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Assessment of ground water quality using Quality Index for drinking purpose in Gajuwaka Industrial Area, Visakhapatnam, Andhra Pradesh, India

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ABSTRACT

The water quality index (WQI) for the groundwater of Gajuwaka Industrial Area,Visakhapatnam was assessed for two seasons in this study. This was determined by collecting the groundwater samples and subjecting the samples to a comprehensive physicochemical analysis. For calculating the WQI, the following 12 parameters have been considered: pH, Electrical Conductivity, total hardness, Total Alkalinity, calcium, magnesium, chloride, nitrate, sulphate, total dissolved solids, fluorides and Biological oxygen demand. The studies showed that the WQI for these samples ranged from 71.72 to 451.28. The high value of WQI has been found to be mainly due to the higher values of Total Dissolved Solids, nitrate, hardness, fluorides, and manganese in the groundwater. The analysis has been used to suggest models for predicting water quality. It also reveals that the groundwater of the area needs some degree of treatment before consumption and it also indicates that the people need to be protected from the perils of contamination.

1. Introduction

Groundwater is increasingly being used for domestic use, industrial water supply and irrigation all over the world. In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population and the accelerated pace of industrialization. The accelerated urban-industrial growth thatis underway is bringing an equally rapid transition from rural to urban societies. Human health is threatened by most of the agricultural development activities particularly in relation to excessive application of fertilizers and unsanitary conditions. Rapid urbanization, especially in developing countries like India, has affected the availability and quality of water. Ramakrishnaiah et al (2009)observed that the contamination of groundwater is due to its overexploitation and improper waste disposal, especially in urban areas. According to WHO organization, about 80% of all the diseases in human beings are caused by water. Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source. Therefore, it becomes imperative to regularly monitor the quality of groundwater and to device ways and means to protect it. Water quality index is one of the most effective tools (table 1- 4) to communicate information on the quality of water to the concerned citizens and policy makers. Thus, it becomes an important parameter for the assessment and management of groundwater. WQI is defined as a rating reflecting the composite influence of different water quality parameters. WQI is calculated from the point of view of the suitability of groundwater for human consumption. The objective of the present work is to discuss the suitability of groundwater in Visakhapatnam for human consumption based on computed water quality index values.

2. Study area

Visakhapatnam located in the 17.6868° N, 83.2185° E latitudes and longitudes covers an area of 1043 sq.km with a population of 20.4L (2011 senses).

3. Materials and Methods

The water quality index from the ground water collected from 40 samples at an interval of two seasons of monsoons and summer in two years of time and analyzed for 12 physico-chemical parameters by following the established procedures (WHO). The parameters PH, electrical conductivity and biological oxygen were monitored at the sampling site and other parameters like total dissolved solids, total alkalinity, total hardness, total suspended solids, calcium, magnesium, chloride, nitrate, and sulphate were analyzed in the laboratory as per the standard procedures (**APHA .1995**).

4. Water Quality Index

In this study, for the calculation of water quality index, twelve important parameters were chosen. The WQI has been calculated by using the standards of drinking water quality recommended by the World Health Organization (WHO), bureau of Indian Standards (BIS) and Indian Council for Medical Research (ICMR). The weight arithmetic index method (**Brown *et. al.,* 1970**) has been used for the calculation of WQI of the water body. Further, water quality rating or sub index (q_n) was calculated using the following expression.

$$q_n = 100\,[V_n - V_{io}] / [S_n - V_{io}]$$

(Let there be **n** water quality parameters and quality rating or sub index (q_n) corresponding to **n**th parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value.)

q_n= Quality rating for the **n**th water quality parameter

V_n = Estimated value of the **n**th parameter in pure water. (*i.e., 0 for all the other parameters in the parameter pH and Dissolved oxygen (7.0 and 14.6 mg/L* respectively)

Wn = K/ S*n*

Wn = unit weight for the **n**th parameters.

Sn = Standard value for the **n**th parameters

K= Constant for the proportionality.

The overall Water Quality index was calculated by aggregating the quality rating with the unit weight linearly.

WQI = q_nWn / Wn

Table. 1: Water Quality Index (WQI) and status of water quality (**Chatterji and Raziuddin 2002**)

Water Quality Index Level	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	Unsuitable for drinking

Table 2: Drinking Water Quality standards recommending Agencies and unit weights.

