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WQI based study on Groundwater Quality in Lakkavarapu Kota region, Vizianagaram District, Andhra Pradesh

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Abstract

Introduction. The present work aims at investigating the groundwater chemistry in Lakavarapu Kota region of Vizianagaram district by analyzing the groundwater samples collected from several sampling locations spread across the study area uniformly.

Materials and methods.360 groundwater samples, 120 samples each in Post-monsoon (November 2018-February 2019), Pre-monsoon (March 2019-June 2019) and Monsoon (July2019-October 2019) are collected from bore holes of 30 selected locations in the study area at regular monthly intervals and analyzed for various quality indicating parameters such as pH, EC, TDS, TH, TA, Ca2+, Mg2+, Na+, CO32-, HCO3-, Cl-, SO42-, NO3-, F- using standard laboratory procedures.

Results. A Weighted Arithmetic Water Quality Index (WAIWQI) method is used to assess the overall quality of groundwater in the study area. It is observed that quality of about 60% of the water samples is good, about 30% is poor and remaining 10% is very poor for drinking purpose in the study area.

Key words: Assessment, Fluoride, Groundwater Chemistry, Nitrate, Quality Indicators, Water Quality Index (WQI)

Introduction

Water is essential for human survival and industrial development. For many rural and small-scale communities, groundwater is the only source of drinking water. Groundwater is the accumulation of water below the ground surface, caused by rainfall and its subsequent percolation through pores and crevices. Occurrence of groundwater is controlled by land form, structure and lithology. The groundwater table fluctuates due to changes in groundwater storage and draft in response to rainfall incidence, applied irrigation, influent and effluent seepages and draft from groundwater.

Groundwater quality depends on the quality of recharged water, atmospheric precipitation, inland surface water and subsurface geochemical processes. The quality of groundwater varies due to a change in chemical composition of the underlying sediments and aquifer. However, in the recent past groundwater quality is getting deteriorated due to various reasons and making it unsuitable for drinking purposes threatening the human health. Therefore, the assessment of groundwater quality for drinking has become a necessary and important task for the present and future groundwater quality management.

Groundwater, in general, is less susceptible to bacterial pollution when compared with the surface water. But it contains several chemical elements like Ca2+, Mg2+, Na+, K+, HCO3-, Cl- and SO42- which play an important role in the classification and assessment of quality of groundwater. Keeping this in view, the present study aims at the assessment of the groundwater quality at different locations of the study area using weighted water quality index method by analyzing groundwater samples over a period of one year during different seasons.

Several studies have been conducted on the quality of groundwater at different locations in India [1-5] and abroad [6-8] using WQI method. The studied related to groundwater chemistry in Vizianagaram district are also conducted. However, they are limited to a part of coastal areas [9-12] and certain villages like S. Kota [13], Addatheega [14], Bobbili [15], and to the spatially distributed open wells among the district [16]. Another study is related to the determination of Fluoride in Bhogapuram [17]. Therefore, a study on groundwater chemistry of entire Vizianagaram district is aimed at and a part of the study related to Lakkavarapu Kota region of Vizianagaram district is herewith presented.

Study Area

Vizianagaram District is one of the north coastal districts of Andhra Pradesh comprising of 1582 Villages and occupying an area of 6,539 square kilometers. The study area considered for this work is Lakkavarapu kota region forming the south-western part of Vizianagaram district. It lies between17-50' and 18-10' of the northern latitudes and 83 -00' and 83-21' of the eastern longitudes (FIG.1) and occupies an area of around 670 sq.km and comprises of 167 villages.



