WATER QUALITY INDEX OF GROUNDWATER IN AND AROUND LAKKIREDDIPALLI AND RAMAPURAM, Y.S.R DISTRICT, A.P INDIA

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Abstract:

Groundwater is an important and valuable source for irrigation, drinking and power sources. The main objective of this paper is to evaluate water quality index of groundwater in and around Lakkireddipalli and Ramapuram by using Water Quality Index (WQI) method. In the present study, a detailed investigation was carried out with an objective of identifying the groundwater quality, prominent water quality parameters controlling the hydrochemical evolution of aquifer system was studied. Water quality index was applied in present study area by using ten water quality parameters like pH, Electrical conductivity (EC), Total dissolved solids (TDS), Total Hardness (TH), Total Alkalinity (TA), calcium (Ca^{2+}), magnesium (Mg^{2+}), chloride (Cl-) sulfate(SO_4^{2-}) ,and fluoride (F^-). According to water quality index classification 70% of samples fall in class B: good category and 23% of samples fall in class C: poor water quality and only 7% of samples fall in class A: excellent water quality.

Keywords: Water quality index, Ground water, Lakkireddipalli, Ramapuram mandals, Y.S.R District, A.P

Introduction

Accessibility to a safe and reliable source of water is essential for sustainable development. The reliability of the water for various purposes depends on the chemical and physical quality of water. Groundwater chemistry is mainly controlled by natural as well as anthropogenic factors. Chemical composition of geologic formations affects the hydro chemical characteristics of groundwater during their circulation in the subsurface [1]. This underground passage through the pore spaces and weathered zones may alter the natural composition of the groundwater by the action of various hydro chemical processes [2]. In other words, composition of water can reveal the various processes in groundwater. Groundwater chemistry can be modified by a variety of anthropogenic sources. These include point sources, such as waste disposal facilities, industrial pollution, wastewater treatment works, on site sanitation, cemeteries, and many others [3]. Groundwater is the vital natural resources required for human consumption for various purposes such as domestic, irrigation, industrial water supply [4].

Systematic assessment of the physicochemical parameters, their sources and controlling hydrochemical processes are essential in maintaining the sustainable ecosystem. Physicochemical parameters as well as hydrochemistry were studied by many researchers to assess the characteristics of groundwater. In India about 6 million people suffer from fluoride contamination and the source for most of the fluoride in ground water is of geologic origin [5]. Protection of ground water has become a high priority management goal but apart from its quantitative characteristics, the quality of water that is its physicochemical characteristics should also be taken into consideration. The main objective of the present work was to assess the ground water quality in and around Lakkireddipalli and Ramapuram mandals Kadapa, Y.S.R District, A.P. 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. Water quality index is one of the most effective, simple and easily understandable tools to assess water quality for its

suitability for various purposes [6]. WQI of groundwater of the present study has been computed in this study to test its suitability for drinking purpose. The main objective of the study area is to interpret the water quality index (WQI) based on the physico-chemical parameters. In an attempt of developing water quality indices of groundwater in different areas, these indices have already been developed for Kadapa municipal city, Y.S.R District [7]. Here, a further attempt has been made to develop the WQI of groundwater of lakkireddipalli, ramapuram, Y.S.R district, A.P India.

Study Area

The climate of the study area is hot and semiarid. The monthly maximum, minimum and mean temperature as measured at Kadapa are 44°C, 14°C and 27°C respectively. The mean annual rainfall recorded at the Kadapa is 759 mm. The YSR district is aptly called the district of pennar as almost the entire district is drained by the Pennar River and its tributaries. The important tributaries joining the river from the north include the rivers Kunderu, sagilere and Tummalavanka while those from the south include the rivers Chitravati, Papaghni, Buggavanka, Cheyyeru, and kalletivagu. Bahuda mandavi, Pukkangi and Gunganeru are the tributaries of the Cheyyeru. The rivers and streams in the district are mostly ephemeral under the influence of heavy spells of rainfall by cyclonic storms in the Bay of Bengal [8]. The major rock types are granites, quartzites, shales, limestones, and granite gneiss. The Archaean comprises the Peninsular Gneissic Complex, represented by granite, granodiorite, granite-gneiss and migmatite. These rock types occur in the south western part of the district. Both the Archaean and Dharwar are traversed by dolerite dykes and quartz reefs. Alluvium consisting of gravel, sand, silt and clay occur along the river courses in the district. Geologically the study area consists of Granite, Quartzites, dolomite. The soil type is predominantly red. This soil is generally of poor quality and extends only to a small depth below the ground level. The top soil has a thickness of 1-2 m and is followed by weathered shales, fractured shales and Phyllites. The proposed study area is in the Lakkireddipalli and Ramapuram Mandals of YSR district and is shown in the figure 1. The study area falls in the Survey of India Toposheet No: 57 J 16 and J 12. The study region is bounded by east longitude $78^0 20^{'} 30''$ - $78^0 49' 30''$ and north latitude 14^0 18’ 0’’ – 14^0 7’ 30’’ (Figure 1).

