

Assessment of Water Quality Status by Using Water Quality Index (WQI) Method in Iron Ore Mine, Sandur, Karnataka, India - A Case Study

P.A Manjunatha¹ and B. Lokeshappa²

PG Student, Department of Civil Engineering, UBDTCE, Davanagere, India¹,

Associate Professor, Department of Civil Engineering, UBDTCE, Davanagere, India²

ABSTRACT: The present study was intended to calculate Water Quality Index (WQI) of an Subbarayanahalli, Iron Ore Mine, Sandur, Karnataka in order to ascertain the quality of water for public consumption, recreation and other purposes. This paper deals with the study on the influence of environmental parameters on the water quality of water body. There are several ways to assess the quality of water as deemed fit for drinking, irrigation and industrial use. Water Quality Index, indicating the water quality in terms of index number, offers a useful representation of overall quality of water for public or for any intended use as well as in the pollution abatement programmes and in water quality management A number of parameters affect the usability of water for a particular purpose. In this study Water Quality Index was determined on the basis of various physico-chemical parameters like pH, electrical conductivity, total dissolved solids, total alkalinity, total hardness, Iron, calcium, magnesium, chloride, nitrate, sulphate, Fluoride and dissolved oxygen.

KEYWORDS: Water Quality Index (WQI), Physico-chemical parameters , Drinking water quality

I. INTRODUCTION

The fresh water is of vital concern for mankind, since it is directly linked to human welfare. The surface and ground water bodies, which are the most important sources of water for human activities are unfortunately under severe environmental stress and are being threatened as a consequence of developmental activities. Subbarayanahalli iron ore mine is one of the leading iron ore producing mine in Hospet, Bellary sector. These water bodies like ground and surface water bodies to provide water for irrigation purposes or domestic use. There is something very beautiful about these water bodies not just aesthetically but also intellectually. They do not just mirror their environment; they also reflect the society around them and accumulate all the 'Sins' of humanity. The condition of these water bodies is rather pathetic. All development of mining activities impact with its surrounding environment so as to reduce the environmental impact caused due to mining activity. To control the adverse impact, to the water bodies and safe environmental management plan has to be implemented which makes environmental protection as essential requirement along economic gains. Most of the waterbodies disappeared due to encroachment and pollution. It is with this background, the present work was undertaken between September-2014 and March-2015.

Water quality index provides a single number that expresses overall water quality at a certain location and time, based on several water quality parameters. The objective of water quality index is to turn complex water quality data into information that is understandable and usable by the public. A single number cannot tell the whole story of water quality there are many other water quality parameters that are not included in the index. However, a water quality index based on some very important parameters can provide a simple indicator of water quality. In general,

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a waterbody with number.

II. STUDY AREA

Study area, Sampling locations, Sampling procedure and Meteorology have been described in detail. Subbarayanahalli iron ore mine is one of the leading iron ore producing mine in Hospet-Bellary sector. The mine is to the extent of 80.93 hectares. The area falls in the survey of India toposheet No.57A/12 and lies inside Kumaraswamy Betta, Forest. It is approachable by good road from Sandur town to Devagiri with distance of about 12 km towards Subbarayanahalli village. The total area lies in between longitude 76032'45" and 76033'48" and latitudes 15000'58" and 15001'55" in the district of Bellary of Karnataka State. Toranagallu is the nearest railway station is at a distance of 40 km along NNE directions.

