

Integrated Study for Ground Water Quality Analysis Using Remote Sensing and GIS

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1. INTRODUCTION

The quality of water may depend on geology of particular area and also vary with depth of water table and seasonal changes and is governed by the extent and composition of the dissolved salts depending upon source of the salt and soil, subsurface environment. 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. It therefore becomes imperative to regularly monitor the quality of groundwater and to device ways and means to protect it. Contamination of groundwater by domestic, industrial effluents and agricultural activity is a serious problem faced by developing countries. The industrial waste water, sewage sludge and solid waste materials are currently being discharged into the environment indiscriminately. These materials enter subsurface aquifers resulting in the pollution of irrigation and drinking water (Girija. T. R. et al., 2007). High rates of mortality and morbidity due to water borne diseases are well known in India. Access to safe drinking water remains an urgent necessity, as 30% of urban and 90% of rural households still depend completely on untreated surface or groundwater (Palanisamy. P. N, Geetha. A et al., 2005). Remote sensing and GIS has been used in this study extensively to assess the water quality

1. 1 DESCRIPTION OF STUDY AREA

The Watershed is located at 79⁰. 59'. 48'' to 80⁰. 05'. 05'' Longitudes and 15⁰. 12'. 53'' to 15⁰. 17'. 50'' Latitudes. It has an average elevation of 15 meters and is covered in the Survey of India toposheet numbers 57M/15 SE, 57M/16 NE, 66A/3 SW and 66A/4 NW. In the study area there are 8 revenue villages.

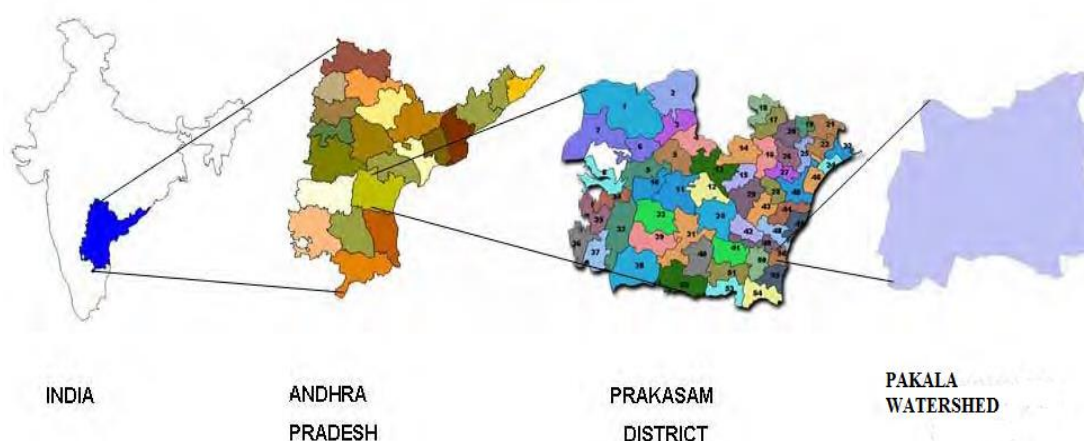
Table 1: village wise area of the study area

S. No.	Village Name	Village Area in HA.
1	Kalivivaya	981 (10)
2	Kanumalla	996 (10)
3	Sanampudi	1274 (12)
4	Singarayakonda	1548(15)
5	Somarajupalli	2194 (22)
6	Mulaguntapadu	338 (4)
7	Pakala	2252(23)
8	Binginipalle	1269(13)

1. 2 Population

The population of singarayakonda Mandal is 39, 704 (as per 2011 census). The population of the study area is 3937 persons (as per 2011 census) The village wise population details given in table:

S. No.	Village Name	Population
1	Kalivivaya	2615
2	Kanumalla	1944
3	Sanampudi	3708
4	Singarayakonda	3937
5	Somarajupalli	5381
6	Mulaguntapadu	5726
7	Pakala	12681
8	Binginipalle	3712

**Figure 2:** Location Map of the study area.

2. 1 Objectives of the Study

- To collect the water samples and analyze physico-chemical parameters.
- Preparation of Attribute database and spatial distribution maps.
- Creation of Water Quality Index using the ARC/INFO GIS platform.

