RESEARCH PAPER | Geology | Volume : 6 | Issue : 2 | FEBRUARY 2016 | ISSN - 2249-555X

Assessment of Groundwater Quality Index in the Kadapa Municipal City, Y.S.R. District, Andhra Pradesh

KEYWORDS: Water quality index, physico-chemical parameters, Groundwater, Chloride.

Sunitha. V	Muralidhara Reddy.B	Sumithra. S
Department of Geology, Yogi Vemana University, Kadapa, A.P.	Department of Geology, Yogi Vemana University, Kadapa, A.P.	Department of Environmental Science Yogi Vemana University, Kadapa, A.P.

ABSTRACT *Water quality index exhibits the overall water quality at a specific location and specific time based on several water quality parameters. The objective of an index is to turn complex quality data in to information that is understandable and useable by the public. For calculating the WQI following eight physcio-chemical parameters such as pH, Electrical conductivity, Total Dissolved Solids, Total Hardness, Alkalinity, Chloride, Calcium and Fluoride were taken to assess the impact of pollutants due to anthropogenic activities. The water quality index value for the ground water ranges from 14.82 to 216.18. In the present study, the quality of water was found to be good except in few areas.*

Introduction:

Ground water is one of the most important natural resources required for human consumption for various purposes such as domestic, irrigation, industrialization and urbanization. Generally, the motion of groundwater along its flow paths below the ground surface increases the concentration of the chemical species [1,2,3]. Hence, the groundwater chemistry could reveal important information on the geological history of the aquifers and the suitability of groundwater for domestic, industrial and agricultural purposes.

Quality of groundwater is equally important to its quantity owing to the suitability of water for various purposes[4,5]. Groundwater chemistry, in turn, depends on a number of factors, such as general geology, degree of chemical weathering of the various rock types, quality of recharge water and inputs from sources other than water rock interaction. Such factors and their interactions result in a complex groundwater quality [1,6,7]. The rapid increase in the population of the country has led to large scale groundwater developments in some areas. Intense agricultural and urban development has caused a high demand on groundwater resources in arid and semi-arid regions of Iran while putting these resources at greater risk to contamination[8,9,10]. The sources for ground water supply mostly depend upon the rainfall and the percolation of the water into the earth. Another important factor is quality of the soil. SwarnaLatha, et al., (2007) [11] used the WQI in water quality assessment at village level, S. Kota, Vizianagaram district. 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[12]. The objective of the present study was to interpret the water quality index (WQI) based on the physico-chemical parameters.

Study Area:

Kadapa is situated in the south central part of the Andhra Pradesh State. It is the district headquarters of Y.S.R Kadapa district covering an area of 164.08 km^2. Coordinates of Kadapa is located at 14^0 29′ N latitude and 78^0 50′ E longitude with a mean elevation of 138 m study area intended boundary falling in Survey of India (SOI) topographic sheet 57 J/14 and 57 J/15 on 1:50,000 scale as shown in Figure-1.

FIG: 1 MAP SHOWING LOCATION OF THE STUDY AREA

Materials and Method:

Laboratory Analysis:

The chemical analysis of water samples were carried out at the Geochemistry Laboratory in Department of Geology, Yogi Vemana University. Water samples were taken at the end of the constant rate pumping tests for each of the boreholes and analyses were done approximately 24 hours after sampling. The methods used include titrimetry, colorimetry and gravimetry using the standard methods as suggested by the American Public Health Association, 2007[13]. Table 1 gives the result of analyses for these parameters in the different water samples for the 25 boreholes.

S.No	EC µs/cm	TDS	pH	F^- mg/l	Cl^- mg/l	TH mg/l	HCO_3^- mg/l	Ca^{2+} mg/l
1	2600	1190	8.57	1.44	72	400	60	124
2	2110	840	8.33	0.900	128	140	24	16
3	1650	700	8.34	0.795	99	140	36	16
4	1740	760	8.52	1.03	92	160	60	32
5	3650	1790	7.98	0.967	426	140	48	28
6	2560	1060	8.17	0.694	213	160	36	24
7	3440	1580	8.06	0.562	518	280	24	28
8	7920	3730	8.43	0.866	135	180	36	48
9	3990	1580	8.39	2.22	227	180	36	28
10	2960	1350	7.87	1.00	75	200	24	28
11	2770	1200	8.06	1.46	263	140	36	24
12	1920	800	8.72	1.71	71	160	48	20
13	2220	1020	8.03	1.35	206	160	36	40