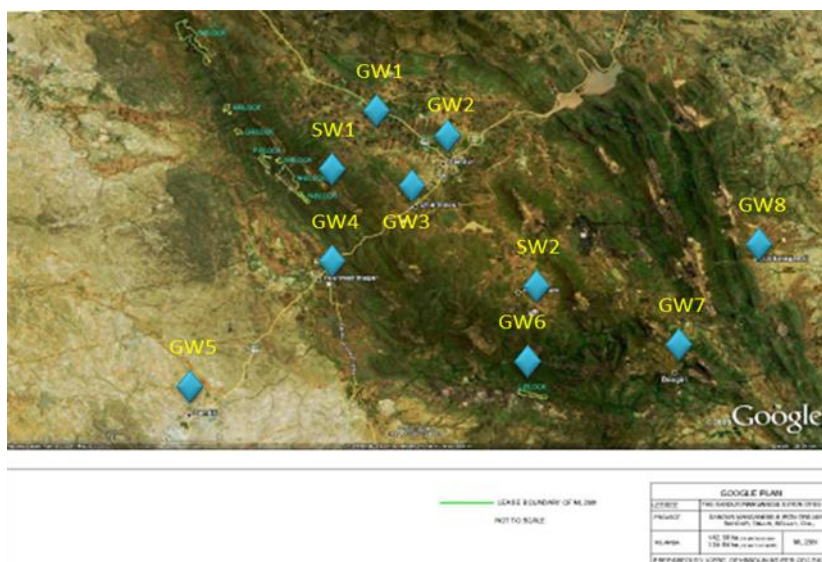


Figure 1: Showing the Google Map of study area Including Sampling Stations.

III. MATERIALS AND METHODS

The water samples like ground water (GW) samples and surface water (SW) samples from the water body were collected at an interval of two months and analysed for 14 physicochemical parameters by following the established procedures. The parameters pH, electrical conductivity and dissolved oxygen were monitored at the sampling site and other parameters like total dissolved solids, total alkalinity, total hardness, calcium, magnesium, chloride, nitrate, sulphate and biological oxygen demand were analysed in the laboratory as per the standard procedures of APHA (1995).

In this study, for the calculation of water quality index, 13 important parameters were chosen. The WQI has been calculated by using the standards of drinking water quality recommended by the World Health Organisation (WHO), Bureau of Indian Standards (BIS) and Indian Council for Medical Research (ICMR). The weighted arithmetic index method (Brown et. al.,) has been used for the calculation of WQI of the waterbody. Further, relative weight (w_i) and quality rating or sub index (Q_i) was calculated using the following expression. The relative weight (W_i) is computed using the following equation:

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

$$W_i = \frac{k}{S_n} \quad (1)$$

Where,

W_i is the relative weight and *i* is the number of parameters.

S_n is standard value for *n*th parameter

K is constant for proportionality

In this step, a quality rating scale (**Q_i**) for each parameter is assigned by dividing its concentration of each water sample by its respective standard according to the guideline laid down in the BIS 10500:2012 and the result is multiplied by 100.

$$(Q_i) = \frac{V_n - V_i}{S_i - V_i} \times 100 \quad (2)$$

Where,

Q_i is the quality rating,

V_n is the concentration of each chemical parameter of each water sample, mg/l

V_i is ideal value of the *i*th water quality parameter obtained from standard tables, **V_i** for pH = 7 and for the other parameter the **V_i** value is 0 (Srinivas P. et al., 2011).

S_i is the standard value for each chemical parameter, mg/l according to the guidelines of BIS (BIS 10500:2012).

For computing the WQI, the sub index **SI** is first determined for each chemical parameter, which is then used to determine the WQI using the following equation :

Sub index (SI)

$$SI = W_i * Q_i \quad (3)$$

Water quality index (WQI)

$$WQI = \frac{\sum W_i * Q_i}{\sum W_i} \quad (4)$$

Where,

SI, is the sub index of the parameter;

The computed **WQI** values are classified into five types, as represented in the table below;

Table1 : Water Quality Index (WQI) and status of water quality(**WQI**) values are classified into five types, "excellent water", "good water", "poor water", "very poor water", "water unsuitable for drinking". WQI values are 0-25, 26-50, 51-75, 76-100 and above 100 respectively.

