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Assessment Of Water Quality Index Of Industrial Area Surface Water Samples

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Abstract: Water quality index (WQI) is a dimensionless number that combines multiple water quality factors into a single number by normalizing values to subjective rating curves. The present work is aimed at assessing the Water Quality Index (W.Q.I) of surface water of Bhilai Steel Plant industrial area. Physicochemical parameters were monitored for the calculation of W.Q.I for the summer seasons 2011. The physicochemical parameters namely pH, Total hardness, TDS, Calcium, Chloride, Sulphate, Phosphate, Sodium, Potassium, EC and DO was determined and it is found that their values were within the permissible limits on the other hand total alkalinities and magnesium values were exceeding the permissible limits as prescribed by Indian Standards. The analysis reveals that the surface water of the area needs some treatment before consumption, and it also needs to be protected from the perils of contamination.
Key Words: physicochemical parameters, Water quality standards, Water Quality Index, Drinking water quality.

INTRODUCTION

Water is an essential component for survival of life of Earth, which contains minerals, important for human beings as well as plant and aquatic life. The availability of water both in terms of quality and quantity is essential for the very existence of mankind (1-3). Water is mainly used for drinking, bathing, fisheries and other domestic purposes. Lack of awareness and civic sense, use of inefficient methods and technology lead to more than 50% of water wastage in the domestic, agriculture & industrial sectors (4-7). Water pollution is rendering much of the available water unsafe for consumption. There is heavy extraction of water for domestic, industrial and agricultural purpose. In India, most of the population is dependent on surface water (damp water) as the only source of drinking water supply (8-9). The groundwater is believed to be comparatively much clean and free from pollution than surface water. But prolonged discharge of industrial effluents, domestic sewage and solid waste dump causes the groundwater to become polluted and created health problems (10). Water quality index (W.Q.I) provides a single number that expresses overall water quality at a certain location and time, based on several water quality parameters (11-12). The objective of water quality index is to turn complex water quality data into information that is understandable and used by the public. A water quality index based on some very important parameters provides a single indicator of water quality. In general, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a water system with number (13-15). Physicochemical properties of water in any aquatic ecosystem are largely governed by the existing meteorological conditions and are essential for determining the structural and functional status of natural water (16). The present study was under taken to define the quality of water samples with special reference to

physicochemical properties to decide its WQI. The analyzed data were compared with standard values recommended by BIS & ICMR (17-18).

STUDY AREA

The Bhilai Steel Plant (BSP) was set up in year 1955-56 to produce pig iron in this region. Its production rate is 2 ≈ 3.15 MT iron year^{-1}. The surface water samples were collected from different sites of BSP in May- June 2011 Figure 1.

METHODOLOGY

The water sample from the industrial area were collected and analyzed for 11 physicochemical parameters by following the established procedures. The parameters pH and dissolved oxygen were monitored at the sampling site and other parameters like total dissolved solids, total alkalinity, total hardness, calcium, magnesium, chloride and sulphate were analyzed in the laboratory as per the standard procedures of APHA (19).

In this study the W.Q.I has been calculated by using the standards of drinking water quality recommended by BIS (1993) and ICMR (1975).