Fig 1: Location map of study area

TABLE 1: Sampling Locations

S No	Sample Id	Sampling Station	Mandal	Latitude	Longitude	Water level (mhgl)	Depth (m)
1	LSI	Denderu	Kothayalasa	17051 46.9	\$3009'39.3	6	50
2	L82	Devada	Kothavalasa	17055 29.8	83008 42.1	6	50
3	LS3	Gamsettipalem	Kothayalasa	17052'06.7	83009'52.1	6	50
4	LS4	Gulivindada	Kothayalasa	17052 16.1	83009 34.5	8	50
5	LSS	Kothavalasa	Kothayalasa	17053'33.2	\$3011'33.2	6	50
6	LS6	Relli	Kothavalasa	17053 28.4	83º13'26.1	7	53
7	LS7	Tummakapalli	Kothavalasa	17054 44.8	\$3010 56.4	6	30
8	LS8	Bheemali	L. Kota	17058 40.3	83013 42.5	4	50
9	LS9	Kallempuda	L. Kota	1803'13.9	83010'32.6	5	50
10	LS10	L. Kota	L. Kota	18001 16.1	83009 24.9	6	50
11	LS11	Rothampeta	L. Kota	17°58'36	83°03'56"	5	46
12	LS12	Themarapalli	L. Kota	1/*50'00.1	8390851.5	4	45
13	LS13	Alemanda	Jami	17050'46.1"	83°14'27.9	5	45
14	LS14	Attada	Jami	18404 10.3	83°18'45.6	6	40
15	L515	Bluesnesingi	Jami	18'02'49.3	83"17'35"	6	40
16	LS16	Chinthada	Jami	180419.1	83°11'28"	4	35
17	LS17	Jami	Jami	18-03 08.2	83°15 54.8	6	25
18	LS18	Thoudrongi.	Jami	18405 30.6	8301101.5	5	10
19	LS19	Venne.	Jami	18'05'20.8	83°16'27.5	5	36
20	LS20	Atheva	Xepada	17*59'52	83°00'17	2	45
21	LS21	Kondagangupudi	Mapada	18º04 06	\$3°04'33"	6	50
22	LS22	Somputam	Nepada	18°02'19	83°07'59"	5	45
23	L323	Nacilapadu.	Xapada	17059 26	83°01'20"	5	50
24	LS24	Nepada	Nepada	180005	83°04'51	5	45
25	LS25	Gopalapalli	S. Kota	18-08 14.4	83°12 00.5"	5	45
26	LS26	Kattam	S. Kota	18405 33.3	83013 54.6	5	15
27	LS27	Mallinudi	S. Kota	1800505.1	83008 06.8	5	50
28	LS28	Mamidipalli	S. Kota	150/08.0	83°11'52.8	3	45
20	1.520	S Kota	S Kota	18906 47 1	R3908 43 1	6	46
30	L\$30	Tennuboddavara.	S. Kota	1\$°10'21.4"	83°07'30.6	6	48

A total number of 360 groundwater samples are collected (120 samples each in post-monsoon (POM), pre-monsoon (PRM) & monsoon (MON)) from different selected sampling locations (vide TABLE 1) of the study area from November 2018 to October 2019.Samples are collected in polythene bottles, pre-cleaned by washing with non-ionic detergents, rinsed with water, 1:1 hydrochloric acid and finally with de-ionized water. Before sampling, the bottles were rinsed three times with sample water. Tube wells are operated at least five minutes before collection of the water samples. The water quality parameter estimation was done using standard methods and techniques [18]. pH and EC are measured using digital pH meter (Elico LI-120) and conductometer (Elico CL-351) respectively. TDS is determined by gravimetric method whereas parameters like Total Hardness (TH), Total Alkalinity (TA), Calcium, Magnesium, Chloride, Carbonates and Bicarbonates are determined by titrimetric method. Nitrate (NO3-) ion is determined using UV-visible spectrophotometer (Elico SL-177) with 1cm quartz cell, using Phenol Disulphonic Acid (PDA) method whereas Fluoride (F- ion) is determined by SPADNS method and other parameters such as Sulphate is determined by turbidimetry using standard barium chloride solution. Sodium ion is measured by flame photometry (Elico CL-361).

Water Quality Index:

Several WQIs have been proposed by Researchers [19-23] and used appropriately by Governmental agencies and researchers. Among several WQIs, the Canadian Council of Ministers of Environment Water Quality Index (CC-MEWQI), National Sanitation Foundation Water Quality Index (NSFWQI), Oregon Water Quality Index (OWQI) and Weighted Arithmetic Water Quality Index Method (WAIWQI) are commonly used [24-27]. The WAIWQI is most popular index used [28] among researchers in developing countries where the infrastructure for data collection is not extensive for the development of vast database of the water quality parameters and reliable rating curves are rare. The present work also uses the same for the analysis of overall quality of water samples analyzed in the study area. Fourteen parameters are considered for calculating the water quality index. Based on WQI values, quality rating of water is classified [29] as shown in the TABLE 2.

