ASSESSMENT OF GROUND WATER QUALITY INDEX (WQI) IN AND AROUND BALGOPALPUR INDUSTRIAL ESTATE, BALASORE, ODISHA, INDIA

Kausik Kumar Das, Tanuja Panigrahi, Bita Mohanty & Dr. R.B. Panda

Abstract: To assess the quality index of ground water in and around Balgopalpur Industrial Estate, water samples from 30 different locations were collected spreading over a period of three seasons in the year (2011-2012) namely post monsoon, winter and summer season (July2011-June2012). The index of water quality was assess by measuring various physic-chemical parameter such as pH, Total Dissolved Solid (TDS), Total Hardness (TH), Total Alkalinity (TA), Calcium, Magnesium, Sodium, Potassium, Iron and Chloride content. After analysis of WQI, all the samples indicates that water of all location is not acceptable for direct consumption and is not within the permissible limit. The Pump house water may be use for direct consumption which is nearly equal to the permissible limit. Other some samples were also can be used for drinking purpose after treatment.

Key words: WQI, Permissible Limit, Balgopalpur Industrial Estate, Physico-chemical Parameter.

1 INTRODUCTION

"Water" the elixir of life referred as nature was worshiped since Vedic days. The Rig-Veda depicts that water functions as givers and sustainers of life. Ground water is a gift of nature. About 210billion m3 including recharge through infiltration seepage and evaporation. Ground water is the main source of drinking water [1]. Ground water accounts for drinking and irrigation as it is the easily available source in Balgopalpur Industrial Area. The presence of higher concentration (i.e. above permissible limit) of any ion in ground water indicates pollution of ground water. Today human activities are constantly adding industrial, domestic and agricultural waste to ground water reservoirs at an alarming rate [2]. Disposal of industrial effluent and sewage into fresh water cause ground water pollution [3]. The rapid growth of urban areas has adversely affected the ground water quality due to over exploitation of resources and improper waste disposal practices. With growing industrial sectors, urban areas also developed near the industrial areas. So, the consumption of fresh water is increased day-by-day.

Kausik Kumar Das, Research Scholar P.G. Dept. Of Environmental Science, F.M. University, Balasore-756020, Odisha, India
E-mail:-kausikkumar9@gmail.com

Tanuja Panigrahi, Bita Mohanty, Research Scholar P.G. Dept. Of Environmental Science, F.M. University, Balasore-756020, Odisha, India
E-mail:-bita.mohanty@gmail.com
E-mail:-tanuja.panigrahi237@gmail.com

Dr. R.B. Panda, Associate Professor in P.G. Dept. Of Environmental Science, F.M. University, Balasore-756020, Odisha, India
E-mail:-rb_panda07@rediffmail.com

Ground water contamination is generally irreversible i.e. once it is contaminated it is difficult to restore the original water quality of the aquifer. Pollution of ground water resources has become a major problem today. Water quality is a major factor in determining the welfare of the society. The presence of various toxic substances in the water bodies causes health hazards. A regular monitoring of water bodies with required number of parameters vis-a-vis the quality of water not only prevents outbreak of disease and occurrence of other health hazards but also checks the water from further deterioration and there by protects it. Water Quality Index (WQI) is one of the most effective expressions which reflect a composite influence of contributing factors on the quality of water for any water system [4]. Therefore the present work deals with WQI of drinking water collected from various locations of Balasore district, Odisha, India (Fig-1). The Index is based on Tiwari and Mishra (1985), [5], Singh (1992), [6] and Yazadandoost and Katdare (2000), [7], [1].

2 STUDY AREA

Balasore is one of the coastal districts of Odisha. It lies on the northern most part of the state having 21 degree 03' to 21 degree 59' North Latitude & 86 degree 20' to 87 degree 29' East Longitude (Fig-2). Geographical area of the district is 3634 sq.km. As per the 2001 Census, the population of this area is 2023000 [8]. The climate of Balasore district is mostly hot and humid. The relative humidity is 55% during June to September, 28% in October to March and 20% during April to May. The soil type of the study area is