3. METHODOLOGY

3. 1 Data collection:

Different data products required for the study include Survey of India (SOI) toposheets bearing with numbers 65H/6, 7, 10 and 11 on 1:50, 000 scale. Fused data of IRS-1D PAN and LISS-III satellite imagery obtained from National Remote Sensing Agency (NRSA), Hyderabad, India. Collateral data collected from related organizations, comprises of water quality and demographic data.

3. 2 Database creation:

Satellite imageries are georeferenced using the ground control points with SOI toposheets as a reference and further merged to obtain a fused, high resolution (5. 8m of PAN) and colored (R, G, B bands of LISS-III) output in EASI/PACE Image processing software. The study area is then delineated and subsetted from the fused data based on the latitude and longitude values and a final hard copy output is prepared for the generation of thematic maps using visual interpretation technique. These thematic maps (raster data) are converted to vector format by scanning using an A0 flatbed deskjet scanner and digitized using AutoCAD software for generation of digital thematic maps using Arc/Info and ARCVIEW GIS software. The GIS digital database consists of thematic maps like land use/land cover, drainage, road network using Survey of India (SOI) toposheets and fused data of IRS-ID PAN and IRS-ID LISS-III satellite imagery.

3. 2. 1 Spatial Database:

Thematic maps like base map and drainage network maps are prepared from the SOI toposheets on 1:50, 000 scale using AutoCAD and Arc/Info GIS software to obtain a baseline data maps of the study area was prepared using visual interpretation technique from the fused satellite imagery (IRS-ID PAN + IRS-ID LISS-III) and SOI toposheets along with ground truth analysis. All the maps are scanned and digitized to generate a digital output.

3. 2. 2 Attribute database:

Fieldwork is conducted and ground water samples are collected from 21 predetermined locations based on the land use and drainage network maps in the study area. Care is taken in collecting the water samples for uniform distribution and density of sampling locations. The water samples were analyzed for various physico-chemical parameters adopting standard protocols (APHA, AWWA, WPCF 1998). The water quality data thus obtained forms the attribute database for the present study (Table 1).

3.3 Integration of spatial and attribute database:

The spatial and the attribute database generated are integrated for the generation of spatial distribution maps of selected water quality parameters namely pH, alkalinity, chlorides, sulphates, nitrates, TDS, total hardness and fluorides. The water quality data (attribute) is linked to the sampling location (spatial) in ARC/INFO and maps showing spatial distribution are prepared to model the variation in concentrations of the above parameters in the 30 ground water samples at various locations using curve fitting technique of ARC/VIEW GIS.

3.4 Estimation of water quality index (WQI):

To determine the suitability of the groundwater for drinking purposes, Water Quality Index (WQI) is computed adopting the method proposed by Tiwari and Mishra, 1985 (Mahuya Das Gupta, 2001, Pradhan, S. K., 2001, Srivastava, A. K., 1994). WQI is computed using the formula given in equation (1), and a water quality index map is prepared. The water quality parameter, their WHO/ICMR standards, Ideal value and the corresponding weightage are given in Table 2.

$$WQI = \text{Antilog} [\sum W_{n=1} \log_{10} q_n] \quad (1)$$

Where, Weightage factor (W) is computed using equation (2)

$$W_n = K / S_n \quad (2)$$

Where,

S_n = Standard value of the parameter

K, Constant = $[1 / (\sum_{n=1}^n 1/S_i)]$

S_i = Standard value of the parameter

Quality rating (q) is calculated by the formula given in equation (3)

$$q_{ni} = \{[(V_{\text{actual}} - V_{\text{ideal}}) / (V_{\text{standard}} - V_{\text{ideal}})] * 100\} \quad (3)$$

Where,

q_{ni} = Quality rating of i^{th} parameter for a total of 'n' water quality parameters

V_{actual} = Value of the water quality parameter obtained from laboratory analysis

V_{standard} = Value of the water quality parameter obtained from the standard tables.