WQI range	Status of water quality
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
Above 100	Unsuitable for drinking

TABLE 2: Classification of water quality based on WQI values

While calculating the WQI, the permissible values (Si) for the parameters considered are as per the WHO/BIS permissible values and are shown in TABLE 3.

Results

The physico-chemical parameters of groundwater samples and water quality index values are shown in the TABLE 3. From the analysis, it is observed that the EC and TDS values showed increasing trend from PRM to POM. HCO3and SO4are found to be higher during POM. Fluoride was higher in PRM. The result shows that quality of about 60% of the water samples is good, about 30% is poor and remaining 10% is very poor for drinking purpose in the study area.

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Sample (D	3	151		1.	1.51		10.00	145		1.1.1.1	154			141	81 M B	86	156	(—)
Isomore	20041	22.50	342071	2010	7201	34207*	2007	33.51	202061	2004*	28.54*	34002	2004*	7830	34205*	2006	22.50	34207*
28	7.68	2,1751	1.41	14	7.328	7.4	14	1.111	14	7,413	7,273	1,111	2.4	13354	7.3	1411	1.28	131
IC.	1912	1740.0	1787.0	1710.8	1681	1116	1022.4	11111.4	1814.8	1005.8	1976.2	1992	1114.1	1711.0	1411.3	947.73	841.12	491
724	1246.8	1111.4	10078	1114.1	1094.8	TELP.1	1220.8	1197.4	1222.8.3	1288	1280.2	1297.8	1018	1117.4	201.27	140.75	424	633
2924	39.73	22.25	36.1	23	18,378	21	32.1	11	14	12.47	10	12	21	21,823	12,1	19.5	16.75	19.5
TH.	1111	222	111.1	194.1	171	340	391.25	111	391.22	141.21	390	266	301.15	311.1	122.5	242	261	285
Ca.	47.4	42.75	43.77	96.24	- 11 C	1.19	46.51	17.11	45.4	17.1	\$1.25	12.1	74.74	51	16.3	1.49	42.4	43.73
34	38.5	11.71	36.4	41.33	40.261	41	43.1	42	40.75	46	13.1	JLAI .	42.11	45.332	43	21	35.25	31.73
Ma	#1	\$2.75	\$2.5	114.75	118	111.1	138.3	141.5	142.5	126	111	illi.f	110.1	141	139	42.5	1.0	62.23
41	144.75	111.1	1011	178.75	17131	171	114.11	11*11	214.8	101.0	210	100	106.15	223,27	111.15	\$1	1.19	1.69
204	26.1	16.15	13.73	14.14	14.5	11.1	14.5	1.11	44.12	14.1	22.73	15.75	-10	25	14.*5	14	34.75	16.1
0.00	15.4	11.833	11.1	2.1	17.51	15.5	15.15	19.75	31	16.85	11.411	14,848	16.73	14.171	11	.14	11,424	14,648
20000	312.3	307.4	310	1.000	111	141	276	147.5	1/2.5	343.5	111	351.35	101.75	014	111	370	261	200
1	0.07	0.4615	0.00*5	0.4775	0.661	0.4313	0.6975	0.7822	0.675	0.333	4.4015	4.147/	0.5405	0.0472	0.4773	0.4223	0.515	0.0525
74	100.0	317.4	130	322.5	111	165	296	14*.5	1723	341.1	MI .	312.12	104.73	0.04	343	290	144	300
NGC .	34.872	34.434	30.733	42.31	41.000	11.141	11.121	11.411	32.796	30.1.1.	31.433	36.00	44.54	40.004	30.703	36.402	40.413	30.546
Tourse .	Onte	Oned	Ored	Oned	Oned	Dead	Zaar	2441	Thes.	Gend	Geed	Geel	Gend	Deed	Oand	Ored	Dest	Cente

TABLE 3: Analysis of Groundwater samples: Physical and Chemical parameters and WAIWQI