Table 2: Bureau of Indian Standards (BIS) for Drinking Water (IS 10500: 2012)

Sl. No.	Characteristics	Desirable limit	Permissible limit
1	Colour, (Hazen units)	5	25
2	Odour	Unobjectionable	Unobjectionable
3	Taste	Agreeable	Agreeable
4	pH	6.5-8.5	No relaxation
5	Total hardness (mg/l as CaCO ₃)	300	600
6	Iron (Fe), mg/l	0.3	1.0
7	Manganese (Mn), mg/l	0.1	0.3
8	Chloride, mg/l	250	1000
9	Total dissolved solids, mg/l	500	2000
10	Calcium, mg/l	100	200
11	Sulphate, mg/l	200	400
12	Nitrate, mg/l	45	100
13	Fluoride, mg/l	-	1.5
14	Alkalinity, mg/l	200	600

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

15	Mercury, mg/l	0.001	-
16	Cadmium, mg/l	0.01	-
17	Lead, mg/l	0.05	-
18	Zinc, mg/l	5	15
19	Chromium, mg/l	0.05	-
20	Coli form, MPN/100 ml	1	-

IV. RESULTS

Table 3: physicochemical parameters of the Water Body in The Month of September and November-2014

Month	sites	pH	TRU	EC µs/cm	TDS Ppm	TA mg/l	TH mg/l	Ca2+ mg/l	Mg2+ mg/l	Fe mg/l	Cl- mg/l	SO ₄ ²⁻ mg/l	NO ₃ ²⁻ mg/l	DO	F mg/l
Sept	GW1	7.8	4	241	130	259	356	105	52	0.4	98	65	64	5.4	1.1
	GW2	8.1	6	1200	698	452	630	180	138	0.53	248	96	35	5	1.05
	GW3	7.5	5	965	436	243	325	123	61	0.42	112	62	40	6	1.25
	GW4	8	9	900	550	410	290	70	40	0.29	170	170	42	4	0.7
	GW5	7.5	4	910	600	340	280	75	38	0.3	200	190	55	5	1.3
	GW6	8.1	7	1050	750	340	350	98	41	0.31	210	215	51	5	1.1
	GW7	7.8	9	1020	650	350	310	105	55	0.7	235	180	46	6	1.2
	GW8	7.9	11	1050	705	290	300	84	52	0.32	210	220	47	5	1.1
	SW1	7.3	6	520	327	180	131	43	18	0.3	5.9	65	35	5.8	1.2
SW2	7.5	8	346	213	52	85	27	21	0.82	13	70	28	5	1.1	
Nov	GW1	6.9	6	478	330	138	132	32	24	0.5	24	71	29	6	1.52
	GW2	7.4	4	594	390	214	222	87	54	0.7	226	123	38	5.1	1.07
	GW3	7.3	2	987	620	320	296	51	49	0.23	92	60	39	4.2	1.5
	GW4	8.0	4	198	65	60	73	43	31	0.09	75	98	21	4	0.7
	GW5	7.5	3	790	450	270	290	75	42	0.11	284	189	44	5	0.75
	GW6	7.9	5	1020	820	410	410	158	73	0.4	316	250	50	5	1.1
	GW7	8.2	4	600	310	290	260	125	98	0.09	218	75	41	5	1.1
	GW8	8.1	5	950	780	310	320	86	43	0.7	300	165	62	5	0.9
	SW1	7.3	2	520	427	180	173	131	50	0.4	50	2.1	25	6	0.6
SW2	6.5	0.98	240	178	110	99	54	28	0.25	24	65	31	5	0.7	

Table 4: physicochemical parameters of the Waterbody in The Month of January and March-2015

Month	sites	pH	TRU	EC µs/cm	TDS Ppm	TA mg/l	TH mg/l	Ca2+ mg/l	Mg2+ mg/l	Fe mg/l	Cl- mg/l	SO ₄ ²⁻ mg/l	NO ₃ ²⁻ mg/l	DO	F mg/l
Jan	GW1	6.1	4	535	318	134	133	60	23	0.4	28	69	23	4	1.4
	GW2	7.1	3	612	371	281	327	75	51	0.35	235	133	31	5.1	0.9
	GW3	7.5	2	1950	924	324	259	75	45	0.29	98	59	41	4.3	1.1
	GW4	7.2	5	955	514	303	311	115	61	0.4	268	165	49	4.1	1.3
	GW5	8.3	3	898	457	274	294	109	54	0.3	289	218	54	5.5	0.87
	GW6	6.8	4	1022	821	417	416	158	69	0.4	312	345	49	4	1.2
	GW7	7.7	5	1009	619	354	367	111	58	0.5	211	196	40	4.9	1.1