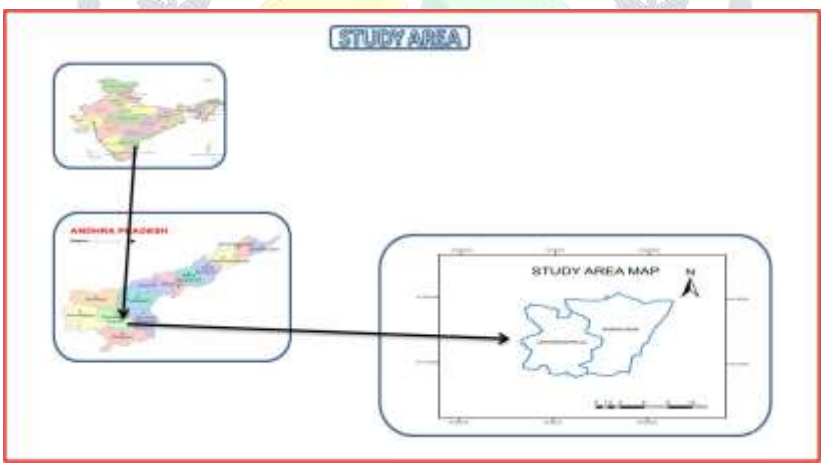

Fig: 1 Location map of Study Area

Materials and Method:

Thirty samples of groundwater used for drinking purpose were collected from either hand pumps or surface water at different villages of Ramapuram and lakkireddipalli Mandals of YSR District, Kadapa during the summer season month of February and March 2018(Fig:2). This season was selected because in this season often contamination increases due to low dilution and this tends to the accumulation of ions. Before sampling, the water left to run from the source for few minutes. Then water samples collected in pre cleaned, sterilized polyethylene bottles of two litre capacity.

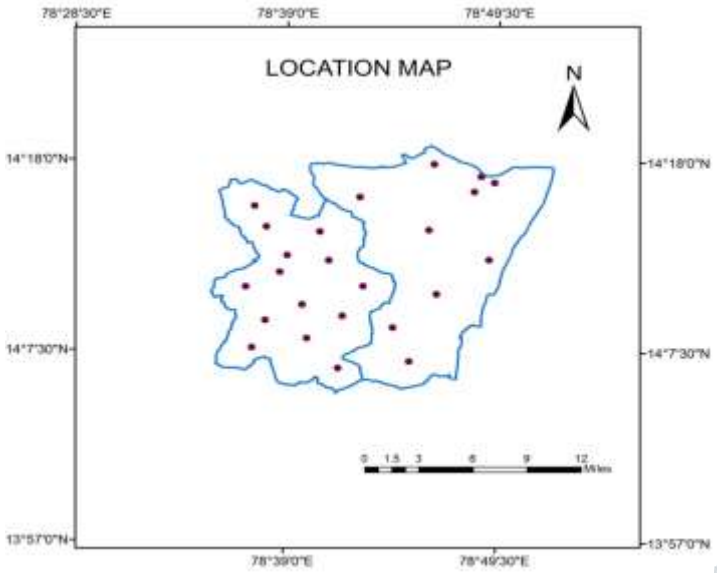

Fig: 2 Sample location map

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. The samples were analyzed to assess various physicochemical parameters according to [9]. The collected groundwater samples were analyzed for pH, electrical conductivity (EC), using pH and EC meters, Total dissolved solids (TDS), Total alkalinity (TA) as $CaCO_3$ and bicarbonate HCO3 were estimated by titrating with HCl, Total hardness (TH) as $CaCO_3$ and Calcium ($Ca^{2+)}$ were analyzed titrimetrically, using standard EDTA, Magnesium (Mg^{2+}),chloride (Cl^-) was estimated by standard AgNO3 titration, sulphate ($SO4^{2-}$), was analysed by spectrophotometer, F^- was determined by using ion selective electrode (Orion 4 star ion meter, Model: pH/ISE). Sodium fluoride was used to prepare the standard solutions. The fluoride concentration in groundwater was determined electrochemically, using fluoride ion-selective electrode[8]. The electrode used was an Orion fluoride electrode, coupled to an Orion electrometer. Standard fluoride solutions (0.1–10 mg/L) were prepared from a stock solution (100 mg/L) of sodium fluoride. As per experimental requirement, 2 ml of total ionic strength adjusting buffer grade III (TISAB III) was added to 20 ml of sample. The methods used include titrimetry, colorimetry and gravimetry using the standard methods as suggested by the American Public Health Association, 2007. Table 1 gives the result of analyses for these parameters in the different water samples for the 20 boreholes. The physical and chemical parameters of groundwater like, Temperature (T), pH, Electrical conductivity (EC), total dissolved solids (TDS), Total Hardness (TH), Total Alkalinity (TA), calcium (Ca^{2+}), magnesium (Mg^{2+}), chloride (Cl-) sulphate(SO_4^{2-}) ,and fluoride (F^-). The analyzed data were compared with standard values recommended by WHO and also correlation coefficient was calculated to assess the relationship between various parameters.