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Lange ID		1,81	2	2 C	134		2	1.82	S	1	1.110	30		1.811	25		1,617	
Pusatine	905/P	985P	3.82512	2010	225.0*	3825.9	301.01	70.52*	3.825/*	101.14	10.52	3405/9	20101	1830	34007	2010	393304	3405.94
22	2.33	7.3	148	7.68	0.218	2.43	0.4	1.278	2.4	1.118	7.818	7.8	1328	2.328	1.428	7.84	1.8	1.405
BC DB	4151.3	4443.3	4422.3	1248.5	1840.5	1876.5	2490	2292.8	2442	417.78	882.3	924.23	241.2	644	943	940.23	944	943.73
704	2931.5	2006.5	2433.3	1211	1198	1223.3	1009.3	1337.3	1599.3	299	383	411	411.5	378	414.11	411.5	401.33	4113
5100	46.75	37	34.5	32.1	20.828	31.75	44.5	44.75	41.5	34.35	32.045	32,728	34.375	33	37.75	4.1	4.33	11
732	706.5	262.8	782.8	370	385	370.8	399	403	298.78	209.25	281	389	258.73	283.8	278.8	282.78	278.78	281.23
Ca	146.73	140.1	ULL	10.1	64.72	49.25	31	21.43	29	44.2	41	41	21	30	26.25	44.4.1	10.1	14
Ma	85	\$1.75	49.03	30	11.1	\$0.117	61.75	64.62	1.44	42.05	41	48.5	18	19.725	17.725	35.2	39	11.1
20	782.28	194.3	+33.1	** *8	47.1	\$1.21	183	183.23	181.21	21.3	28.78	12.1	147	180.8	149.1	34.3	11.3	1++1
¢1,	1078	1078.8	1076	120.1/	123	111.1	274.35	\$77.55	274.3	54	11.11	33.5	216.J	211.1	313	44.3	44.5	45.5
\$04	39	27	28.3	10.2	11.71	10.25	10	71.71	- 54	12.72	10.5	48	tt.J	0	10.5	43.812	42	43.5
COL	31.1	21.28	38.21	20.4	15.78	22.28	14.416	12,903	11013	14.8	11.101	17411	14.411	12.985	17.018	15.071	14.828	17.165
2003	114	111	\$97.8	117.1	217.4	332.3	333	227.5	220	247.8	282.3	297.4	141	133	1.8.8	220	213	230
1	0.955	1.0225	0.8915	0.345	0.475	0.51	0.965	1.8825	4.6	0.305	0.015	0.215	0.41	6.111	8.3123	0.4425	4,3373	0.39
73.	606	605	617.3	347.5	337.3	333.3	313	343.5	3.10	307.5	202.5	\$17.5	142	111	275	240	231	255
w.gr	10.344	\$7.218	18.907	33.799	39.163	30.097	10.821	28.288	43.14	30.778	30.011	36.913	11.1411	43 473	13 074	37.278	41.813	33.023
Inter	Very	Van	Ven	Ored	Gend	Gred	Pres	Peer	Pres	Ored	Ored	Gred	Gerd	Gerei	Gend	Gerel	Geri	Greek

TABLE 3: Analysis of Groundwater samples: Physical and Chemical parameters and WAIWQI

Long's D		1513			1514			1811			1318			1.117			1.515	
Iwanes	2010	30.519	34251*	2010	20.519	10207	2013*	723.0+	3,800/*	2010	723.0*	5408/*	2010	20.10*	340819	100.0*	22.3.P	3425/*
7 ¹²	7.878	1.315	148	2.63	7.425	7.84	2.878	7.425	7.171	1.128	2.1	7.425	1.45	7.45	7.878	7.88	7.33	7.45
80	2098.3	2010.8	2614	101.1	TIT	403.73	1499.8	1471.5	1206.4	2147	2044.3	2017.8	1237	1450.5	1241.1	414.72	783.28	\$10.25
TDS	1443	1471.8	1492.5	488	481	111	919.33	\$42.J	949.72	1420.8	1341.5	1248.5	1000.3	941.35	1006.3	111.1	122.5	117.75
3106	24.73	01.05	34.5	14.3	13.22	15.33	4.1	4.4	9.05	16.1	11315	15.025	17.1	11.25	14.275	11	4.42	7.25
TH	296.72	.090	383	314	321.23	111.73	179.1	210	262.3	174	1.41	373	330	111.11	328.75	194	196.5	197
ć.	119.63	114.72	121.75	1.46	44	71.4	111	11.11	*1.5	66.*2	41.3	41.11	76.23	12.12	11.15	16.75	16.11	14
Mg	72.7	74	71.15	32.5	33	13.711	18.72	11.14	10.5	48.5	41.51	46.11	36.33	34.73	34	11.J	24.3	15
Na	222.5	203	222.25	10.1	80	80	10.27	10.75	72.23	224.5	234.5	231	04.5	01.5	04.23	27.1	30	26.23
51	338.5	322.8	221.28	128.79	121.25	126.1	1092.73	113	101.8	336.21	337	333.78	1.82.8	155	153.3	411	45.73	44.13
504	34	12.1	11	10.13	24.3	11	24.5	24	34.5	417	116.55	111.1	24	22	22.23	12.1	1.0.1	12.75
603	13.6	14.302	15.953	19.22	14	17.96	11.15	48	20.063	11.4	15.025	15.74	24.5	\$1.75	36.15	12.85	18.5	12.25
100.00	325	\$15	111	343.2	23.17	040	215	207.3	330	330	321.5	335	281.8	343	250.5	180	173.75	106.3
1	0.611	0.72	0.83	0.313	0.378	0.41	0.441	0.585	0.401	0.341	0.8228	0.338	0.41	0.828	0.3023	0.325	0.4	0.31
24	141	111	111	282.5	287.8	249	210	221.8	340	330	345.5	333	275.8	243	250.8	200	1.02	218.25
単位	14.71	37.877	12,229	41,414	45,345	37,069	39,291	44.555	33.638	26.24*	43.314	33,346	31,149	44.334	37,129	24,45	21.799	26.312
Distant.	Teet	Pre-	Peer	Ored	Qued	Qued	Qued	Geed	Gend	Quel	Qued	Over	Orei	Geed	Over	Ored	Geed	Geed

