ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com
Journal DOI: 10.21474/IJAR01

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

ASSESSMENT AND MAPPING OF WATER QUALITY INDEX OF GROUNDWATER IN RENIGUNTA NEAR TIRUPATI, ANDHRA PRADESH USING GEOGRAPHICAL INFORMATION SYSTEMS.

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Manuscript Info *Abstract*

Manuscript History:

Received: 18 February 2016
Final Accepted: 19 March 2016
Published Online: April 2016

Key words:
Groundwater, Water quality parameters, Water Quality Index, Spatial distribution, Renigunta.

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The present work is aimed at assessing the quality of groundwater in renigunta by water quality index (WQI). For this, groundwater samples were collected from 12 sampling stations and subjected to physico-chemical analysis of 16 parameters includepH, total dissolved solids, total hardness, calcium, magnesium, sodium, potassium, sulphate, bicarbonate, chloride, nitrate and fluoride, and heavy metals such as iron, copper, chromium and cadmium. From the analyzed data, water quality index has been calculated. The topographic map covering renigunta, was obtained from Survey of India (SOI) and sampling locations have been taken using GPS in order to prepare the contour map showing distribution of water quality index. The result of the work is presented in the form of map which gives better understanding of the present water quality scenario of the study area.

Introduction:-

World is heading towards huge freshwater crisis due to rapid growth of population, urbanization and industrialization. Groundwater remains the only option to supplement the ever increasing demand of water. It is estimated that approximately one-third of the world's population use groundwater for drinking (Nickson et al., 2005). In recent years, the increasing threat to the groundwater quality due to human activities has become a matter of great concern. Majority of groundwater quality problems present today are caused by contamination and by overexploitation, or by combination of both. According Central Ground Water Board (CGWB), half of India's groundwater poisonous.

Water quality index is one of the most effective tools (Chopra et.al., 1999) to communicate information on the quality of water. So it becomes an important parameter for the assessment and management of groundwater. Water quality index means summarizing of large amounts of water quality data into simple terms for reporting to management and the public in a consistent manner. It tells us whether the overall quality of water bodies poses a potential threat to various uses of water. The objective of the present work is to discuss the suitability of groundwater for human consumption based on computed water quality index values.

Study area:-

The study area covers Renigunta town which is 9 km away from holy city Tirupati. Geographical coordinates of Renigunta area 13°39'0'' North, 79°31'0'' East. Renigunta is a census town in Chittoor district of Andhra Pradesh. The total population of Renigunta was 26,031 (Census India, 2011). Renigunta's climate is classified as tropical. In

winter, there is much less rainfall than in summer. Average annual temperature is 28.6 ^{o}C. Average precipitation is 939 mm (climatedata.org, 2015). The location map of the study area is shown in Figure 1.

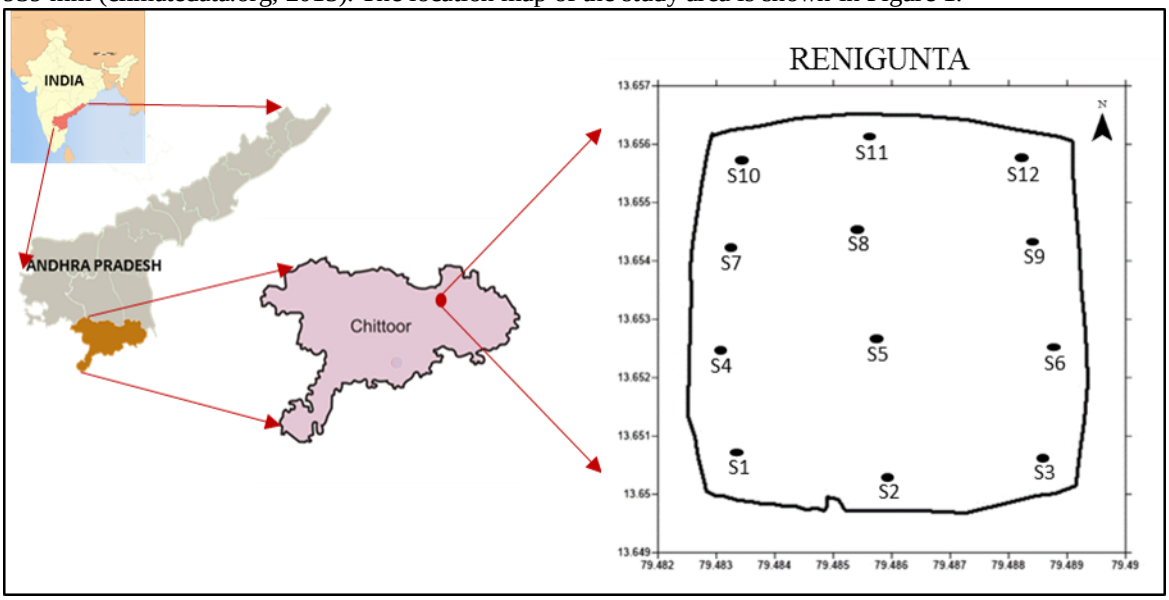

Figure 1: Location map of the study area with sampling stations.