RESULTS AND DISCUSSION

Hydrogeochemistry:

Hydrogeochemistry is a sub-discipline of hydrogeology which is referred to as Chemical hydrogeology in some references and Groundwater geochemistry. This sub-discipline has been developed to deal with quality, contamination, chemistry, chemical processes and reactions that take place in various groundwater systems. Due to the importance of water quality issues, this sub-discipline has gradually changed into a well established field of research.

Table 1: Results of chemical; analysis of groundwater of the study area

S. No	pH	EC	TDS	TH as $CaCO_3$	Ca^{2+}	Mg^{2+}	TA	Cl^-	Sulphate	F^-
1	8.41	3983	2549	160	32	42	109.2	127.8	185	0.87
2	8.3	2942	1883	220	40	88	121.6	99.4	223	2.65
3	8.76	1482	948	120	24	94	328.8	227.2	162	1.6
4	8.47	1708	1093	160	32	92	182.8	78.1	169	2
5	8.82	2196	1405	40	24	48	231.6	92.3	162	2.93
6	8.19	1216	778	420	72	96	280.4	752.6	112	1.24
7	8.04	2922	1870	500	216	33	134	489.9	156	0.8
8	8.42	3041	1946	380	56	96	243.6	773.9	189	1.83
9	8.88	2682	1716	120	72	92	182.8	156.2	153	0.655
10	8.84	1502	961	140	48	83	463.2	220.1	158	0.55
11	8.18	2935	1878	560	104	60	60.8	937.2	172	1.25
12	8.01	2905	1859	520	112	58	85.2	717.1	163	0.774
13	8.14	1470	941	480	64	83	207.2	397.6	161	0.68
14	8.57	3057	1956	160	48	96	194.8	383.4	168	1.2
15	8.62	2811	1799	200	56	48	207.2	198.8	134	1.4
16	8.09	1814	1161	380	96	83	109.6	390.5	96	0.25
17	7.89	4166	2666	580	168	54	158.4	518.3	186	1.25
18	8.33	1552	993	180	48	60	158.2	49.7	176	1.34
19	8.55	2875	1840	200	32	63	182.8	63.9	168	1.34
20	8.86	4072	2606	260	32	94	170.2	92.3	184	1.25
21	8.71	1776	1137	80	72	86	170.2	163.3	97	1.34
22	8.05	3908	2501	340	72	40	231.6	227.2	195	1.42
23	8.9	1974	1263	160	32	92	280.4	113.6	103	1.04
24	8.16	2841	1818	300	56	35	256	319.5	182	1.39
25	8.17	3821	2445	180	488	94	109.6	305.3	234	1.34
26	8.99	2027	1297	260	24	81	256	92.3	123	1.65
27	8.8	1425	912	160	376	86	158.2	78.1	89	1.49
28	8.24	3905	2499	180	80	94	304.8	120.7	203	1.23
29	8.23	1578	1010	320	72	31	85.2	347.9	169	1.46
30	8.8	1965	1258	420	168	40	231.2	511.2	178	0.459

Table 2: Statistical analysis of the study area (n=30)

Chemical Parameters	Mean	Median	Std Deviation	Minimum	Maximum
pH	8.44733	8.415	0.326644	7.89	8.99
EC	2551.7	2746.5	927.1969	1216	4166
TDS	1632.939	1757.5	593.3615	778	2666
TH as CaCO3	272.6667	210	151.4512	40	580
Ca^{2+}	93.86667	60	103.733	24	488
Mg^{2+}	71.4	83	23.12276	31	96
Total Alkalinity	196.52	182.8	84.97481	60.8	463.2
Cl^-	301.5133	223.65	243.163	49.7	937.2
SO_3^-	161.6667	168	35.93225	89	234
F^-	1.289267	1.295	0.57349	0.25	2.93