Volume : 6 | Issue : 2 | FEBRUARY 2016 | ISSN - 2249-555X

14	3910	1740	7.84	1.49	362	220	36	40
15	7370	3350	7.48	0.812	859	560	36	100
16	4500	1840	8.21	1.38	248	160	60	20
17	2790	1180	8.02	0.923	298	200	60	40
18	3030	1380	7.80	1.51	376	200	60	28
19	2470	1050	8.25	0.881	163	120	48	12
20	2390	1050	7.99	1.90	213	280	48	24
21	2360	1030	8.57	0.557	170	120	36	28
22	2660	1180	8.66	0.963	298	200	60	40
23	4950	2170	7.98	1.73	611	220	36	20
24	2780	1120	8.54	0.93	121	140	36	24
25	1660	720	8.24	1.01	121	100	12	12

Table. 1: Physico-chemical parameters of groundwater of the study area

The water quality index (WQI) has been calculated by using the standards of drinking water quality recommended by the World Health Organization (WHO)[14] and Indian Standard Institute (ISI)[15]. The calculation of WQI was made using a weighted arithmetic index method given below (Brown, et al., 1972)[16] in the following steps.

Calculation for water quality rating:

$q_n = 100\,[(V_n–V_i)/(S_n–V_i)]$

Where q_n = Water quality rating for the n^{th} parameter, V_n = Observed value of the n^{th} parameter, S_n = Standard permissible value of n^{th} parameter, V_i = Ideal value of n^{th} parameter.

All the ideal values (Vi) are taken as zero for drinking water except for pH 7.0, dissolved oxygen = 14.6 mg/L and Fluoride = 1 mg/L.

Calculation of quality rating for pH:

For pH the ideal value is 7.0 (for natural water) and a permissible value is 8.5 (for polluted water). Therefore the quality rating for pH is calculated from the following relation:

$q_{pH} = 100\,[(V_{pH}–7.0)/(8.5–7.0)]$

where V_{pH} = observed value of pH during the study period.

Calculation of quality rating for fluoride:

The ideal value (Vi) for fluoride is 1 mg/L and standard permitted value for drinking water is 1.5 mg/L. Therefore quality rating is calculated from the following relation:

$q_F = 100\,[(V_F-1)/(1.5-1)]$

where V_F = observed value of fluoride.

Calculation of Unit weight (W_n):

Unit weight was calculated by a value inversely proportional to recommended standard

Value S_n of the corresponding parameter.

$W_n = K/S_n$

Where W_n = unit weight for the nth parameter.

S_n = standard value of the nth parameter, K = constant for proportionality.

Proportionality constant was calculated by using the equation:

$K = 1/\sum(1/S_n)$

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

$WQI = \sum q_n W_n / \sum W_n$

RESULTS AND DISCUSSION:

Class	WQI Value	Water quality status
I	< 50	Excellent
II	50 - 100	Good water
III	100 -200	Poor water
IV	200 - 300	Very poor water
V	300	Water unsuitable for drinking

Table. 2: Water quality classification based on WQI value.

S. No.	Parameters	Standards (S_n)	Recommended Agency	Unit weight (W_n)
1	pH	6.5 – 8.5	ISI 1983	0.1447
2	EC	1000 µs/cm	WHO	0.0012
3	Total Dissolved Solids	500	ISI 1983	0.0024
4	Total Hardness	300	ISI 1983	0.0040
5	Chloride	250	ISI 1983	0.0049
6	Calcium	75	ISI 1983	0.0164
7	Fluoride	1.5	ISI 1983	0.8198
8	Alkalinity (CO_3^-)	200	ISI 1983	0.0061
				$\sum W_n$ = 0.9995

Table. 3: Drinking water standards, recommending agencies and unit weights

Parameters	Standard Value	Ideal Value	Unit weight (W_n)	Observed value	Quality rating (q_n)	$W_n q_n$
pH	6.5 – 8.5	7.0	0.1447	8.57	104.67	15.15
EC	1000 µs/cm	0	0.0012	2600	260	0.312
Total Dissolved Solids	500	0	0.0024	1190	238	0.571
Total Hardness	300	0	0.0040	400	133.33	0.533
Chloride	250	0	0.0049	27	10.8	0.053
Calcium	75	0	0.0164	124	165.33	2.711
Fluoride	1.5	0	0.8198	1.44	88	72.14
Alkalinity (CO_3^-)	200	0	0.0061	60	30	0.183
			$\sum W_n$ = 0.9995			$\sum W_n q_n$ = 91.65
WQI = 91.69						

Table.4: Sample 1 Water Quality Index (WQI)

Location	WQI	Remarks
S2	30.75	Excellent
S3	47.94	Excellent
S4	72.13	Good
S5	17.95	Excellent
S6	63.57	Good
S7	85.33	Good
S8	40.18	Excellent
S9	216.18	Very Poor
S10	10.47	Excellent
S11	87.94	Good
S12	134.62	Poor
S13	69.72	Good
S14	91.78	Good
S15	42.69	Excellent
S16	76.75	Good