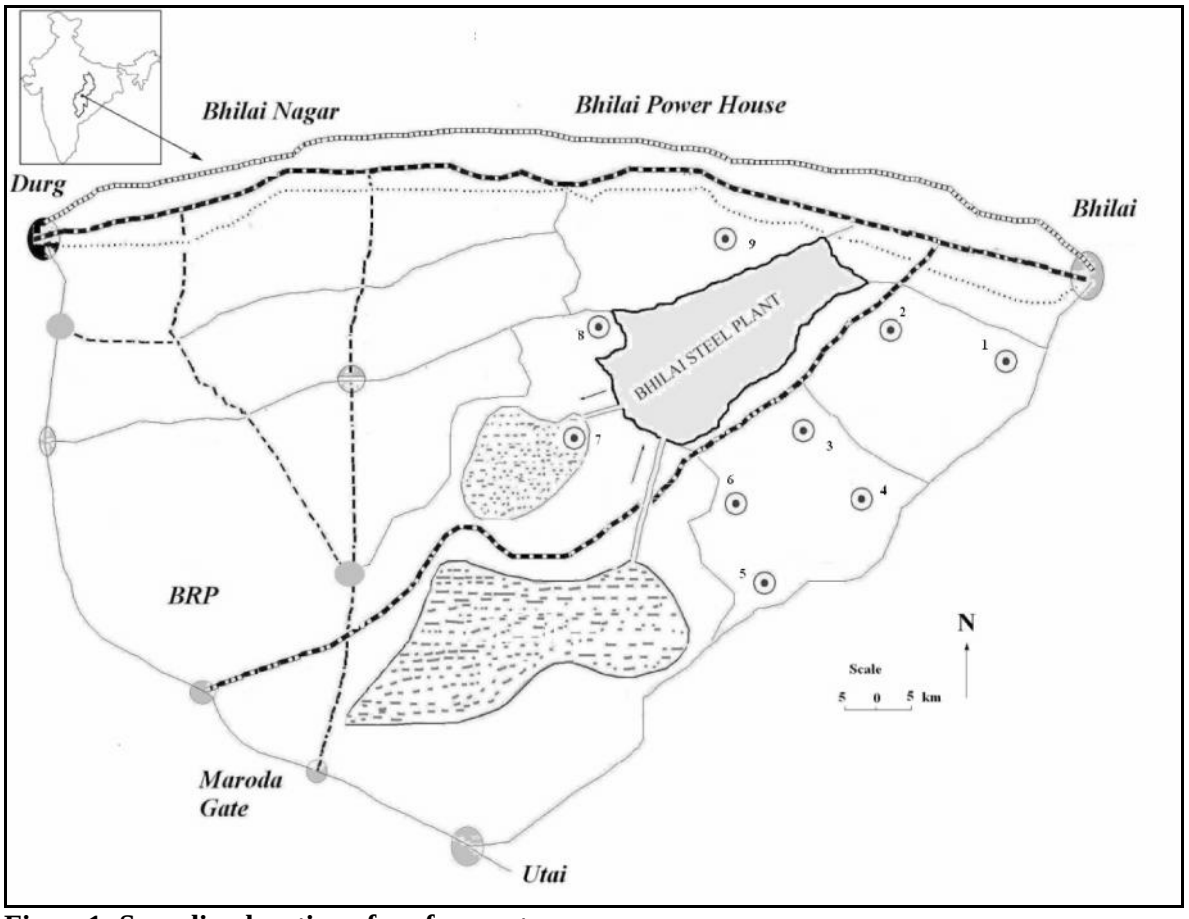

Figure1: Sampling location of surface water

Table 1 Water Quality Index (W.Q.I.) and status of water quality	
Water Quality Index	Water Quality Status
0 – 25	Excellent Water Quality
26 – 50	Good Water Quality
51 – 75	Poor Water Quality
76 – 100	Very Poor Water Quality
> 100	Unfit for drinking

Table 2 Drinking Water standards recommending agencies and unit weight.
(All values except pH is in mg/L)

Parameters	Standards	Recommended Agency	Unit weight(Wn)
pH	6.5-8.5	ICMR / BIS	0.2188
Total Alkalinity	120	ICMR	0.0155
Total Hardness	300	ICMR / BIS	0.0062
EC(µS/cm)	300	ICMR	0.371
TDS	500	ICMR / BIS	0.0037
Calcium	75	ICMR / BIS	0.025
Magnesium	30	ICMR / BIS	0.061
Chloride	250	ICMR	0.0074
Sulphate	150	ICMR / BIS	0.0124
DO	5.0	ICMR / BIS	0.3723
Nitrate	45	ICMR / BIS	0.0413
			∑Wn =1.1346

The weighted arithmetic index method has been used for the calculation of W.Q.I. Further quality rating or sub index (qn) was calculated using the following expression-

Qn = 100 x [Vn-Vo] / [Sn-Vo]

Where, qn = Quality rating for the nth water quality parameter.
Vn = Estimated value of the nth parameter at a given sampling station.
Sn = Standard permissible value of the nth parameter.
Vo = Ideal value of nth parameter in a pure water.
Unit weight was calculated by a value inversely proportional to the recommended standard values Sn of the corresponding parameters.

$$Wn = K/Sn$$

Where, Wn = Unit weight for the nth parameter.
Sn = Standard value for nth parameter.
K = Constant for proportionality

The overall Water Quality Index (W.Q.I) was calculated by aggregating the quality rating with the unit weight linearly.
WQI = ∑qn Wn ⁄ ∑Wn