Application of the WQI

This study is an effort to assess the water quality of lakkireddipalli, Ramapuram of Y.S.R District, A.P. For this purpose, ten water quality parameters like pH, EC,TDS,TH,Ca, Mg, TA, Cl^- Sulphate, and F^- have been selected. Values used for each parameter are the mean value of different points measured under this study. In the formulation of WQI, the importance of various parameters depends on the intended use of water. Water quality parameters are studied from the point of view of suitability for human consumption. The standards values of various parameters for the drinking water used in this study are those recommended by the [10] and [11]. The calculation and formulation of the WQI involved the following steps:

Ten water parameter were considered for calculation of water quality. The water quality index (WQI) has been calculated by using the standards of drinking water quality recommended by the World Health Organization (WHO)[10] and Indian Standard Institute (ISI) [11]. The calculation of WQI was made using a weighted arithmetic index method given below [12] in the following steps.

Calculation for water quality rating:

$$q_n = 100\,[(V_n - V_i)/(S_n - V_i)]$$

Where

qn = Water quality rating for the nth parameter
V_n = Observed value of the nth parameter
S_n = Recommended Standard of corresponding parameter
V_i = Ideal value of nth parameter

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

Calculation of Unit weight (Wn):

$$W_n = K/S_n$$

Unit weight was calculated by a value inversely proportional to recommended standard Value Sn of the corresponding parameter.

Where

Wn = unit weight for the nth parameter
Sn = standard value of the nth parameter
K = constant forProportionality

Proportionality constant was calculated by using the equation:

$$K = 1/\Sigma\,(1/S_n)$$

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

$$WQI = \Sigma q_n W_n / \Sigma W_n$$

Table: 3 Relative weight for each parameter

Chemical Parameters	Sn	1/Sn	K	Wn=K/Sn	Ideal Value (Vi)	Observed value (Vn)	Quality rating (Qn)	Wn *Qn	WQI
pH	8.5	0.1176	1.2345978	0.145246799	7	8.41	94.00	13.65	62.904
EC	1500	0.0007		0.000823065	0	3983	265.53	0.22	
TDS	1500	0.0007		0.000823065	0	2549	169.93	0.14	
THas CaCO3	500	0.002		0.002469196	0	160	32.00	0.08	
Ca2+	200	0.005		0.006172989	0	32	16.00	0.10	
Mg 2+	150	0.0067		0.008230652	0	42	28.00	0.23	
Total Alkalinity	200	0.005		0.006172989	0	109.2	54.60	0.34	
Cl^-	600	0.0017		0.002057663	0	127.8	21.30	0.04	
Sulphate	250	0.004		0.004938391	0	185	74.00	0.37	
F^-	1.5	0.6667		0.823065192	0	0.87	58.00	47.74	
Total		0.81		1				62.90	

Table 4: WQI at Individual Sampling Stations

Sample No	WQI	Water quality status
1	62.90395233	Good Water
2	159.8258725	Poor Water
3	107.0311361	Poor Water
4	125.7373313	Poor Water
5	180.01664	Poor Water
6	81.97357557	Good Water
7	56.21462756	Good Water
8	116.774767	Poor Water
9	56.09241166	Good Water
10	50.62111606	Good Water
11	82.05454017	Good Water
12	54.26313354	Good Water
13	50.46725572	Good Water
14	83.14130335	Good Water
15	94.26641652	Good Water
16	26.03682047	Excellent
17	79.71694748	Good Water
18	87.96461263	Good Water
19	90.255918	Good Water
20	88.62919178	Good Water
21	91.75169051	Good Water
22	90.22334277	Good Water
23	77.43186715	Good Water
24	89.53104287	Good Water
25	88.21633099	Good Water
26	111.7006653	Poor Water
27	101.7179594	Poor Water
28	82.08456067	Good Water
29	93.4303933	Good Water
30	44.97821137	Excellent

Table: 5 Water quality classification based on WQI value.