Volume : 6 | Issue : 2 | FEBRUARY 2016 | ISSN - 2249-555X

S17	25.28	Excellent
S18	38.43	Excellent
S19	33.27	Excellent
S20	159.44	Poor
S21	89.79	Good
S22	24.89	Excellent
S23	132.88	Poor
S24	28.28	Excellent
S25	14.82	Excellent

Table. 5: WQI at Individual Sampling Stations.

pH:
The pH of water is very important of its quality and provides important piece of information in many types of geochemical equilibrium or solubility calculations[17]. The limit of pH value for drinking water is specified as 6.5 to 8.5[15]. In most natural waters, the pH value is dependent on the carbon dioxide-carbonate-bicarbonate equilibrium. As the equilibrium is markedly affected by temperature and pressure, it is obvious that changes in pH may occur when these are altered. Most ground waters have a pH range of 6 to 8.5[18].The pH of groundwater in the study area ranged from 7.48 to 8.72. pH values for all the samples are within the desirable limits. It is observed that most of the groundwater is alkaline in nature. Though pH has no direct effect on the human health, all biochemical reactions are sensitive to variation of the pH.

Electrical Conductivity:
The conductivity measurement provides an indication of ionic concentrations. It depends upon temperature, concentration and types of ions present[17]. The maximum limit of electrical conductivity in drinking water is prescribed as 1500 μS/cm[14]. The electrical conductivity of the groundwater ranged from 1650 μS/cm to 7920 μS/cm at 25°C.

Total Dissolved Solids:
The concentration of dissolved matter in water is given by the weight of the material on evaporation of the water to dryness followed by heating for one hour at 180°C. In the process of drying and heating some of the dissolved matter may dissolve decompose or volatilize with escape of gases. The Total Dissolved Solids of the groundwater in the study area ranged from 700 to 3730 mg/L. The desirable limit of TDS in drinking water is 500 mg/L. Potability of the water decreases when the concentration exceeds this limit and may cause gastro-intestinal irritation[15]. It is observed that 79% of the groundwater from the area during pre-monsoon and post-monsoon falls into fresh water category.

Total Hardness:
Hardness is an important criterion for determining the usability of water for domestic, drinking and many industrial purposes[18] and results from the presence of divalent metallic ions, of which calcium and magnesium are the most abundant in the groundwater. Other elements could be included are strontium, barium and some heavy metals. These, however are seldom determined under usually present in insignificant amounts relative to calcium and magnesium. The Total hardness of the groundwater in the study area ranged from 100 to 560 mg/L. The limit of total hardness for drinking water is specified as 300 mg/L[17].

Calcium:
The range of calcium content in groundwater is largely dependent on the solubility of calcium carbonate, sulfate and rarely chloride. The solubility of calcium carbonate varies widely with the partial pressure of CO_2 in the air in contact with the water. The salts of calcium and magnesium are responsible for the hardness of water. The permissible limit of calcium in drinking water is 75 mg/L[15]. The calcium concentration of the groundwater in the study area ranged from 12 to 124 mg/L during pre-monsoon period.

Chloride:
Chloride bearing rock minerals such as sodalite and chlorapatite which are very minor constituents of igneous and metamorphic rocks, and liquid inclusions which comprise very insignificant fraction of the rock volume are minor sources of chloride in groundwater. It is presumable that the bulk of the chloride in groundwater is either from atmospheric sources or sea-water contamination. Most chloride in groundwater is present as sodium chloride, but the chloride content may exceed the sodium due to base- exchange phenomena and also weathering of phosphate minerals and domestic sewage[18].The upper limit of chloride concentration for drinking water is specified as 250 mg/L[15]. The chloride concentration of the groundwater in the study area ranged from 71 to 859 mg/L during pre-monsoon period.

Fluoride:
Fluoride in drinking water has now become one of the most important geo-environmental and toxicological issues in the world. During the last three decades, high fluoride concentrations in drinking water sources and the resultant disease "Fluorosis" is being highlighted throughout the world. In developing countries, especially in the tropical regions, rural communities, who mostly depend on groundwater sources for their domestic water supplies, face this problem seriously. According to Indian standard specification for drinking water 1.5 mg/L fluoride is the maximum permissible limit. The Fluoride content in the study area ranged from 0.56 to 2.22 mg/L.

Total Alkalinity (CO_3- and HCO_3-):
The primary source of carbonate and bicarbonate ions in groundwater is the dissolved carbon dioxide in rain, which, as it enters the soil, dissolves more carbon dioxide. An increase in temperature or decrease in the pressure causes reduction in the solubility of carbon dioxide in water [21]. The alkalinity of natural waters is due to the salts of carbonates, bicarbonates, borates, silicates and phosphates along with hydroxyl ions in the free salt. However, the major portion of the alkalinity in natural waters is caused by hydroxide, carbonate and bicarbonates, which may be ranked inorder of their association with high pH values. The bicarbonate concentration of the groundwater in the study area ranged from 12 to 60 mg/L during pre-monsoon period. The permissible limit of carbonate (CO_3^-) in drinking water is 10 mg/L and the rejection limit is 50 mg/L. The permissible limit of bicarbonate (HCO_3^-) in drinking water is 500 mg/L[20]. Most of the water samples of the study area contain no carbonate ions.