Sample 10		Line			1.820		· ·	1321			1.532	<u>.</u>		1323			1524	
Talamanan	2010	28.50	54007	1004	22.517	10201*	2004*	22.51	34207*	2004	7850	34200-	2010	22.M*	34207*	2002	28.50*	10251*
28	2.4	2.4	2.4	11.5	13	14	24	1.221	24	2.44	7.43	24	7.6	24	14	1.423	1.411	1.111
80	1258.4	1209.5	1223	6437.5	4543.4	6480.2	146.0	100.00	\$37.75	3034.8	2277.5	2983.8	2507	1455	2318	1362.8	1011	1044.4
754	114.5	105.75	104.5	4134	4004	4141	141.1	544	356	1043.3	1043.3	1011.5	1425	1991.3	1424.3	1021.8	000.23	1023.3
3008	44	40.78	43.8	17.1	34.	17	14 28	1221	13.28	28.78	21	22.8	23.5	-21.8	24.8	41.1	34	41
TH	2.03.0	207.5	232	1207.0	1210	1307	209.25	201.15	212.1	616.73	467.4	474.28	366.23	242.4	243	294.1	281.27	299
Ca .	34.11	34	37.95	218.5	114.5	154.3	44.3	41	41.1	118.5	115	119.5	44	41.3	44.21	43.83	43.5	45
34g	27.3	22.2	34.3*1	141.5	143.3	143.1	21.1	24	51	10.070	Ot.J	44.5	41.1	110.12	45.5	44.315	44	41.75
3/8	123	127.8	128.8	993.5	233	932.3	12.73	83.21	61.21	245.15	244.0	243.8	142.8	141.01	143.5	131.5	134.5	132 28
A	193.73	198	184	1291.3	1296.5	1393	47.1	81	10	343	388.25	366.25	222.8	223	223.73	203.25	205.5	202.23
504	43	41.3	40.0	292.75	290.5	141.3	15.5	14	25.73	189.25	198	190	144.5	040	143.5			1.1
C05	13.4	11.424	14.085	111.3	500	113.73	11.1	11.1	11	13.05	12.005	12.431	14.55	12.005	12.438	34.03	31	34.5
10008	205	100	1006.75	343	878	393	110	161	180	#21.1	411	43.8	218	205	228	23.6	227.8	243
1	0.445	0.315	0.413	0.845	0.943	0.763	0.405	4.474	0.3417	4.7375	0.84	6.7615	0.43	0.8915	0.19	0.743	0.305	0.665
7.4	225	210	316	685	385	413	100	143	200	445.5	435	433	255	223	340	233	347.5	243
NQI .	39.541	42.115	35.814	\$1.882	33 983	28.582	35.095	31.401	21.414	62.634	84.243	11 214	61 101	67.805	#1.41	81 814	84 228	88.188
Same .	And	deed	Good	197	197	1.87	Gred	Gred	Ored	Peer	Per	Part	Part	Pear	Pear	Pear	2	P

