly called as the 'Steel City of Central India'.

III. MATERIAL AND METHODS

Water samples were collected from BSP area of Bhilai at nine different sampling site i.e. LF SMS II (BSP), Continuous Slave Castle (BSP), Newai Dam (Utai Road, Bhilai), Chemical Zone (Blast Furnace 8), Shivnath River (Rajnandgaon Road, Durg), Pond Water (Civic Centre, Bhilai), Hand Pump (Street-4, Sector-4, Bhilai), BSP Water tank (Sector-4, Bhilai) and Boring (Kailash Nagar, Bhilai).

Table 1: Methods used for estimation of physicochemical parameters

S.N.	Parameters/Units	Method / Apparatus	Reference
1	pH & EC	pH Meter Orian 5-Star	APHA (1995)
2.	Alkalinity mg/l		
4.	TDS mg/l	Field Water Testing Kit	TWAD Board
5.	Chloride mg/l		
8..	F, Fe, Pb, Cr mg/l	UV VIS Spectrophotometer Varian	APHA (1995)

Fig. 1: Location map of sampling points

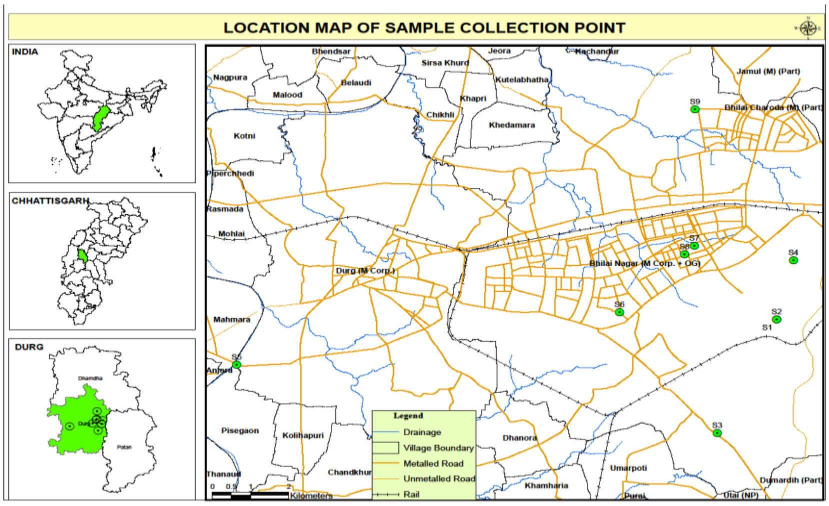

Table 2: Geographical coordinates of sampling points

SI	Sample code	Name of Area	Latitude	Longitude
1	WWS1	LF SMS II (BSP)	21.175597°	81.3853051°
2	WWS2	Continuous Slave Castle (BSP)	21.175597°	81.3853051°
3	DWS3	Newai Dam (Utai road, Bhilai)	21.143812°	81.369655°
4	FWS4	Chemical Zone (Blast Furnace 8)	21.192216°	81.389751°
5	RWS5	Shivnath River (Rajnandgaon road, Durg)	21.164175°	81.246036°
6	PWS6	Pond Water (Civic Centre, Bhilai)	21.177948°	81.344804°
7	BWS7	Hand Pump (Street-4, Sector-4, Bhilai)	21.196482°	81.364288°
8	TW8	BSP Water tank (Sector-4, Bhilai)	21.194162°	81.361718°
9	BWS9	Boring (Kailash Nagar, Bhilai)	21.234864°	81.364864°

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International Journal of Advanced Research in Science, Engineering and Technology
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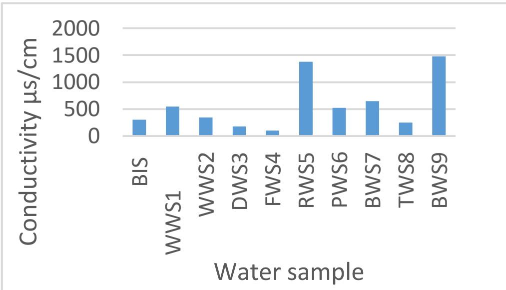
IV. RESULT AND DISCUSSION



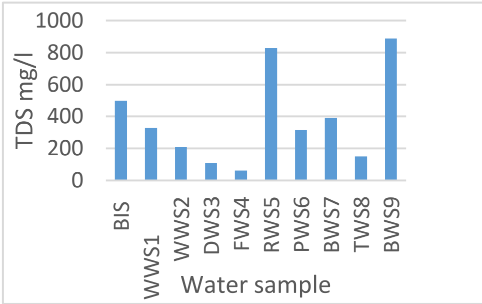
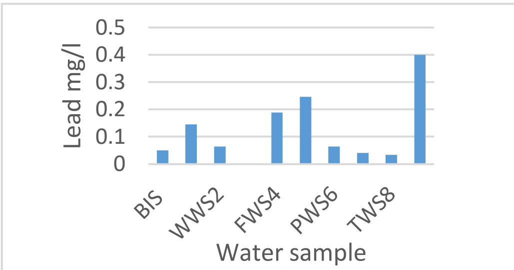