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

	GW8	8.1	6	957	587	315	325	74	39	0.3	309	169	60	5.5	0.8
	SW1	7.4	1	524	322	180	172	57	18	0.2	57	30	25	3	0.4
	SW2	6.9	0.9	341	167	110	98	39	25	0.14	38	49	29	5	0.7
Mar	GW1	6.8	4	439	315	239	194	77	38	0.17	145	89	35	5	0.38
	GW2	7.6	3	581	397	498	568	180	84	0.1	197	102	28	3.15	0.69
	GW3	7.1	7	859	520	484	523	210	112	0.09	112	121	67	3	1.47
	GW4	7.8	4	920	450	280	278	68	35	0.4	180	160	50	4	0.8
	GW5	8.2	5	900	430	250	270	89	41	0.09	190	180	23	5	1.2
	GW6	7.6	5	1000	550	350	340	65	43	0.25	195	91	48	4.5	0.6
	GW7	8	5	530	302	318	350	75	46	1.0	165	98	36	5	0.91
	GW8	8.1	4	960	530	280	290	53	34	0.32	210	122	50	4.2	1.1
	SW1	7.3	6	516	331	180	173	92	62	0.15	78	18	25	5	0.9
	SW2	7.4	6.5	245	125	58	74	45	13	0.34	34	45	38	6	1

EC-Electric conductivity, TDS-Total dissolved solids, TA-Total alkalinity, TH-total hardness, DO-Dissolved oxygen, GW-Ground water, SW-Surface water

Table 5: Water Quality Index Calculation for GW1, September-2014

Sl.Nos	parameters	Si	Wi	Vn	Qi	Qi X Wi
1	pH	6.5-8.5	0.058824	7.8	53.33	3.137059
2	EC,µs/cm	2000	0.00025	241	12.05	0.003013
3	TDS,mg/l	500-2000	0.00025	190	9.5	0.002375
4	TA,mg/l	200-600	0.000833	259	43.16667	0.035972
5	TH,mg/l	300-600	0.000833	356	59.33333	0.049444
6	Ca,mg/l	75-200	0.0025	105	52.5	0.13125
7	Mg,mg/l	30-100	0.005	52	52	0.26
8	Fe,mg/l	0.3-1	0.5	0.4	40	20
9	Cl,mg/l	250-1000	0.0005	98	9.8	0.0049
10	SO ₄ ,mg/l	150-400	0.00125	65	16.25	0.020313
11	No ₃ ,mg/l	45	0.005	64	64	0.32
12	DO	6	0.083333	5.4	106.9	8.5675
13	F,mg/l	0.6-1.2	0.333333	1.1	73.33	24.44333
	Total		=0.991907			=56.97516
$WQI = \frac{\sum Wi \times Qi}{\sum Wi} = 56.51$						

Hence, WQI for GW1 ,September 2014=56.51

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

Table 6: Water Quality Index (WQI) calculated for all the samples in the month of September to March-2014-2015

Sl.No	Locations	WQI in Sept	WQI in Nov	WQI in Jan	WQI in Mar
1	GW1	56.51	65.27	45.34	18.98
2	GW2	64.12	69.94	30.33	31.98
3	GW3	56.59	54.79	39.75	47.33
4	GW4	44.87	33.19	39.84	31.39
5	GW5	56.98	19.98	31.29	39.46
6	GW6	55.49	35.38	39.21	32.30
7	GW7	75.27	35.51	40.45	40.56
8	GW8	55.31	36.59	31.35	40.74
9	SW1	32.71	33.24	12.41	20.28
10	SW2	32.60	22.72	24.21	14.05