alluvial in nature. The soil is highly suitable for paddy cultivation. Table-1 summarizes the demographic features and vital statistics of the district Balasore [8]. Since early eighties of the twentieth century many industries have been set up within a radius 12km from Balasore town. The main four industrial areas are Balgopalpur, Somnathpur, Ganeswarpur and Chhanpur. The major industries located in Balgopalpur Industrial Area are Balasore Alloys Ltd. and Emami Papers Ltd. Two important rivers of Odisha, namely Budhabalanga and Subarnarekha have passed through Balasore district from west to east before submerging into the Bay of Bengal. The river Sono is an important tributary of river Budhabalanga. It arises from the Similipal hill range of Mayurbhanj district of Odisha and joins the river Budhabalanga near Fuladi in Balasore district of the same state [8]. These rivers are main source of fresh water in Balasore district for domestic uses like agriculture, irrigation and also industrial purpose. The people of Balasore district mostly depends upon the ground water for drinking purpose. In Balasore district, so many deep bore wells have already been drilled by Government, but most of the families rely on private household well and tube well as their source of fresh water.

TABLE-1: DEMOGRAPHY AND MAJOR STATISTICS OF BALASORE DISTRICT AS PER CENSUS 2001

Sl.NO.	Item	Unit	Magnitude
1.	Total Population	lakhs	20.24
2.	Urban Population	Lakhs	2.20
3.	Rural Population	Lakhs	18.04
4.	Geographical Area	Sq. km	3806
5.	%SC population to the total population	-	18.84
6.	%ST population to the total population	-	11.28
7.	No. of Blocks	-	12
8.	No. of Subdivision	-	2
9.	No. of Grampanchayat	-	289
10.	No of Tahasil	-	7
11.	No of Villages	-	2952
12.	No of towns	-	5
13.	No of Municipality	-	1
14.	Normal Rainfall	MM	1568.4

(Source: District Statistical Handbook, Balasore, 2007)

3 MATERIALS AND METHOD

Ground water samples of thirty different locations were collected in and around Balgopalpur Industrial Estate spreading over a period of three seasons in one year from July 2011 to June 2012 namely post monsoon, winter and summer. Water samples were mainly collected from tube wells and were analysed as per standard procedure described by APHA (1992), [9]. The sampling locations are arranged in the table-2. For calculating the Water Quality Index (WQI), the method followed by Tiwari and Mishra (1985), [5], Singh (1992), [6] and Patel and Desai (2006), [10] have been employed. In this method the quality rating scale has been assigned to the parameter which is also weighed according to its relative importance in the overall water quality. The maximum weight of 4 has been assigned to the parameters like pH and TDS to their major importance in water quality assessment. The weight of TA is 3. Other parameters like sodium, potassium and iron are assigned the minimum weight of 1 as they play fewer roles in the water quality assessment. The standards for drinking water as per recommended by WHO are given in table-3.

TABLE-2: ARRANGEMENT OF SAMPLING LOCATIONS

Sl. No.	Name of Location	Abbreviated form	Distance from the Industries (Km)	Sampling source
01	Chakulia	T1	2	Tube well
02	Chakulia School	T2	2	Tube well
03	Kuanrpur	T3	2	Tube well
04	Kuanrpur Chhak	T4	2	Tube well
05	Baharda	T5	2	Tube well
06	Baharda School	T6	2	Tube well
07	Nuagan	T7	2	Tube well

08	Nuagan School	T8	2	Tube well
09	Ghasipada	T9	3	Tube well
10	Raghunathpur	T10	3	Tube well
11	Fartipur (up)	T11	2	Tube well
12	Boitabank (up)	T12	2	Tube well
13	Boitabank School (up)	T13	2	Tube well
14	Boitabank Pump house (up)	T14	2	Tube well
15	Nagapal (up)	T15	3	Tube well
16	Jaguli (up)	T16	3	Tube well
17	Jaguli School (up)	T17	3	Tube well
18	Bhimeswar	T18	3	Tube well
19	Bhimeswar School	T19	3	Tube well
20	Balipal	T20	4	Tube well
21	Hatiagand	T21	5	Tube well
22	Hatiagand School	T22	5	Tube well
23	Mitrapur (up)	T23	4	Tube well
24	Mukhura (up)	T24	3	Bore well
25	Chandipur(up)	T25	3	Bore well
26	Nuapadhi	T26	3	Tube well
27	Remuna	T27	3	Tube well
28	Kathasangada	T28	10	Tube well
29	Dumuda	T29	10	Tube well
30	Dihasahi	T30	10	Tube well