RESULTS AND DISCUSSION

The physicochemical parameters of water quality were analysed using standard methods given in APHA (American Public Health Association). The observation and graphical representations of physicochemical characteristics of collected water samples are given in Table 3. It should be recognized that, like dissolved oxygen, pH also varies in streams naturally throughout the day due to the photosynthesis and respiration cycles in the presence of algae in water bodies. The pH is measure of the intensity of acidity or alkalinity and the concentration of hydrogen ion concentration. pH has no direct adverse effects on health; however, higher values of pH hasten the scale formation in water heating apparatus and also reduce germicidal potential of chloride. High pH induces the formation of tri halo methane which is toxic. The pH values of water samples of present study ranged from 6.35 to 6.9 which are within the prescribed limit of standards. Calcium and Magnesium concentration is higher in sampling site 5 are slightly higher than the standard limit given by BIS. Chloride, sulphate, nitrate and pH values of all the investigated samples are within the prescribed limit given by WHO, ICMR and BIS (17- 18, 20). Other parameters like, Alkalinity, Hardness, EC and TDS are found above the permissible limit of the surface water. All observed physicochemical parameters of surface water from different locations are shown in the Box and Whisker Plot Figure 1.

WQI is established through the measurement of various important physicochemical parameters of the surface water. The values of various physicochemical parameters for the calculation of WQI are presented in Table 3. The values of WQI showed the higher percent of poor category of surface water was found in the sampling site. It may be due to the effective ionic leaching, over exploitation and anthropogenic activities such as discharge of effluents from industrial, agricultural and domestic uses. It is found that the 47% of surface water on the sampling location are of very poor quality. This clearly indicates that water samples for this region are highly polluted. They are not suitable for drinking purpose and other useful

human activities. The water quality index (WQI) indicates that sampling site S6 is highly polluted (Figure 3). The order of WQI for different sampling sites follows:

S6 > S3 > S4 > S5 > S9 > S1 > S2 > S7 > S8.

The surface water collected from four sampling site (S6, S3, S4 and S5) are more polluted as than other 5 sites. These four sites are near to industrial waste dumping yard so they are more polluted due to collection of industrial effluents, wastes and sewage water. We observed that, the water quality from various stations is not used for human consumption by local people.

Table 3 Physicochemical parameters of surface water samples (mg l^{-1}) except pH values

Parameters	S1	S 2	S 3	S4	S5	S6	S7	S8	S9
pH	6.5	6.8	6.4	6.9	6.4	6.3	6.6	6.4	6.5
Alkalinity	178	194	167	187	174	148	159	156	179
Hardness	328	412	615	712	614	523	459	618	478
EC (µS/cm)	807.6	918.6	977.2	1164.6	890.6	989.6	903.2	894.6	915.6
TDS	452.3	542.2	654.6	745.2	614.5	568.7	546.2	505.7	618.3
Calcium	38.4	62.3	27.2	40	100	36	44.4	43.2	50
Magnesium	14.2	34.1	11	14.3	39	12	14.5	14	12.1
Chloride	96	58	101	77	109	97	71	66	112
Sulphate	40.4	35.6	22	37.6	32.2	26.7	25.2	36.4	27.2
DO	5.14	5.57	6.14	5.35	5.06	4.78	6.47	6.91	5.47
Nitrate	0.26	0.34	0.37	0.48	0.52	0.37	0.41	0.28	0.34
WQI	**(WQI)1 =80**	**(WQI)2 =79.8**	**(WQI)3 =86.8**	**(WQI)4 =83.9**	**(WQI)5 =84.2**	**(WQI)6 =94.2**	**(WQI)7 =76.4**	**(WQI)8 =75.4**	**(WQI)9 =81.8**