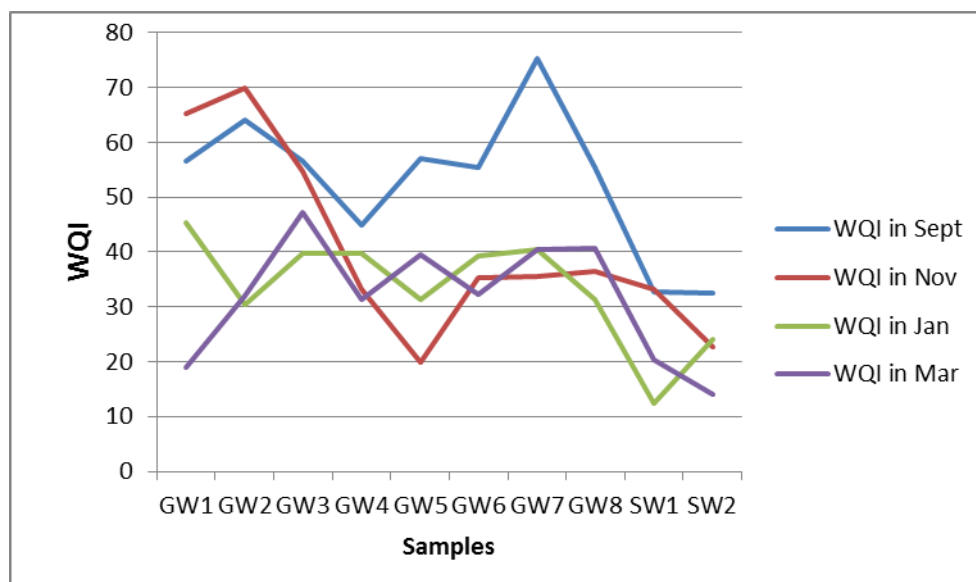


Figure 2: Water Quality Index in the month of September to march(60 days interval)

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

V. CONCLUSIONS

Water quality Index of the present waterbody is established from important various physicochemical parameters in different Month. The values of various physicochemical parameters for calculation of Water quality index are presented in Table 6. Month wise Water Quality Index calculations are depicted in the Table 5. The Water Quality Index obtained for the water body in different samples in different months of study period i.e., In the month of September, November, January and March maximum WQI shows 75.23,69.94,45.34 and 47.33 respectively, which indicate the some of samples shows good water quality some of the samples shows poor quality of water (Chatterji and Raziuddin 2002).

This water quality rating study clearly shows that, the status of the waterbody is good. In some area Water quality is poor and it is unsuitable for the human uses. It is also observed that the pollution load is relatively high during September month when compared to the different months. The above water quality is also supported by the following physicochemical parameters variations observed during the different month of the study. Among all the physicochemical parameters selected for the Water Quality Index calculations, pH is an important parameter which determines the suitability of water for various purposes. In the present study pH ranged between 6.2 & 7.8. In many of the collections the pH remained exactly neutral. However, when the average values for three four months are taken into account the waterbody was found to be slightly alkaline (Ambasht 1971).

Petre(1975), Shardendu and Ambasht (1988), Swarnalatha and Narasingarao (1993) and Sinha (1995) have also made similar observations in their studies on different water bodies. Electrical Conductivity and total dissolved solids were also found to be very high. Month wise it is found to be high during January month.

Chloride is one of the most important parameter in assessing the water quality. Munawar (1970) is of the opinion that higher concentrations of chlorides indicate higher degree of organic pollution. In the present study the concentration of chloride fluctuated between 156 mg/l and 298 mg/l. Seasonally, chloride was found to be high during March and low during september month. A similar observation has been made by Shastry et.al.,(1970) and Sinha (1995).

The concentration of dissolved oxygen regulates the distribution of flora and fauna. The present investigation indicated that the concentration of dissolved oxygen fluctuated between 4mg/l and 6mg/l. Monthly, the concentration of dissolved oxygen was more during monsoon and least during summer. This observation is in conformity with the observations of Reddy et al., (1982)., Ghosh and George (1989)., Swarnalatha and Narasingarao (1993) and Venkateswarlu (1993).

From the foregoing observations of the physicochemical parameters, it can be concluded that the water body shows moderately good in condition. A relatively higher concentration of chlorides and sulphates also indicate the unsuitability of water for domestic use. Hence, application of Water quality index technique for the overall assessment of the water quality of a water body is a useful tool.