Fig. 2: Concentration of conductivity in waste water, surface water and ground water
Fig. 3: Concentration of TDS in waste water, surface water and ground water



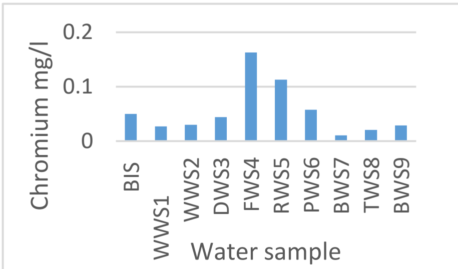


Fig. 4: Concentration of lead in waste water, surface water and ground water
Fig. 5: Concentration of chromium in waste water, surface water and ground water

The diagrams show the levels of pollutants in the ground water samples & surface water samples and comparison with the recommended standards by BIS (1993) [14] and WHO (2004) [15]. The data reveals that there were considerable variations in the examined samples from different sources with respect to their physical and chemical characteristics and this indicates that the quality of water considerably varies from location to location. The sequence of the abundance of the major cations and anions is chloride>fluoride>iron>lead>chromium. All the investigated data were compared with BIS standard values given for drinking and industrial & irrigation purpose.

Hydrogen ion concentration (pH) - Determination of pH is very important because it influences the other physicochemical parameters and the availability of metal ion in the water and waste water. In addition; all the biochemical reactions are sensitive to the variation in pH and it is one of the most important operational water quality parameters [16]. The recommended pH range necessary for drinking water is from 6.5 to 8.5. The investigation in our samples showed the pH value ranges from 6.3 to 8.2, it indicates the pH of water is within the BIS recommended value.

Conductivity - Electrical conductance is a measure of the ability of an aqueous solution to carry an electric current that depends on the presence and total concentration of ions, their mobility and valance and on the temperature. It is a useful tool to assess the purity of water [17]. The BIS permissible limit for EC of water is 300 µS/cm and the conductivity values in all the water samples varied widely from 103 to 1480 µS/cm. It depends upon temperature, concentration and types of ions present [18]. High conductivity of water sample shows an alarming condition towards mixing of electrolytes from industrial waste.

Alkalinity - Total alkalinity is a measure of the ability of water to neutralize acids. The alkalinity of groundwater is mainly due to carbonates and bicarbonates [19]. Data represents the variation in total alkalinity of water samples ranged from a minimum of 40 mg/l and maximum of 170 mg/l. The alkalinity of all the samples of ground and surface water was in accordance with the BIS desirable level 200 mg/l, but was less than the maximum permissible limit and in the absence of alternate water source; alkalinity up to 600 mg/l is acceptable for drinking. Almost all natural supplies have a measurable amount of this ion, ranging from 0 to about 50200 mg/l. High alkalinity, while not detrimental to humans may cause drinking water to have a flat, unpleasant taste [20].

TDS - Total dissolved solid (TDS) is a measure of the combined concentration of all inorganic and organic substances contained in water. TDS values depend on climate, the host rock, and the residence time of the groundwater in the geological matrix. The permissible limit of TDS in drinking water is 500 mg/l (WHO, 2004). The present study showed that TDS found in range from 62 –888 mg/l. Result of TDS in the samples RWS5 (828 mg/l) and BWS9 (888 mg/l) are above the permissible limit. TDS analysis has great implications in the control of biological and physical waste water treatment processes. The most remarkable observation of investigation was the alarmingly high level of total dissolved solids at the two sites. The salinity of water containing more than 500 mg/l of TDS is not considered desirable for drinking water supplies, but in unavoidable cases 1500 mg/l is also allowed.

Chloride - According to BIS the permissible limit for chloride contents in water sample is 250 mg/l. The current analysis result reveals that the chloride values of water samples ranged from 45 to 100 mg/l and are within the permissible limit of BIS. Every water supply contains some chloride. Chloride is common in nature, generally as a salt. Porosity of soil and permeability also plays a key role in building up the chlorides concentration [19].

Fluoride - According to the recommendation of WHO and BIS most ground water samples have low or acceptable concentrations of fluoride (<1.5 mg/l). Presence of large amounts of fluoride is associated with dental and skeletal fluorosis (>1.5 mg/l) and inadequate amounts with dental caries (<1 mg/l).The concentration of fluoride in all the samples found below detection limit with the exception of TWS8 (0.206 mg/l) and BWS9 (0.452 mg/l) that is also within the recommendation of WHO and BIS.

Iron - Concentrations in all the investigated water samples were found within the permissible limit of BIS and WHO standards. The concentration of iron ranged from 0.036 to 0.265 mg/l. Water with high iron concentrations may be discolored and stain washed clothing. Iron concentrations however do not pose potential health risk as they fall well within the recommended daily dietary allowance (7mg – 18mg) [20].

