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Research Article

Study of Ground Water Quality of Bhubaneswar City, Odisha, India, using Water Quality Index

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Abstract

Water quality index has been applied in the present study to assess the suitability of groundwater quality for drinking purposes in Bhubaneswar area of Odisha state, India. This was carried out by subjecting 27 groundwater samples collected from nine selected sites. Analysis was done for physico-chemical and microbiological parameters. Eight parameters (except TC(Total Coliform) and FC (Faecal Coliform)) have been considered for calculating the WQI such as pH, Turbidity, Conductivity, Total Hardness, Chloride, Total Dissolved Solid, Iron, Floride. WQI shows water samples of Khandagiri area suitable for drinking purpose(WQI<50). Rest of the samples have WQI >300. Such waters are not suitable for drinking purposes under normal conditions and further action is required. Higher values of WQI has been found to be mainly due to high values of Fe, Turbidity, Conductivity and TDS. Co- relation studies show Cond, TH, TDS, Cl- are highly co-related to each other.

Keywords: *Ground water, Physico-chemical parameters, water quality index*

1. Introduction

Changes in local topography and drainage system directly affect both quality and quantity of ground water (Vasanthavigar *et al*. 2010). Ground water quality depends on the quality of recharged water, atmospheric precipitation, inland surface water and sub-surface geochemical processes.

Water pollution not only affects water quality but also threats human health, economic development and social prosperity (Milovanovic, 2007: Reza and Singh, 2010). Once the ground water is contaminated its quality cannot be restored by stopping the pollutant from the source therefore it becomes very important to regularly monitor the quality of groundwater and to device ways and means to protect it. WQI a technique of rating water quality is an effective tool to assess spatial and temporal changes in ground water and communicate information on the quality of water to the concerned citizens and policy makers (Mishra and Patel, 2001) (Horton,1965),(Shwetatagy and *et al*,2013). WQI has been successfully applied to assess the quality of ground water in the recent years and to understand the water quality issues by integrating complex data and generating a score that describes water quality status.

Periodic estimation of ground water quality is highly necessary in order to ascertain the quality of water to be used for human consumption. The main objective of this study is the ground water pollution and its suitability for drinking and domestics purposes as a large population of Bhubaneswar city depends on ground water for drinking purposes.

1.1 Description of Study Area

The capital city of Odisha Bhubaneswar is located between 20o 12'N and 20o 25' N latitude and 85^{o} 44'E to 85^{o} 55'E longitude on the western fringe of coastal plain across the main axis of eastern Ghats in Khurda district of Odisha. Geologically Bhubaneswar region belongs to the Gondwana land mass, one of the oldest and most stable land mass in the world. The rock ranges from the Archean to the recent period. Major part of the area is covered with the quarterly alluvium and lateritic soil. The depth of the water table ranges from 5-12 m in the laterictic and the weathered sandstones. 40-50 m in the fractured and friables sand stones forming the deeper aquifers that are under semi - confined to confined conditions. The rock types in and around the western parts of the city store water recharged by rainfall. The depth is maximum up to 6m bgl in December that fall to 8m bgl in May.

1.2 Methodology

27 ground water samples were collected from nine different locations (three from each location). The samples were collected in clean 2L polythene bottles.

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The bottles were rinsed before sampling and tight sealed after collection. The temperatures were measured on the spot. Analysis was carried out for various water quality parameters such as pH, Turbidity, Conductivi ty, TH(Total Hardness), Chloride, TDS(Total Dissolved Solid), Iron, Floride, TC(Total Coli form), FC(Fecal Coli form), as per standard procedures recommended by APHA(2000). The water quality parameter values are expressed in mg/l except pH and EC in μ mho/cm. All chemical//reagents used were of analytical reagent grade. Samples of L-01 in winter, summer,and rainy are numbered as 1,2,3 respectively. Similarly 4,5,6 for L-02, 7,8,9 for L-03, 10,11,12 for L-04, 13,14,15 for L-05,16,17,18 for L-06, 19,20,21 for L-07, 22,23,24 for L-08, 25,26,27 for L-09.