V_{ideal} for pH = 7 and for other parameters it is equalent to zero.

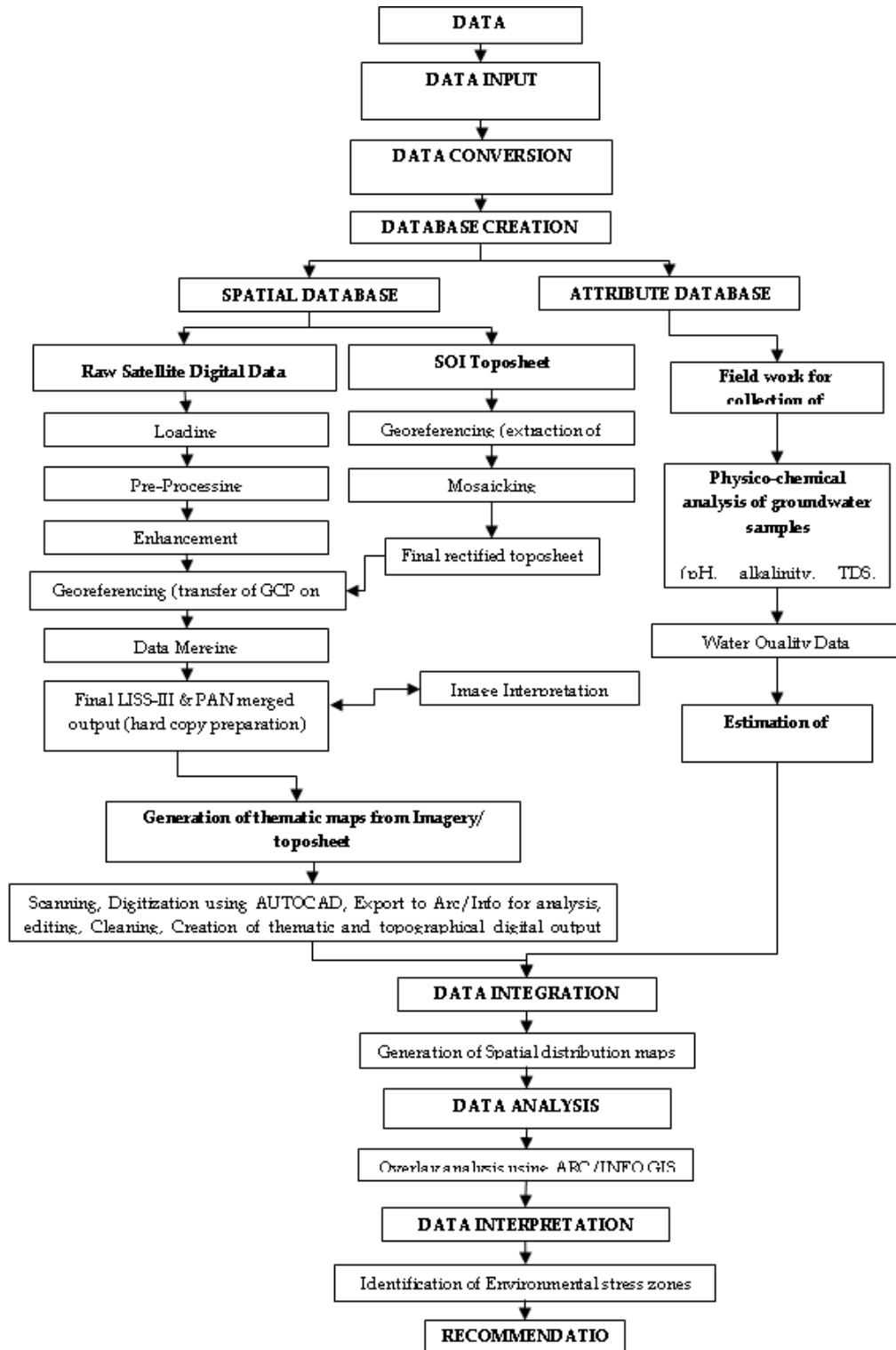


Figure 1: Flow chart showing the methodology adopted for the present study

4. RESULTS AND DISCUSSION

As per the above analysis in :-

Pakala village sample no. 8, 9, 11 has under unfit for drinking class, sample no. 6, 7, 15, 16, 17, 22, 24 has under Very poor class, sample no. 1, 2, 3, 18, 19, 20, 21 has under poor class, sample no. 4, 5, 12, 13, 23, 25 under Good class, Sample no. 14, 10 has been identified in excellent class.

Binginipalle village sample no. 7, 8, 12, 24 has under unfit for drinking class, sample no. 6, 11, 17, 21, 23 has under very poor class, sample no. 5, 10, 13, 15, 19, 25 has under poor class, sample no. 4, 9, 14, 16, 18, 22 has under good class, sample no. 1, 2, 3, 20 has been identified under excellent class.

Singarayakonda Village sample no. 1, 5, 7, 12, 14, 22 has under unfit for drinking class, sample no. 6, 10, 13, 19, 24 under very poor class, sample no. 2, 9, 17, 18, 20, 25 has under poor class, sampleno. 4, 11, 15, 23 has been under Good class, Sample no. 3, 8, 16, 21 has been identified under Excellent class.

Sanampudi Village sample no. 3, 6, 10, 14, 15, 24 has under very poor class, sample no. 1, 2, 8, 11, 12, 13, 17, 18, 19, 20, 22, 25 has under poor class, sample no. 4, 5, 7, 16, 21, 23 has under Good class, sample no. 9 has been identified in excellent class.