Lead - The values of lead in all water samples tested ranging from 0.033 – 0.400 mg/l hence need a special attention. The values of lead obtained for some samples investigated were above the values of BIS and WHO standard with the exception of sample DWS3 (BDL), BWS7 (0.041mg/l) and TWS8 (0.033 mg/l). Lead has many toxic effects on human health with children being the most vulnerable population (Payne, 2008). Corrosion of plumbing systems is an important source of excessive lead in drinking-water (World Health Organization, 2004) [15]. Excessive exposure to lead is associated with various neuro-developmental problems and a 4.1-fold increased risk of attention deficit hyperactivity disorder in children [21].

Chromium - The chromium value in few samples tasted below the permissible level, the values ranged from 0.027 to 0.058 mg/l with the exception of samples FWS4 (0.163 mg/l), RWS5 (0.113 mg/l) and PWS6 (0.058 mg/l). Possible sources of Cr in industrial effluent could be linked to chrome plating and alloys for corrosion prevention [22]. During the chrome tanning process, 40% unused chromium salts are usually discharged in the final effluents which is a serious threat to the environment [23, 24].

Nemerow's Pollution Index –NPI - Chen Jie et al., (2012) [25] intends to introduce a method by joining the improved Nemerow index method. The pollution causing parameters are determined through Nemerow's pollution index using the average values of physico-chemical parameters indicated in Table 1. NPI is evaluated for all the parameters for each sample analyzed, thus identifying the pollution causing parameters. The equation used in evaluating the NPI is reproduced below:

$NPI = C_i / L_i$, Where; C_i = observed concentration of i parameter, L_i = permissible limit of i parameter.

In above expressions unit of C_i and L_i should be identical. Each value of NPI shows the relative pollution contributed by single parameter. It has no units. L_i values for different water quality parameters are indicated in Table 1. NPI value exceeding 1.0 indicate the presence of impurity in water. It indicates its presence in surplus amount in the water samples and particular parameter has the potential of contributing pollution to the water body or the underground water studied.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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Table: 3: NPI values of different sampling stations

Parameters	WWS1	WWS2	DWS3	FWS4	RWS5	PWS6	BWS7	TWS8	BWS9
pH	0.905	0.929	0.964	0.776	0.741	0.811	0.858	0.952	0.905
Conductivity	1.82	1.146	0.59	0.343	4.6	1.75	2.166	0.833	4.933
TDS	0.656	0.414	0.22	0.124	1.656	0.63	0.78	0.3	1.776
Alkalinity	0.35	0.2	0.25	0.35	0.4	0.45	0.65	0.2	0.85
Chloride	0.28	0.22	0.28	0.32	0.28	0.3	0.36	0.18	0.4
Iron	0.373	0.423	0.883	0.19	0.393	0.043	0.082	0.012	0.017
Lead	2.9	1.28	BDL	3.76	4.92	1.28	0.82	0.66	8
Chromium	0.54	0.6	0.88	3.26	2.26	1.16	0.22	0.42	0.58

The analysis reveals that the quality of waste water, surface water and ground water at station 1 is polluted due to EC, TDS, iron, lead and chromium, as the NPI value of these parameters is more than 1(NPI>1). Similarly at station 2 the pollution is due to EC, TDS, chloride, iron, chromium and lead. At station 3 the pollution is due to EC, TDS, chloride, chromium, iron and lead, at station 4 the pollution is due to EC, TDS, iron, chromium and lead. At station 5, the pollution is due to EC, TDS, chromium, iron and lead at station 6 the pollution is due to EC, TDS, chloride, chromium, iron and lead. At station 7 the pollution is due to EC, TDS, chloride, chromium, iron and lead, at station 8 the pollution is due to EC, TDS, iron, chromium and lead. At station 9 the pollution is due to EC, TDS, chloride, chromium, iron and lead. Evaluation of NPI for physicochemical parameters indicates that the studied water is not good for drinking but suitable for commercial and irrigation purpose.

V. CONCLUSION

It is very clear from the data of surface water quality standards of BIS that all the investigated samples were within the range of Class E that is water for irrigation, industrial cooling and controlled water disposal. When we compare the investigated results with drinking water parameters prescribed by BIS and WHO values of lead in all water samples tested ranging from 1.0 – 2.22 mg/l hence need a special attention. The values of lead obtained for some samples investigated were above the values of BIS and WHO standard with the exception of sample DWS3 (BDL), RWS5 (4.92 mg/l) and BWS9 (8 mg/l).The chromium value in a few samples tasted below the permissible level with the exception of samples FWS4 (3.26 mg/l), RWS5 (2.26 mg/l) and PWS6 (1.16 mg/l). This is a matter of great concern because both the elements lead and chromium are very toxic when found above the permissible limits.

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