Sample ID	-	LADE	`		1.424	ì	_	1.817	_		1.628	_	<u> </u>	L329		_	1.510	
Parameters	1011	PRM*	MON*	PON*	28:11*	MON-	PON+	PRM*	MON*	PON*	PRM*	MON*	POM+	PRM-	MON*	1011	PRM*	MON
11	7.915	7.01	7.45	.*.1	1.1.1	7.11	2.421	7.415	5.3	7.14	0.010	7.171	7.30	7.13	7.019	7.01	7.175	7.21
10 J	1054.3	1245	1000	1421.3	1400.2	1420	1006.5	1864.8	1913.5	3636.3	11113	1133.1	3327.3	3327	1540.5	2073.2	2004.8	2030.3
TDE	714.5	700.5	718	020.75	.010.75	034.21	1236	1213.3	1044	2470.3	2425.5	2477.1	2208.3	2278.3	0097.0	1346.3	1923	1111.4
3003	1.8	10	14.23	10.33	1.1	11.5	17.4	14.22	10	42	41.3	42.5	24.3	13	12	11.73		00
T12	241.75	214.1	288	358	318	328	407.8	325	475.5	417.4	812	#30	811	811	432.1	412.73	421.3	414.11
Ca .	451	41.5	42.75	88.7	45.5	18.1	122.25	44	89.78	60.8	11.41	18.78	44.1	44	47.8	45.75	11	87.1
14	42.1	41	41.11	33.724	31	33.21	12.8	18.1	54.95	103.8	101.0	100 78	00.5	101.32	99.15	31.1	13.8	111
No.	49.3	111	31.15	300	110.0	1.99	010.15	205	105.1	111.15	317	1111	177	197	163.1	1.54	164.05	142.25
41	11	-80	77.78	143	166.5	163	317.4	330	315	335	\$41.15	1111.1	411	411	400.3	111.71	116.5	114.11
904	18	14	18.5	17.3	24 J	16.5	02	50.03	12.15	199	199.35	197	144	142.75	104.5	\$7.25	95.25	87.5
001	16.00	13.071	15,305	14.53	20.177	17.013	11	14.75	18.827	11.7	54	17.308	21.4	14.1	20.3	10.0	17.071	15.51
10000	260	250	270	230	250	366.3	205	300	314	343	317.3	141.J	410	405	412.3	305	200	300
5	0.445	0.365	0.345	0.3375	0.425	0.017	0.845	6.673	0.725	1.005	1.015	0.005	4.713	0.702	0.478	0.0075	0.07	0.00
TA	244	278	295	279.1	270	248	228	338	224	343	397.8	342.3	430	423	402.5	328	220	329
wg:	39.365	43.394	11 381	30.341	34,271	26.054	65 308	72.437	36.924	28.18	80 834	16.01	31.764	81.065	14.423	68.032	10.939	66 521
Same .	Ored	Oned	Ored	Out	Ored	Quel	Peet	2941	Zeet	Yoy	Vary	Vay	2mint	2000	2444	Test	29.00	2000

TABLE 3: Analysis of Cro	oundwater samples:	Physical and	Chemical ;	parameters and	WAIWOI

*Average of four determinations. All units are in mg1 except pH (no units) and EC (micro Siemens/cm). EC= Electrical Conductivity; TDS= Total dissolved solids; TH= Total Hardness; TA= Total alkalinity.

Conclusions

- 1. The results indicated that the water samples at 12 sampling stations out of 30 of the study area do not meet the required standards for drinking purpose based on WAIWQI analysis.
- 2. All the five revenue mandals of the study area are found to have poor and very poor quality groundwater at certain villages. The sampling stations where poor and very poor quality of groundwater is noticed in the respective revenue mandals are as follows.
 - a) Ganisettipalem (LS3) and Tummikapalli (LS7) in Kothavalasa Mandal
 - b) Kallempudi (LS9) in L. Kota Mandal
 - c) Alamanda (LS13) in Jami Mandal
 - d) Sompuram (LS22), Vavilapadu (LS23), Vepada (LS24) and Athava (LS20) in Vepada mandal
 - e) Mallipudi(LS27), Mamidipalli(LS28), Srungavarapukota(LS29) and Tennuboddavara (LS30) in S. Kota Mandal.

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