TABLE-3: WATER QUALITY PARAMETERS USED IN THE PRESENT STUDY

Sl. No.	Parameters	Standards (WHO)	Weight (Wt)	Unit Weight (Wi)
01	pH	7.0-8.5	4	0.182
02	TDS	500-1500	4	0.182
03	TH	100-500	2	0.091
04	TA	<120	3	0.136
05	Magnesium	30-150	2	0.091
06	Calcium	75-200	2	0.091
07	Chloride	200-600	2	0.091
08	Iron	0.1-1.0	1	0.045
09	Sodium	20*	1	0.045
10	Potassium	10*	1	0.045

*BIS recommended standard (ISI)
N.B.:-All the parameters are reported in mg/L except pH

TABLE-4: QUALITY RATING SCALE FOR WATER QUALITY PARAMETERS (QI)

Sl. No.	Degree of pollution rating (qi)	Permissible 100	Slight 80	Moderate 50	Severe 0
01	pH	7-8.5	8.6-8.8	8.9-9.2	>9.2
02	TDS	500	500-1000	1000-1500	>1500
03	TH	100	100-300	300-500	>500
04	TA	50	50-85	85-120	>120
05	Magnesium	30	30-90	90-150	>150
06	Calcium	75	75-137	137-200	>200
07	Chloride	200	200-400	400-600	>600
08	Iron	0.1	0.11-0.4	0.41-1.0	>1.0
09	Sodium	20	20-80	80-140	>140
10	Potassium	10	10-70	70-130	>130

All the parameters are reported in mg/L except pH

3.1 CALCULATION OF WQI

The unit weight of each parameter calculated by the formula,

$$Wi = \frac{(Wi)i}{\Sigma(wi)i} \quad \text{as } \Sigma wi = 1$$

The quality rating scale (qi) for ten physic-chemical parameters is given in table-4. The value for the parameters have been divided into four stages viz. Permissible, slight, moderate and severe for which quality rating (qi) ranges from 0 to 100. The all seasons average values of the physic-chemical parameters and assign WQI values are given in table-5 for calculating the sub index (SI) is the first finding for each parameter which is (SI)i = qiwi\

And thus the formula is

$$WQI = \frac{\Sigma(SI)i}{\Sigma wi}^{ts}$$

WQI = Σqtwi as wi = 1

As an example, the WQI for sample S1 has been calculated from the above formula and is given in the table-6.

TABLE-5: AVERAGE VALUES OF PHYSICO-CHEMICAL PARAMETERS AND ASSIGN WQI VALUE (LOCATION NUMBER1-10)

Sl. No.	Parameters	Location Number									
		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
01	pH	8.6	8.5	8.3	8.3	8.4	8.3	8.2	8.2	8.0	7.9
02	TDS	200	290	230	240	165	160	125	120	110	100
03	TH	56	75	60	65	260	270	130	120	100	100
04	TA	420	400	400	410	300	330	300	300	120	120
05	Magnesium	10.14	24.21	20.21	20.21	55.22	50.2	27.12	27.12	20.12	21.22
06	Calcium	14.43	20.84	14.43	14.43	40.68	41.6	20.84	20.84	14.43	16.16
07	Chloride	300	350	350	330	300	320	200	200	180	185
08	Iron	0.8	0.9	0.9	0.9	1.7	1.6	0.7	0.8	0.6	0.7
09	Sodium	144.2	145	144	144	183.5	180.5	142	145	11	13
10	Potassium	27.25	28.2	27.2	27.2	60	71	27.75	60	3.5	4.5
	WQI	73.19	76.83	76.83	76.83	70.94	70.94	76.83	76.83	92.2	92.2

All the parameters are reported in mg/L except pH

TABLE-5: CONTINUE...AVERAGE VALUES OF PHYSICO-CHEMICAL PARAMETERS AND ASSIGN WQI VALUE (LOCATION NUMBER 11-20)

Sl. No.	Parameters	Location Number									
		T11	T12	T13	T14	T15	T16	T17	T18	T19	T20
11	pH	7.7	7.8	7.7	7.6	7.4	7.2	7.3	7.3	7.3	7.5
12	TDS	50	45	45	40	120	125	115	120	120	230
13	TH	165	170	110	90	140	45	150	140	145	150
14	TA	110	220	200	45	60	120	110	100	90	195
15	Magnesium	32.15	33.85	30.36	21.06	28.28	27.12	20.21	20.21	21.2	21.7
16	Calcium	36.89	40.16	40.16	20.16	27.17	36.89	27.11	14.43	14.43	14.43
17	Chloride	150	45	50	45	50	45	60	65	70	175
18	Iron	1.0	1.3	1.2	0.4	0.6	0.5	0.6	0.6	0.6	1.0
19	Sodium	145	118	11	9	11	11	11	9	11	9
20	Potassium	3.5	5	4.5	5.5	21.27	13.5	3.5	3	3.5	3
	WQI	84.06	75.91	78.16	99	92.21	91.3	90.38	90.38	90.38	82.23