S.No.	Parameters	Standards	Recommended agency	Unit Weight
1	pH	6.5-8.5	ICMR/BIS	0.2190
2	Electrical Conductivity	300	ICMR	0.371
3	Total Dissolved Solids	500	ICMR/BIS	0.0037
4	Total Alkalinity	120	ICMR	0.0155
5	Total hardness	300	ICMR/BIS	0.0062
6	Total suspended solids	500	WHO	0.0037
7	Calcium	75	ICMR/BIS	0.025
8	Magnesium	30	ICMR/BIS	0.061
9	Chlorides	250	ICMR	0.0074
10	Nitrates	45	ICMR/BIS	0.0412
11	Sulphates	150	ICMR/BIS	0.01236
12	Biological oxygen demand	5.00	ICMR	0.3723

(***Note:*** *All values are expressed in mg/L except pH and Electrical Conductivity)*

Table. 3: Calculation of WQI samples

S.No	Parameters	Observed Values	Standard Values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n
1	pH	7.28	6.5-8.5	0.2190	13.33	2.92
2	Electrical Conductivity	842	300	0.371	280.67	104.13
3	Total Dissolved Solids	3	500	0.0037	0.60	0.0022
4	Total Alkalinity	563	120	0.0155	112.60	0.42
5	Total hardness	260	300	0.0062	104.00	0.77
6	Total Suspended Solids	40	500	0.0037	26.67	0.33
7	Calcium	245	75	0.025	81.67	0.51
8	Magnesium	69	30	0.061	92.00	2.30
9	Chlorides	18	250	0.0074	60.00	3.66
10	Nitrates	74	45	0.0412	61.67	0.96
11	Sulphates	10	150	0.01236	22.22	0.92
12	Dissolved Oxygen	3.7	5.00	0.3723	74.00	27.55
				$\sum W_n$= 1.138	**$\sum q_n$ =929.42**	**$\sum W_nq_n$= 144.45**
Water Quality Index = $\sum W_nq_n$ / $\sum W_n$ = 126.89						

5. Result & Discussion

Water Quality Index provides a single number that express 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 whole story of water quality; there are many other 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 indices incorporate from multiple water quality parameters into mathematical equation that rates the health of a water body with number.

Procedure of WQI calculation for the Sample No.1 has been presented in Table. 3 the same calculation method has been followed for all the samples and the determined values of WQI with assigned quality rating cumulatively presented in Table below.

Table .4 Calculation of average WQI of two years (**2015 – 2016)**

S.No.	Location	WQI - 2015	WQI -2016	Average WQI of 2015 and 2016	Quality Rating
1	Malkapuram	117.81	121.33	119.57	Unsuitable For Drinking
2	Sriharipuram	91.90	97.27	94.59	Very Poor Water Quality

3	Gajuwaka	93.6	99.26	96.43	Very Poor Water Quality
4	Mindi	129.93	138.62	134.28	Unsuitable For Drinking
5	Akkireddypalem	112.67	114.73	113.70	Unsuitable For Drinking
6	Autonagar	233.76	240.82	237.29	Unsuitable For Drinking
7	Peddagantyada	91.81	91.51	91.66	Very Poor Water Quality
8	Kurmanapalem	109.23	112.49	110.86	Unsuitable For Drinking
9	Steel Plant	157.86	163.31	160.59	Unsuitable For Drinking
10	Paravada	116.06	118.56	117.31	Unsuitable For Drinking
11	Gnanpuram	126.05	132.57	129.31	Unsuitable For Drinking
12	Velampeta	193.91	193.3	193.61	Unsuitable For Drinking
13	Kotaveedi	214.2	218.41	216.31	Unsuitable For Drinking
14	Fishing Harbour	102.81	106.05	104.43	Unsuitable For Drinking
15	Old-post Office	151.74	154.64	153.19	Unsuitable For Drinking
16	Appughar	453.11	449.45	451.28	Unsuitable For Drinking
17	East point colony	279.57	281.3	280.44	Unsuitable For Drinking
18	Kailasha hill	174.47	175.96	175.22	Unsuitable For Drinking
19	Visalakshinagar	114.17	115.36	114.77	Unsuitable For Drinking

6. Conclusions

The WQI for 40 samples ranges from 89.21 to 660.56. Almost ninety nine percent of the samples exceed 100, which is an upper limit for drinking water. The high value of WQI at these stations has been found to be mainly from the higher values of iron, nitrate, total dissolved solids, hardness, fluorides, bicarbonate, chloride and manganese in the groundwater. About 63.5% of water samples are poor in quality. The reason may be due to the geographical location of Visakhapatnam. It is a highly industrialized city with agricultural activity upstream. It is a hilly area with chances of mineral inflow into the ground water from the eastern ghats. Moreover its proximity to the ocean suggests sea water intrusion into the ground water aquifers. In this part, the groundwater quality may improve if the inflow good quality of freshwater during rainy season. Magnesium and chloride are significantly interrelated and indicates that the hardness of the water is permanent in nature. The analysis reveals that the groundwater of the area needs some degree of treatment before consumption, and it also needs to be protected from the perils of contamination.

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