1.3 Result and Discussion

1.3.1. pH

pH varies between 5.6 to 7.5 during study period. A little variation in pH was noticed during different seasons. At Unit-1X area the water was found more acidic compared to other areas, it may be due to sampling sources close to sewage channel having higher pH. It is also noticed that in summer the acidic character slightly increases compare to rainy and winter seasons. It may be due to decrease of water Level in summer.

1.3.2. Turbidity

Turbidity was found between 4 to 63 NTU. No seasonal variation was observed in samples. Contaminated ground water however can have considerable high turbidity (well and others, 1989, Gschwend and others, 1990, puls and powell,, 1992, Backhus and others, 1993). High turbidity of ground water may be due to impact of underground soil and rock.

1.3.3. Conductivity

Conductivity ranged from 107 to 1395 micromho/cm. But a marked spatial variation was observed in the samples. Samantarapur area recorded relatively higher conductance which might be attributed from the sewage contamination.

1.3.4. Total Hardness

Total hardness represented by $CaCO_3$ in water samples ranged from 24 to 145 mg/l.. High values were observed in the samples of Samantarapur area. High values of hardness observed seemed to have been influenced by their proximity to the sewage drains as higher hardness was observed in samples which are located close to it.

1.3.5. Chloride

The chloride content of water samples varies from 18 to 312 mg/l. Higher values were noticed in Samantarepur area, rest of the samples were found below permissible limit (250mg/l) set by WHO.

1.3.6. Total Dissolved Solid

TDS of samples varied from 79 to 776 mg/l. Samples drawn from Samantarapur area recored high values of TDS. A well marked temporal variation was observed in the samples. The samples of summer season exhibit high concentration of TDS compared to other seasons. Drying up of the clay material above the water table during summer period might have led to oxidation which increase the stability of minerals by the infiltrating water during the recharge period.

1.3.7. Iron

Iron concentration ranged from 0.34 to 7.6 mg/l. Except Khandagiri area all the locations recorded much higher values than the prescribed limit by WHO i.e 0.3 mg/l. The iron occurs naturally in the aquifers but levels in ground water can be increased by dissolution of ferrous borehole and hand pumps components.

1.3.8. Fluoride

Fluoride concentration varied from 0.06 to 0.45 mg/l. A little variation was observed among the samples. All the samples were found below permissible limit set by WHO and other regulatory organizations**.**

1.3.9. TC and FC

The ground water of the study area was safe as none of the locations were above WHO limit for
TC and FC

1.4 Correlation Coefficient

Statistical techniques are designed to explain complex relations among the variables. Due to the change of Physico-Chemical characteristics of groundwater of study area the compositional behavior of various ions show wide variation. In order to establish the natural process and the sources of pollution, a 8 × 8 correlation matrix from normalized variables and 3 observations for each point has been computed.

Water quality Index

WQI is an excellent management and general administrative tool to communicate water quality of an area.

The quantitative assessment of water quality index was calculated using eight parameters(excluding TC & FC) using ISI standards using following formula,

$$WQI = \sum_{i=1}^{n} Wi\ qi$$

Wi is a unit weight factor and it is a constant for all the parameters

The quality rating qi is determined by qi = 100(Vi - Vs)/(Si - Vs)

Where Vi is estimated value of nth parameter

Si is standard value of nth parameter

Vs is ideal value of nth parameter in pure water. All ideal values are taken as zero for drinking water except pH =7.0

Conclusion and Suggestions

The physico-chemical and microbial parameters show that ground water is safe for consumption being with safe limits prescribed by WHO. But the tube wells located adjacent to the unprotected septic tanks are highly contaminated. The high amount of iron content found in water samples may be due to the soil which is laterictic in nature or may be due to the age old hand pumps contain iron pipe which require immediate replacement with PVC. Excess iron in ground water may be due to Lateric soil which can be removed with minor treatment and water can be used for drinking purpose.