Materials and methods:-

Sample collection:-

Groundwater samples were collected from 12 locations (Figure 2) during post-monsoon period (November 2015). Each of the groundwater samples was analyzed for 16 parameters includepH, total dissolved solids, total hardness, calcium, magnesium, sodium, potassium, sulphate, bicarbonate, chloride, nitrate and fluoride, and heavy metals such as iron, copper, chromium and cadmium using standard procedures recommended by APHA.The results were compared with BIS 10500:2012 standards (Table 1) and WQI was calculated for each and every sample by considering WHO standards (Table 1).

Table 1: Drinking water quality standards according to BIS (10500:2012) and WHO.

Parameter	BIS		WHO Standards
	Desirable Limit	Maximum Permissible Limit	
pH	6.5-8.5	No relaxation	7.0-8.5
TDS	500	2000	500
Total Hardness	200	600	100
Calcium	75	200	75
Magnesium	30	100	50
Sodium	-	-	200
Potassium	-	-	12
Sulphates	200	400	200
Bicarbonate	-	-	500
Chlorides	250	1000	200
Nitrates	45	No relaxation	45
Fluorides	1.0	1.5	1.5
Iron	0.3	No relaxation	0.3
Copper	0.05	1.5	0.05
Lead	0.01	No relaxation	0.01
Chromium	0.05	No relaxation	0.05
Cadmium	0.003	No relaxation	0.003

*All units except pH are in mg/l

Water Quality Index:-

In computing WQI, first of all, each of the selected parameters has been assigned a weight (w_i) based on their perceived threat to the water quality. The maximum weight was assigned to parameters which have major importance in water quality assessment. Minimum weight was assigned to the parameters which may not be harmful (Papiya Mandal et.al, 2012 and Jasmin et.al, 2014) (Table 2). Then, the relative weight (W_i) is calculated using following equation:

$$Wi = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (1)$$

Where, W_i is the relative weight, w_i is the weight of each parameter and n is the number of parameters. Calculated relative weight (W_i) values of each parameter are also mentioned in Table 2.

Table 2: Weightages and Relative weights of water parameters.

Chemical Parameter	Weight (w_i)	Relative Weight (W_i)
pH	4	0.0754
TDS	4	0.0754
TH	2	0.0377
Ca^{2+}	2	0.0377
Mg^{2+}	2	0.0377
Na^{+}	2	0.0377
K^{+}	2	0.0377
SO_4^{2-}	4	0.0754
HCO_3^{-}	3	0.0566
Cl^{-}	3	0.0566
NO_3^{-}	5	0.0943
F^{-}	4	0.0754
Fe	4	0.0754
Cu	2	0.0377
Cr	5	0.0943
Cd	5	0.0943

Lastly, a quality rating scale (q_i) for each parameter is calculated using following equation:

$$q_i = (C_i / S_i) \times 100 \quad (2)$$

Where, C_i is concentration of each parameter, and S_i is standard concentration of each parameter according WHO guidelines for drinking-water quality (4^{th}ed.).

After that SI (Sub index) is determined for each parameter, which is then used to determine the WQI as per the following equations

$$SI_i = W_i q_i \quad (3)$$

$$WQI = \sum SI_i \quad (4)$$

Based on computed WQI values of less than 50, 50-100, 100-200, 200-300 and greater than 300, water quality is classified as excellent water, good water, poor water, very poor water, and water unsuitable for drinking.

Creation of map:-

The topographic map (57 O/6) of 1:50,000 scale covering the study area were obtained from the Survey of India (SOI). The topographic map acquired from SOI was georeferenced using Surfer software version 11, and boundary of the study area was delineated. Water quality index data obtained was used as attribute database in preparing contour map by Surfer 11. Location of the sample acquisition points was recorded using hand held Geo Positioning System (GPS). The spatial and attribute database generated were integrated for the generation of the spatial distribution map of Water Quality Index.

Results and discussion:-

Results of physico-chemical analysis of groundwater samples are presented in Table 3.

Table 3: Results of Physico-Chemical analysis of groundwater samples.