REFERENCES

- [1] Ambasht R.S.,(1971), "Ecosystem study of a tropical pond in relation to primary production of different vegetation zones. *Hydrobiologia*", 12:57-61.
- [2] APHA(1995). AMPHA. Standard methods for the examination of water and waste water, 19th Edition, American Public Health Association, Washington DC.
- [3] BIS 10500:(2012)BIS, Analysis of Water and Waste water, Bureau of Indian Standards, New Delhi.
- [4] BIS(1983). Standards for Water for Drinking and other purposes, Bureau of Indian Standards, New Delhi.
- [5] Chatterjee, A.A., 1992. Water quality of Nandakanan lake India., *J. Environ. Hlth.* 34(4): 329-333
- [6] Chowdhury R.M, Muntasir S.Y and Hossain M.M, "Water quality index of water bodies along Faridpur-Barisal road in Bangladesh", *Glob. Eng. Tech. Rev.*, 2(3). 1-8. 2012.
- [7] Chaterjee C and Raziuddin M(2002), "Determination of water quality index (WQI) of a degraded river in Asanol "Industrial area, Raniganj, Burdwan, West Bengal. *Nature, Environment and pollution Technology*", 1(2):181-189.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

- [8] Ghosh A and George J P(1989),“*Studies on the abiotic factors and zooplakton in a polluted urban reservoir Hussain Sagar, Hyderabad: Impact on water quality and Embryonic Development of Fishes. Indian J.Environ.Hlth*”,31(1): 49-59.
- [9] Horton R.K.,(1965),An index number system for rating water quality. *Journal of Water Pollution.Cont.Fed.*,3:300-305
- [10] Munawar M.,(1970), “*Limnological studies on fresh water ponds of Hyderabad, India-II, J. Hydrobiologia*”,35:127-162.
- [11] Naik S and Purohit K.M.,(1996),“*Physico-chemical analysis of some community ponds of Rourkela. Indian Journal of Environmental Protection*”,16(9): 679-684.
- [12] Naik S and Purohit K.M.,(1998), “*Status of water quality at Bondamunda of Rourkela industrial complex-Part-I Physico-Chemical Parameters,Indian Journal of Environmental Protection*”, 18 (5) : 346-353
- [14] Petre T.,(1975),“ *Limnology and fisheries of Nyumba Yamung, a man made lake in Tanzania*”, J. Trop. Hydrobiol. Fish”,4: 39-50.
- [15] Reddy K.R, Sacco P.D ,Graetz D.A, Campbell K.L and Sinclair L.R.,(1982),“*Water treatment by aquatic ecosystem: Nutrient removal by reservoirs and flooded fields*”,J.Environmental Management,6(3): 261-271.
- [16] Shastry C.A,Aboo K.M, Bhatia H.L and Rao A V.,(1970),“ *Pollution of upper lake and its effect on Bhopal water supply. J. Environmental Health*”,12: 218-238.
- [17] Shardendu and Ambasht R.S,(1988), “ *Limnological studies of a rural pond and an urban tropical aquatic ecosystem:oxygen enforms and ionic strength. J.Tropical Ecology*”,29 (2): 98-109.
- [18] Srinivas J, Purushotham A.V and Murali Krishna K.V.S.G.(2013)“*Determination of water quality index in industrial areas of Kakinada, Andhra Pradesh, India*”, *Int. Res. J Env. Sci.*, 2(5). 37-45.
- [19] Sinha S.K.,(1995),“*Potability of some rural ponds water at Muzaffarpur (Bihar)-A note on water quality index, J. Pollution Research*”,14(1): 135-140.
- [20] Swarnalatha N and Narasingrao A.,(1993),“*Ecological investigation of two lentic environments with reference to cyanobacteria and water pollution*”.*Indian J. Microbial. Ecol.*, 3:41-48
- [21] Venkateswarlu V(1993), “*Ecological studies on the rivers of Andhra Pradesh with special reference to water quality and pollution. Proc. Indian. Acad. Sci. (Plant Sci)*”,96:495-508
- [22] WHO, 1992.International Standards for Drinking water. World Health Organization, Geneva, Switzerland.