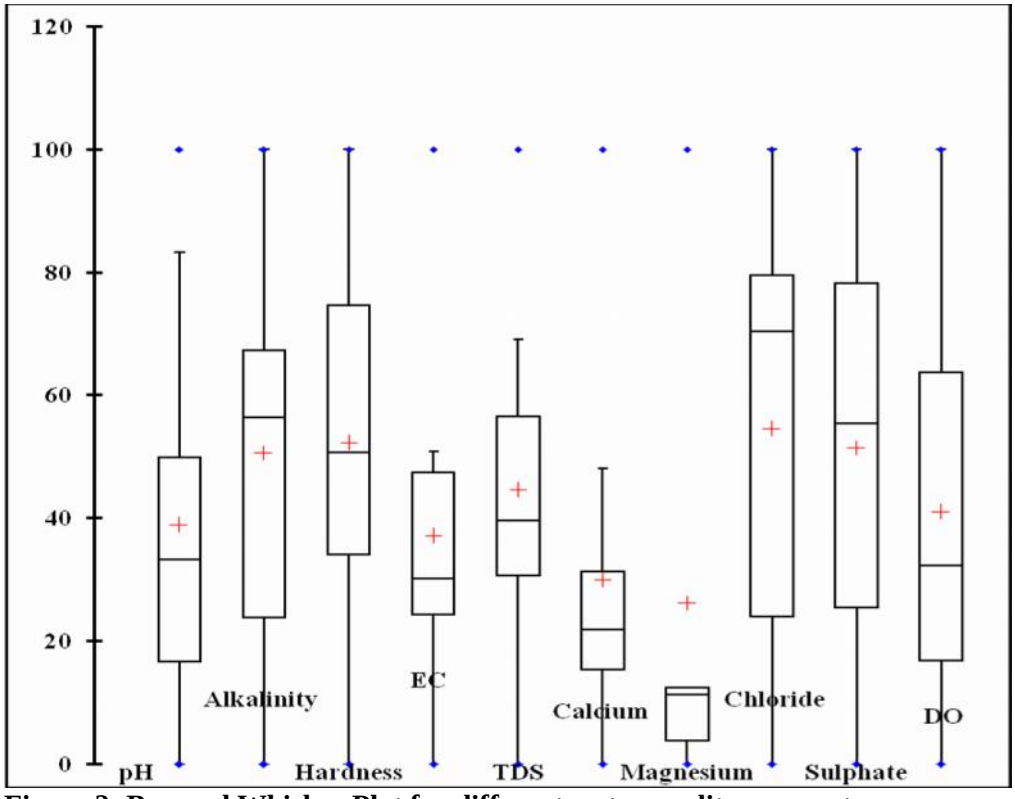

Figure 2: Box and Whisker Plot for different water quality parameters

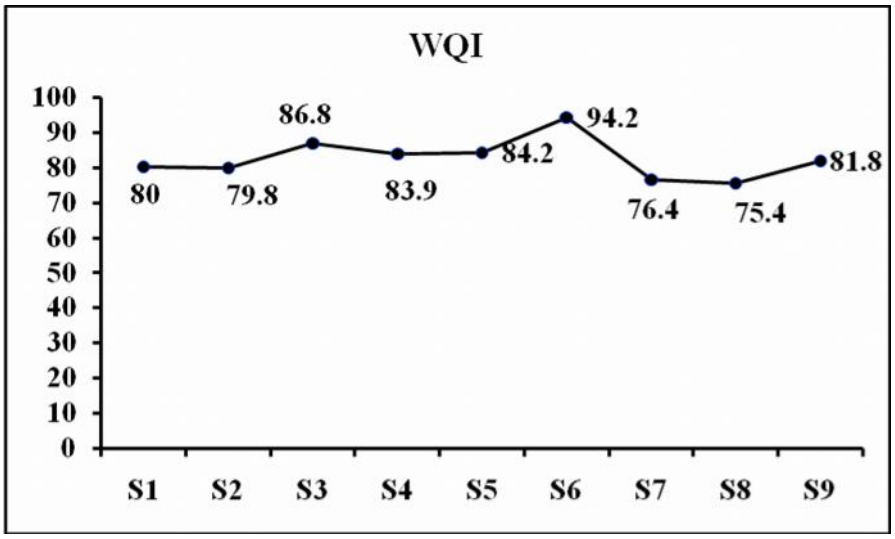

Figure 3: WQI values for different sampling site

CONCLUSION

The water quality indices (WQI) were in the range 80- 94.2 indicating very poor water qualities around the industrial area. The four sampling sites close to the steel plant increasing to severe pollution along the rest of the sites. It is recommended that the surface around the steel plant should not be used for human activities before being treated by appropriate methods. WQI can play a big role in mitigating the pollution problems after encountered in different surface water bodies. Application of Water Quality Index (WQI) in this study has been found useful in assessing the overall quality of water and to get ride of judgment on quality of the water. This method appears to be more systematic and gives comparative evaluation of the water quality of sampling stations.

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