Parameter	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
pH	7.3	6.9	7.2	6.8	6.7	7.2	7.1	7.1	6.9	7.4	6.9	6.7
TDS	1620	1806	2008	1374	1882	1836	1454	1876	2194	2326	2032	2024
TH	290	326	288	240	292	416	398	460	442	538	480	526
Ca^{2+}	102	76	106	77	66	152	69	55	52	70	50	56
Mg^{2+}	28	38	31	28	46	29	27	36	54	37	55	41
Na^{+}	235	299	316	289	222	286	249	248	273	292	256	266
K^{+}	11	12	23	11	11	9	9	12	19	16	18	16
SO_4^{2-}	93	138	125	119	296	106	95	268	190	156	144	170
HCO_3^{-}	530	490	568	430	442	676	344	358	408	426	392	436
Cl^{-}	182	168	338	112	236	138	107	208	360	302	194	210
NO_3^{-}	18	16	21	24	19	36	29	68	59	74	88	82
F^{-}	0.4	0.4	0.8	1	0.4	1.1	0.8	1	1.2	0.8	0.7	0.7
Fe	0.22	0.38	0.42	0.35	0.47	0.55	0.41	0.49	0.61	0.36	0.58	0.53
Cu	0.31	0.31	0.31	0.32	0.34	0.33	0.35	0.33	0.32	0.33	0.31	0.29
Cr	0.058	0.059	0.058	0.057	0.058	0.056	0.06	0.062	0.059	0.06	0.054	0.052
Cd	0.782	0.736	0.748	0.79	0.798	0.752	0.786	0.802	0.859	0.826	0.762	0.71

*All units except pH are in mg/l

At all the stations, pH is within limits given by BIS. Not even single station have TDS concentration within desirable limit and it ranges from 1374 to 2326 mg/l. TH ranges from 240 to 538, thus at all the sampling stations the TH is more than the desirable limit. Calcium concentrations are within the desirable value of 75 mg/l except at S1, S2, S3, S4 and S6. Magnesium concentration at S1, S4, S6, and S7 are well within the desirable limit, whereas at remaining stations concentration of magnesium was found to be more than desirable and less than permissible limits. Sodium values ranges from 222 to 316 mg/l and Potassium ranges from 9 to 23 mg/l. Sulphate concentration varied from 93 to 296 mg/l and it is more than desirable limit at only two stations i.e., S5 and S8. Concentrations of bicarbonate ranges from 344 to 676 mg/l. At S9 and S10, chloride concentration is more than 250 mg/l, whereas at remaining stations chloride concentration less than 250 mg/l. Out of twelve stations, seven stations have nitrate concentration less than 45 mg/l. The stations having nitrates concentration more than 45 mg/l are S8, S9, S10, S11 and S12. The fluoride concentration more than the desirable limit of 1 mg/l are found at S6 and S9, while remaining are within desirable limit.

Concentration of iron ranges from 0.22 to 0.61 mg/l and it is within desirable limit only at S1. Concentration of copper ranges from 0.31 to 0.35 mg/l. That means at all the stations copper concentration is within desirable limits. At all the stations chromium concentration is more than desirable limit and it ranges from 0.052 to 0.062 mg/l. Cadmium is found to be in excessive levels at all the stations. Cadmium concentration ranges from 0.71 to 0.859 mg/l which is more than the desirable limit of 0.003 mg/l given by BIS.

The computed WQI values ranges from 2388 to 2866. So groundwater in the study area is unsuitable for drinking. The higher values of WQI are due to higher values of cadmium in the groundwater. Spatial distribution of water quality index is shown in Figure 2.

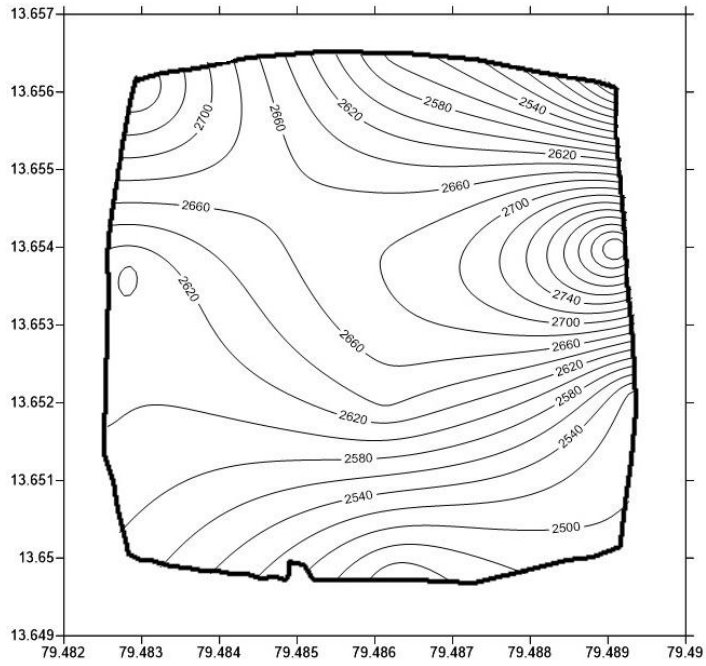

Figure 2: Spatial distribution of water quality index.

Conclusions:-

It is observed that chromium and cadmium concentrations are more than permissible limits in the study area, especially cadmium levels are very high. Chromium and Cadmium are carcinogenic, so proper treatment is required. As per WQI, the groundwater in the study area is unsuitable for drinking. Necessary measures are to be taken to supply safe drinking water to the people living in study area. The final output has been given in the spatial distribution of water quality index in the study area.

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