Conclusion:
To assess the groundwater conditions in the study area twenty five samples were collected from hand pumps at different streets. The pH of groundwater in the study area is ranged from 7.48 to 8.72. The electrical conductivity of the groundwater is ranging from 1650 to 7920 μS/cm at 25⁰C. The water quality of the Kadapa town varied from excellent to good. The highest values of WQI are observed at sampling stations S9, S12, S20 and S23. The high value of WQI at these stations has been found to be mainly from values of fluoride, Electrical conductivity. Hence these four sampling stations need some degree of

Volume : 6 | Issue : 2 | FEBRUARY 2016 | ISSN - 2249-555X

treatment before consumption and it also needs to be protected from contamination.

REFERENCE 1. Domenico P.A., and Schwartz F.W., Physical and chemical hydrogeology, John Wiley and Sons, New York, pp. 824 (1990). 2. Freeze R.A., and Cherry J.A., Groundwater, Prentice-Hall, Englewood Cliffs, NJ, USA, (1979). 3. Kortatsi B.K., Hydrochemical framework of groundwater in the Ankobra Basin, Ghana, Aquatic Geochemistry, 13(1), pp. 41–74, (2007). 4. Schiavo M.A., Havser S., Gusimano G., and Gatto L., Geochemical characterization of groundwater and submarine discharge in the south-eastern Sicily, Continental Shelf Research, 26(7), pp. 826–834, (2006). 5. Subramani T., Elango L., and Damodarasamy S.R., Groundwater quality and its suitability for drinking and agricultural use in Chithar River Basin, Tamil Nadu, India, Environmental Geology, 47, pp. 1099–1110, (2005). 6. Guler C., and Thyne G.D., Hydrologic and geologic factors controlling surface and groundwater chemistry in Indian Wells-Owens Valley area, southeastern California, USA, Journal of Hydrology, 285, pp. 177–198, (2004). 7. Vazquez Sunne E., Sanchez Vila X., and Carrera J., Introductory review of specific factors influencing urban groundwater, an emerging branch of hydrogeology, with reference to Barcelona, Spain, Hydrogeology Journal, 13, pp. 522–533, (2005). 8. Moghaddam A., and Najib M., Hydrogeologic characteristics of the alluvial tuff aquifer of northern Sahand Mountain slopes, Tabriz, Iran, Hydrogeology Journal, 14, pp. 1319–1329, (2006). 9. Jalali M., Chemical characteristics of groundwater in parts of mountainous region, Alvand, Hamadan, Iran, Environmental Geology, 51, pp. 433–446, (2006). 10. Khazaei E., Stednick J.D., Sanford W.E., and Warner J.W., Hydrochemical changes over time in the Zahedan aquifer, Iran, Environmental Monitoring and Assessment, (2006). 11. SwarnaLatha P., NageswaraRao K., Ramesh Kumar P.V., Harikishna M., Water quality assessment at village level- a case study, Indian J. Environ. Protection, 27(11), 996 -100, (2007). 12. Ramakrishnaiah C.R., Sadashivaiah C., Ranganna G., Assessment of water quality index for the ground water in Tumkurtaluk, Karnataka state India, 6(2), 523-530, (2009). 13. American Public Health Association (APHA), Standard methods for the examination of water and wastewater, American Public Health Association, Washington, DC, (2007). 14. World Health Organization (WHO)., International Standards for Drinking Water, Geneva, (1983). 15. ISI, Drinking water standards, Table 1, Substance and characteristics affecting the acceptability of water for domestic use 18, 10500, Indian Standard Institution, New Delhi, (1983). 16. Brown R.M., Mccleiland N.J., Deiniger R.A., Oconnor., Water quality Index – crossing the physical barrier, Proc. Int. Conf. on water pollution research Jerusalem, 6, 787-797, (1972). 17. Hem, J.D., Study and interpretation of the chemical characteristics of natural water, 3rd edition, Scientific Publishers, Jodhpur, pp. 2254, (1991). 18. Karanth K.R., Groundwater Assessment, Development and Management, Tata Mc graw Hill, New Delhi, pp. 720, (1987). 19. Karanth K.R., Groundwater assessment, Development and Management, Tata McGraw-Hill, New Delhi, pp. 720, (1989). 20. Todd D.K., Groundwater Hydrology, Wiley- India Edition, (1980).