Kanumala Village sample no. 4, 22, 25 has under unfit for drinking, sample no. 3, 12, 13 has under very poor, sample no. 2, 8, 10, 14, 16 has under poor, sample no. 1, 6, 9, 17, 19, 20, 23, 24 under good, sample no. 5, 7, 11, 15, 18, 21 has been identified in excellent class.

Somarajupalli village sample no. 5, 12, 18 has under unfit for drinking class, sample no. 4, 9, 19, 24 has under Very poor class, sample no. 3, 8, 15, 23 has under poor class, sample no. 2, 7, 10, 17, 21, 22 under Good class, Sample no. 1, 6, 11, 13, 14, 16, 20, 25 has been identified excellent class.

Kalikivaya village sample no. 6, 7, 16, 20 has under unfit for drinking class, sample no. 5, 8, 15, 19 has under Very poor class, sample no. 4, 9, 14, 18, 23 has under poor class, sample no. 2, 10, 13, 17, 21, 22, 24, 25 under Good class, Sample no. 1, 3, 11, 12 has been identified excellent class.

Mulaguntapadu village sample no. 6, 16, 23 has under unfit for drinking class, sample no. 13, 22 has under Very poor class, sample no. 7, 8, 11, 17, 20, 24, 25 has under poor class, sample no. 3, 4, 5, 9, 10, 12, 14, 15, 18 under Good class, Sample no. 1, 2, 19, 21 has been identified excellent class.