All the parameters are reported in mg/L except pH

TABLE-5: CONTINUE...AVERAGE VALUES OF PHYSICO-CHEMICAL PARAMETERS AND ASSIGN WQI VALUE (LOCATION NUMBER 21-30)

Sl. No.	Parameters	Location Number									
		T21	T22	T23	T24	T25	T26	T27	T28	T29	T30
11	pH	7.5	7.5	7.5	7.5	7.5	7.9	7.6	8.2	7.8	8.0
12	TDS	250	270	60	240	80	110	40	80	110	40
13	TH	145	145	140	160	236	140	195	90	200	80
14	TA	25	120	180	160	300	200	200	360	340	300
15	Magnesium	21.2	21.2	27.21	31.41	48.19	31.41	39.2	18.12	42.73	15.80
16	Calcium	20.84	20.84	35.27	35.27	38.48	35.21	35.27	20.84	28.68	19.2
17	Chloride	180	200	45	50	40	45	45	85	90	90
18	Iron	0.7	0.8	0.4	0.6	0.6	0.7	1.1	0.9	1.0	0.6
19	Sodium	142	145	11	46	34	34	11.9	48.2	48.25	46.75
20	Potassium	60	71	4.5	3	5	4.5	3.5	21.25	20.20	27.25
	WQI	76.83	83.63	83.58	79.51	79.51	79.51	75.91	82.25	76.36	82.25

All the parameters are reported in mg/L except pH

TABLE-6: CALCULATION OF WQI FOR SAMPLE T1

Sl. No.	Parameters	Value of water samples	Quality rating (qi)	Unit Weight (Wi)	Sub Index (qiWi)
01	pH	8.6	80	0.182	14.56
02	TDS	200	100	0.182	18.2
03	TH	56	100	0.091	9.1
04	TA	420	0	0.136	0
05	Magnesium	10.14	100	0.091	9.1
06	Calcium	14.43	100	0.091	9.1
07	Chloride	300	80	0.091	7.28
08	Iron	0.8	50	0.045	2.25
09	Sodium	144.2	0	0.045	0
10	Potassium	27.25	80	0.045	3.6

WQI value	73.19

All the parameters are reported in mg/L except pH

4 RESULTS & DISCUSSION

From the seasonal variation of sampling the average value of physico-chemical parameters and WQI of the above 30 samples are given in the table-5. In the quality rating scale for water quality parameters (qi) shows that TDS & Ca is individually permissible (100) but in case of WQI, it is found that none of the station of sampling shows a WQI of 100 throughout the study period. The highest value of WQI observed in sampling station (T14) is 99 and the lowest value of WQI in sampling station T5 & T6 is 70.94. From this it is found that out of 30 samples 14 numbers of tube well water indicates that the pollution level is slight and ranges between 80-100 and another 16 numbers of sampling station, the water indicates moderate type of pollution and ranges between 50-80 in the quality rating scale (qi). More important that all the samples are alkaline in nature and pH are more than 7. It also seen that with respect to iron eight samples were crossing the critical permissible level i.e. 1 mg/l. In the pump house water, except iron all parameters are permissible. So, after removal of iron it can be used for drinking purpose. But in case of all the tube well water which collected from different sampling station in and around Balgopalpur area of the Balasore district is not suitable for direct consumption and proper steps for treatment is essential before using it for drinking purpose [1]. This method for calculating WQI was also attempted Tiwari & Mishra, 1985; Krishna et al, 1991; Das et al, 2012.

5 CONCLUSION

After the calculation of WQI it is clearly found that, the value of some sampling station of the study area is slightly permissible rating of pollution and some of the sampling station the sample water is rating moderately pollution. So, proper treatment is essential before using it for various purposes mainly drinking purpose. Some techniques that can be used to raise the quality of the water that are Activated Carbon Filtration, Distillation, Ion Exchange, Reverse Osmosis, Ultraviolet Radiation, Fish bone Charcoal etc.

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