The regression analysis explains the pattern of the relationship between the variables and the subsequent application of co-relation analysis determined the extent to which the variables are related. It measures the degree of co-relation that exists between two variables. Significant positive correlation has been observed between Fe and Turb (r = 0.6368), TH and Cond (r = 0.9255), Cl- and Cond (r = 0.9895), TDS and Cond (r = 0.9922), TH and Cl- (r = 0.8638), TDS and TH (r = 0.9452), TDS and Cl- (r = 0.9719). Similarly negative correlation has been observed between Fe and F- (-0.6251). The correlation is preferred as the deviation in one variable is followed by a corresponding and proportional deviation in the other. The value of correlation coefficient lies between -1 to +1.

To assess the suitability of ground water quality, WQI (water quality index) has been computed. Except Khandagiri area in all locations the WQI was found much higher (WQI>300) . The high value of WQI at this site has been found to be mainly from the higher values of iron , turbidity, conductivity and TDS. It is hightime that groundwater quality monitoring should be encourages in order to ensure ground water quality protection and conservation.

Table 1 Physico – Chemical and microbiological Characteristics of ground for 2012

Locations		pH	Turb	Cond	TH	Cl-	TDS	Fe	F-	TC	FC
L-01	Winter	6.4	4	109	28	21	79	0.35	0.17	>2	>2
	Summer	6.2	4	112	29	22	84	0.39	0.18	>2	>2
	rainy	6.1	6	107	26	20	80	0.34	0.16	>2	>2
L-02	Winter	5.9	4	169	28	25	110	1.3	0.41	>2	>2
	Summer	5.6	5	174	30	30	116	1.5	0.45	>2	>2
	rainy	5.8	6	166	24	26	107	1.2	0.40	>2	>2
L-03	Winter	6.5	4	478	96	69	314	3.7	0.09	>2	>2
	Summer	6.3	4	485	98	76	328	4.2	0.12	>2	>2
	rainy	6.7	4	456	91	72	328	3.9	0.08	>2	>2
L-04	Winter	6.4	36	162	45	18	98	6.5	0.09	>2	>2
	Summer	6.2	34	169	47	24	106	6.9	0.09	>2	>2
	rainy	6.6	39	153	42	20	93	6.4	0.08	>2	>2
L-05	Winter	7.3	32	269	74	22	168	5.4	0.24	>2	>2
	Summer	7.0	29	282	78	26	174	5.5	0.25	>2	>2
	rainy	7.5	33	268	71	23	156	5.3	0.23	>2	>2
L-06	Winter	6.3	29	1312	141	296	738	2.4	0.24	>2	>2
	Summer	6.0	27	1395	145	312	776	2.7	0.25	>2	>2
	rainy	6.4	32	1306	139	299	748	2.3	0.21	>2	>2
L-07	Winter	6.0	35	156	38	24	97	5.0	0.15	>2	>2
	Summer	5.8	34	158	45	28	128	5.2	0.16	>2	>2
	rainy	6.1	39	154	32	21	109	4.9	0.12	>2	>2
L-08	Winter	6.2	59	462	79	81	324	6.3	0.11	>2	>2
	Summer	5.9	54	472	85	84	346	6.5	0.12	>2	>2
	rainy	6.2	63	452	74	79	332	6.1	0.1	>2	>2
L-09	Winter	6.5	20	196	32	38	92	7.5	0.06	>2	>2
	Summer	6.2	19	212	39	42	108	7.6	0.08	>2	>2
	rainy	6.8	22	193	29	36	98	7.4	0.07	>2	>2

L-01 = Khandagiri area L-02 = Unit-IX area L-03 = Capital Hospita area L-04 = Chandrasekharpur area
L-05 = Unit-I area L-06 =Samantarapur area L-07 =Rasulgarh area L-08 =Laxmisagar area L-09=Unit-III area