Class	WQI Value	Water Quality Status	% of Samples in Study area
A	< 50	Excellent	7.00%
B	51-100	Good	70%
C	101-200	Poor Water	23%
D	201-300	Very Poor Water	Nil
E	> 300	Water unsuitable For Drinking	Nil

According to water quality index classification 70% of samples fall in class B: good category and 23% of samples fall in class C: poor water quality and only 7% of samples fall in class A: excellent water quality as shown table 2.

pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. pH is considered as an important ecological factor and provides an important piece factor and piece of information on many types of geochemical equilibrium or solubility calculation. pH ranges from 7.9 to 8.99 indicating alkaline nature. The permissible limit of pH for drinking water is 6.5–8.5 [10]. Most samples are wit in the permissible limit. pH values of all the collected samples are well within the safe limit as prescribed by [13] Electrical conductivity is an indication of ionic concentrations and is dependent on temperature concentration and types of ions present [14] It is an useful tool to evaluate the purity of water. The most desirable limit of EC in drinking water is prescribed as 1,500 μmhos/cm [13] (WHO 2004; W.H.O, 1983). Electrical conductivity of the groundwater is ranging from 1216 to 4166 μS/cm with a mean of 2551 μS/cm. All samples are exceeded the maximum permissible limit except two samples. The mineral constituents dissolved in water constitute dissolved solids. The concentration of dissolved solids in natural water is usually less than 500 mg/L, while water with more than 1500 mg/L is undesirable for drinking and many industrial uses. The total concentration of dissolved minerals in water is a general indication of the over-all suitability of water for many types of uses. Water with more than 1000 mg/L of dissolved solids usually gives disagreeable taste or makes the water unsuitable in other respects. The high value of TDS influences the taste, hardness, and corrosive property of the water [15,16] Total dissolved solids (TDS) in water comprise all inorganic salts including carbonate, bicarbonate, chloride, fluoride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, and potassium [17]. TDS of groundwater samples ranges from 778 mg/L to 2666 mg/L and most of the samples are within the permissible limit of TDS 1500 mg/L except in few locations. Water that has a hardness of less than 75 mg/L is considered soft. A hardness of 75 to 150 mg/L is not objectionable for most purposes. Water with more than 150 mg/L hardness is unsafe. The removal of temporary hardness by heat causes the deposition of calcium and magnesium carbonates as a hard scale in kettles, cooking utensils, heating coils, and boiler tubes resulting in a waste of fuel. The maximum allowable limit of TH for drinking purpose is 500 mg/L and the most desirable limit is 100 mg/L as per the WHO international standard. Groundwater exceeding the limit of 300 mg/L is considered to be very hard[17]. Total hardness ranges from 40 to 580 mg/L. According to groundwater is considered as safe:<75, moderate to hard: 75-150; Hard 150-300; Very hard:>300. According to classification, all the groundwater of the present study area is rated as very hard. Total Alkalinity concentration of the groundwater samples in the study area is ranging from 60 to 463 mg/Ls. Calcium in the groundwater of the study area is varying from 24 to 488 mg/L. The permissible limit of calcium in drinking water is 200 mg/L [13]. Magnesium values varied between 31 to 96 mg/L. The required permissible limit of magnesium in groundwater for drinking purpose is 150 mg/L and all samples exceed the permissible limit of Mg except three samples . Sulfate is one of the major anion occurring in natural waters. The sulfate concentration in the study area ranges between 89 and 234 mg/L all samples fall within the desirable limit of 250 mg/L. The chloride concentration in the groundwater samples vary from 49.7 to 937 mg/L. Nearly 4 samples are above the

permissible limit of 600 mg/l. Fluoride concentrations in the study area varied between 0.25 to 2.93 mg/L with a mean of 1.29 mg/L.

Conclusion:

Groundwater quality assessment for drinking purpose in Lakkireddiaplli, Ramapuram mandals of Kadapa Y.S.R district were examined by various physico chemical parameters such as pH, electrical conductivity, total dissolved solids, total hardness, calcium, magnesium, carbonate, bicarbonate, chloride, sulphate and fluoride. The suitability for drinking purpose is determined by comparing with Indian and WHO standards. Fluoride concentration (1.5-3.0 mg/L) is observed in Kasireddipalli,Gopagudipalli, Mulapalli, Kalpanayenicheruvu, Medharapalli villages. The study reveals that children are highly prone to the health risks caused by dental fluorosis through the intake of elevated fluoride water. Therefore, the study indicates that the frequent monitoring of groundwater is a vital step to avoid human health risks and that groundwater must be tested prior to consumption to avoid health risks, especially in children.

According to water quality index classification 70% of samples fall in class B: good category and 23% of samples fall in class C: poor water quality and only 7% of samples fall in class A: excellent water quality. Hence it may be concluded that the quality of groundwater in certain parts of study area is affected and not fit for human consumption. In the study area, many of ionic concentrations in the groundwater are at higher levels indicating that they are problematic in one way or the other, if they are consumed without proper treatment. It is significant to note that groundwaters of variable quality exist in this area and the quality of the groundwater is being deteriorated in some parts. This is mainly because of percolation from sewage, waste disposal sites and industrial effluents. Therefore, it is advisable that constant monitoring and proper treatment of groundwater is essential, as prerequisite for use of these waters for drinking purpose.

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