Table No. 3: Ground Water Quality Data

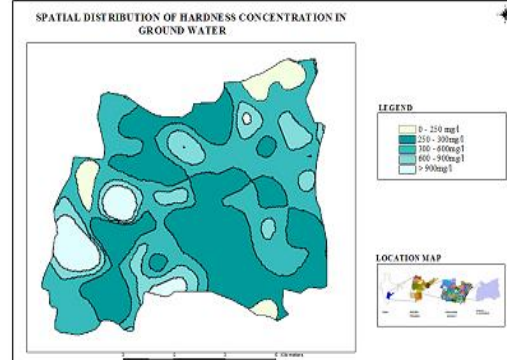
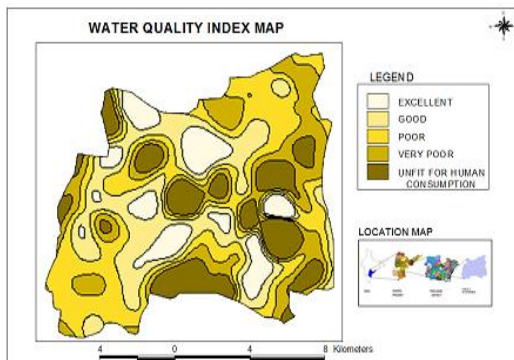
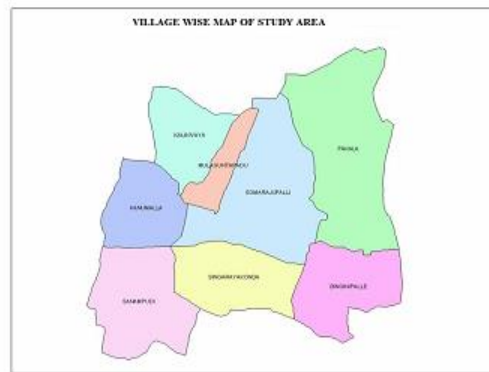
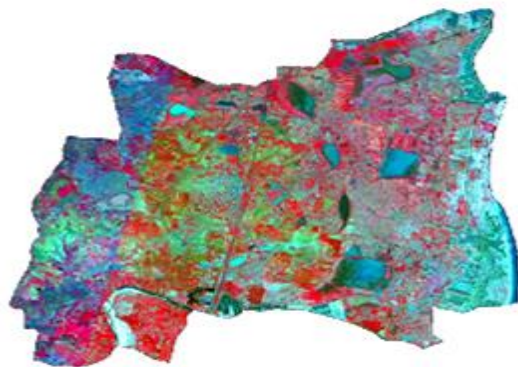
S. No	Location	pH	E.C µmhos/cm	Alkalinity mg/l	Cl mg/l	NO ₃ mg/l	TDS mg/l	Hardness mg/l	Na ⁺ mg/l	K ⁺ mg/l	SO ₄ ²⁻ mg/l	F ⁻ mg/l	WQI	WQR
	PAKALA													
1		6.8	1450	230	227.2	62	940	490	96	11	100	1.13	61.76	Poor
2		7.4	1180	210	199.93	35	780	325	102	36	38	0.86	53.51	Poor
3		7.2	1380	210	219.93	140	895	490	85	12	52	0.95	54.48	Poor
4		6.9	1280	170	139.87	33	674	410	42	5	100	0.95	47.27	Good
5		7.1	850	230	289.325	15	104	550	106	4	130	0.95	46.91	Good
6		7.3	1070	230	176.6	15	690	420	41.4	8	37	1.4	83.31	V.poor
7		7.4	1115	250	114.97	145	740	400	70	4	20	1.28	75.98	V.poor
8		6.8	1390	300	110	250	890	460	100	3	32	3.78	100.71	U.drinking
9		7.89	1675	265	202	284	980	540	122	19	49	2.6	111.78	U.drinking
10		7.61	434	130	42.6	51	270	160	23	2.5	20	0.593	4.55	Excellent
11		7.52	1215	255	146	122	790	460	59	4	46	3.18	113.18	U.drinking
12		6.8	1375	210	276.19	30	868	420	105	10	105	0.9	50	Good
13		6.9	1460	200	252.76	46	940	520	46	26	125	0.85	45.09	Good
14		7.71	440	80	52	56	260	320	20	2.2	17	0.125	12.05	Excellent
15		7.3	1405	140	265	92	920	510	85	5	80	1.3	75.87	V.poor
16		7.4	1040	240	155.49	41	690	330	85	4	24	1.5	87.52	V.poor
17		7.5	1070	250	94.07	54	695	330	90	5	100	1.5	85.36	V.poor
18		7.2	1150	280	248.85	34	720	430	65	10	85	0.6	52.21	Poor
19		7.2	1180	240	139.95	162	780	380	96	3	16	1.35	71.97	Poor
20		7.3	950	180	99.96	168	630	310	73	4	15	1.15	67.59	Poor
21		7.2	1180	270	149	65	775	410	51	5	51	1.25	62.74	Poor
22		6.6	1460	230	265.9	312	950	420	136	3	15	1.26	75.33	V.poor
23		7.2	825	210	99.46	42	528	280	55	4	25	0.83	46.83	Good
24		6.3	1250	220	197.7	89	796	360	134	5	18	1.32	83.77	Very poor
25		6.71	1470	240	174.94	49	960	470	157	12	35	1.14	39.75	Good
	BINGINIPALLE													