Table 2 Correlation Matrix for different parameters of ground water for the year 2012

	pH	Turbidity	Conductivity	TH	Cl-	TDS	Iron	Floride pH
1	0.0209	0.0055	0.2461	-0.0818	-0.0143	0.3275	-0.2376	
Turbidity		1	0.1736	0.2399	0.1482	0.2056	0.6368	-0.2925
Conductivity			1	0.9255	0.9895	0.9922	-0.1651	0.0933
TH				1	0.8638	0.9452	-0.0268	-0.0325
Cl-					1	0.9719	-0.2068	0.1029
TDS						1	-0.1632	0.0754
Iron							1	-0.6251
Floride								1

Table 3 WQI at different locations in three different seasons for the year 2012

Locations	Winter	Summer	rainy
L-01	45	53	42
L-02	400	512	367
L-03	349	520	329
L-04	638	677	561
L-05	1341	1414	1268
L-06	563	681	500
L-07	797	881	633
L-08	765	855	678
L-09	492	660	566

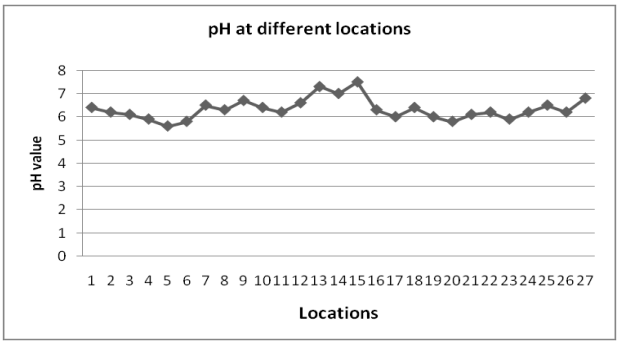

Fig 1 pH at different locations

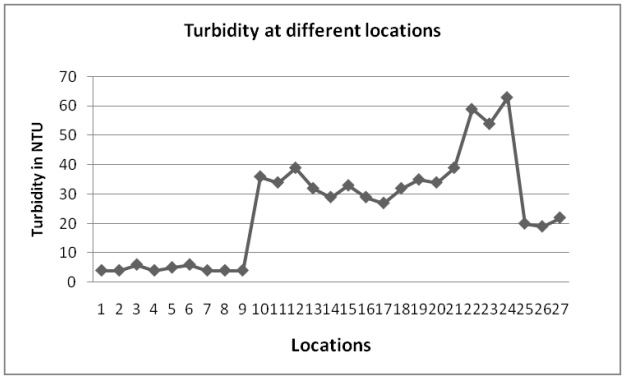

Fig 2 Turbidity at different locations

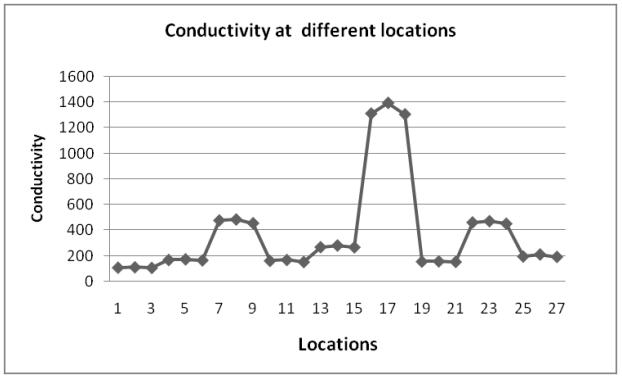

Fig 3 Conductivity at different locations

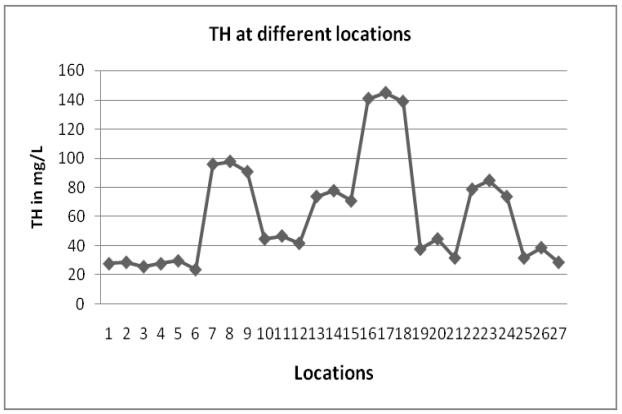

Fig 4 TH at different locations

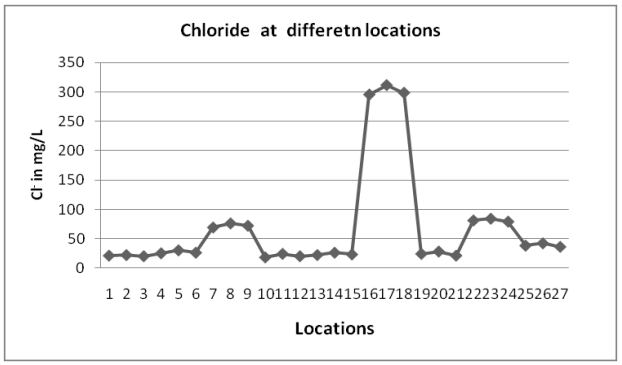

Fig 5 Chloride at different locations

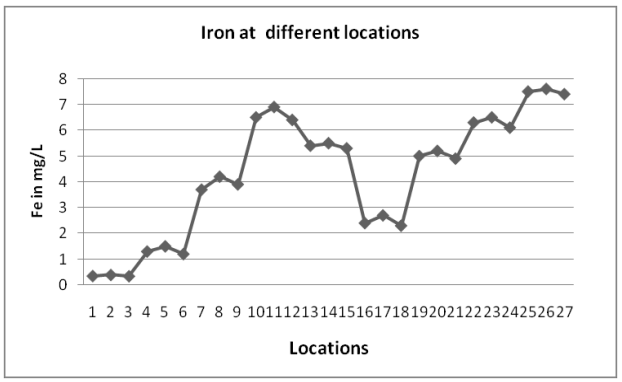

Fig 7 Iron at different locations

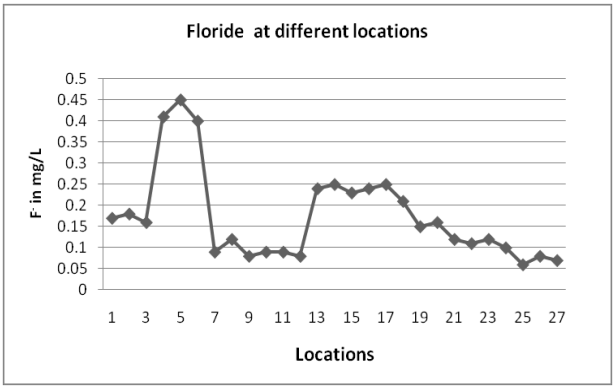

Fig 8 Floride at different locations

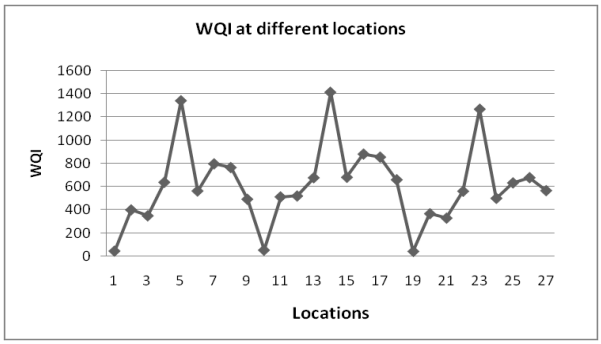

Fig 9 WQI at different locations

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