1		7.61	434	130	42.6	51	270	160	23	2.5	20	0.593	4.55	Excellent
2		7.36	701	171	51.12	53	585	280	15	2	45	0.5	17.47	Excellent
3		7.46	1070	275	92	120	690	400	53	2.1	34	0.98	24.1	Excellent
4		6.9	795	220	70.9	65	552	300	42	4	10	1.39	46.74	Good
5		7.5	1160	330	118.9	87	775	300	120	4	17	1.25	61.68	Poor
6		7.1	945	200	184.9	38	625	400	42	3	74	1.48	89.78	V.poor
7		7.9	1050	350	94.9	29	690	440	30	18	14	1.46	63.72	U.drinking
8		7.7	1400	260	259.9	69	940	500	85	11	18	1.47	95.69	U.drinking
9		6.7	1130	240	184.24	63	700	340	70	5	10	1.15	48.55	Good
10		6.72	925	365	39	36	600	380	36	3	19	1.76	67.62	Poor
11		6.5	905	200	120.7	76	628	270	76	6	43	1.4	84	V.poor
12		7.61	1416	365	205.9	52	865	340	110	2.1	57	3.06	109.06	U.drinking
13		7.2	1015	220	99.96	152	620	340	73	8	18	1.25	67.39	Poor
14		7.43	1165	425	89	25	750	400	77	6	18	2.75	47.39	Good
15		7.2	1170	310	149.1	56	760	390	88	3	8	0.85	61.8	Poor
16		7.03	1260	430	75	25.1	844	310	122	28	67	1.2	45.74	Good
17		7.5	965	200	154.14	58	590	400	34	3	16	1.45	69.45	V.poor
18		7.2	700	100	89.97	132	416	210	30	2.1	14	0.86	49.22	Good
19		7.1	1005	160	114.76	143	624	300	96	2.1	54	1.2	53.71	Poor
20		6.9	1530	210	274.9	128	965	610	69	4	58	0.89	12.05	Excellent
21		7.71	440	80	52	56	260	320	20	2.2	17	0.125	81.027	V.poor
22		7.1	960	210	776.15	42	625	330	65	6	8.1	1.48	47.42	Good
23		6.8	950	160	149.9	34	620	390	45	5	72	1.54	91.53	V.poor
24		7.2	1090	225	159.95	62	665	400	65	2.1	35	1.37	146	U.drinking
25		6.8	1100	250	134.9	62	720	350	89	3	50	1.7	70.54	Poor
	SINGARA YAKONDA													
1		7.77	995	220	142	56	605	400	38	3	44	2.73	115.23	U.drinking
2		7.3	1100	210	164.94	74	726	345	89	3	40	1.3	68.38	Poor
3		7.77	995	220	142	56	605	400	38	3	44	2.73	23.9	Excellent
4		7.6	1450	367	134.8	83	940	590	32	25	95	0.68	48.13	Good
5		6.95	1175	230	163.3	126	748	440	63	5.5	52	3.58	133	U.drinking
6		7.3	1258	470	84.9	39	825	400	80	25	27	1.2	78.15	V.poor

7		6.88	1095	200	142	130	665	420	51	4.5	45	4.77	206.5	U.drinking
8		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
9		7.2	1310	200	250.7	76	820	430	100	4	36	1.3	70.81	Poor
10		7.8	1464	290	242.21	90	970	510	64	38	15	1.3	86.45	V.poor
11		7.72	805	200	64	122	515	350	18	3	10	0.489	37.09	Good
12		6.85	970	240	106.5	32	625	450	40	2	31	3.56	162.6	U.drinking
13		7.7	1351	370	139.9	64	890	525	44	31	50	1.4	86.05	V.poor
14		7.5	1038	290	134.9	51	668	440	38	3	35.5	4.4	238.3	U.drinking
15		6.8	1660	395	66	25	1100	740	35	4	46	3.63	48.87	Good
16		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
17		7.3	1535	220	269.9	85	995	570	88	5	100	1.2	66.11	Poor
18		6.8	1030	210	144.99	109	676	360	70	3	10	1.4	64.26	Poor
19		7.6	1210	325	129.9	48	795	470	44	25	52	1.24	68.97	V.poor
20		7.3	1078	120	220.9	65	650	410	80	4	35	1.2	72.98	Poor
21		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
22		8.13	261	171	76.68	2.84	165	400	29.5	2	19	4.5	125.14	U.drinking
23		6.81	965	290	92	31	620	360	61	3	21	0.825	10.1	Good
24		7.8	1360	370	94.9	56	900	390	68	40	74	1.29	87.73	V.poor
25		7.1	1085	140	169.9	163	725	370	82	3	29	1.3	65.14	Poor
	SANAM PUDI													
1		7.9	860	160	159.9	65	585	120	65	4	24	1.38	64.5	Poor
2		6.73	1635	540	160	45	1070	630	77	10	21	3.6	65.13	Poor
3		7.8	1260	350	124.9	43	820	40	51	30	92	1.3	79.54	Very poor
4		7.77	865	280	78.1	126	525	350	37	5	28	0.554	40.49	Good
5		7.94	187	110	42	6.2	280	200	27	3	21	0.683	46.6	Good
6		7.6	1330	377	124.9	62	880	540	50	28		1.32	77.49	Very poor
7		7.32	1645	320	248.5	120	1028	720	70	8	5	0.514	35.03	Good
8		7.1	1030	210	69.97	112	659.2	450	25	6	110	1.4	66.48	Poor
9		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
10		6.76	520	520	121	78	980	560	74	23	9	1.45	77.39	Very poor
11		7.5	1670	550	129.9	103	1160	540	28	48	120	1.26	69.5	Poor
12		7.5	1350	430	104.7	81	890	670	28	57		1.25	54.175	Poor
13		6.98	1020	320	94.7	36	670	410	45	3	25	1.5	63.18	Poor
14		6.79	1350	425	128	62	870	450	100	4	31	2.51	98.44	Very poor
15		6.63	1563	370	213	80	995	320	200	28	109	1.49	33.25	Very poor
16		7.85	465	140	49.7	56	295	200	14	4	19	0.352	28.6	Good
17		6.7	1150	240	189.94	15	765	350	100	8	40	1.2	65.96	Poor
18		6.95	1050	260	103	66	690	340	58	25	29	1.38	58.84	Poor
19		7.1	970	340	36	60	625	340	58	4	26	1.36	63.87	Poor
20		6.3	890	190	154.9	22	560	350	70	2	15	1.39	58.32	Poor
21		7.85	362	115	42.6	51	230	160	8	4	12	0.427	46.6	Good
22		6.9	1250	320	254.9	42	850	490	60	5	16	1.12	55.82	Poor
23		7.9	461	150	56.8	52	285	200	13	4.5	11	0.526	36.22	Good
24		6.93	1145	115	131	292	750	380	68	30	50	0.41	90.01	Very poor
25		7.4	1320	329	129.9	123	870	530	57	33	24	0.89	65.13	Poor
	KANU MALA													
1		6.89	1150	290	114	116	736	460	63	6	37	1.18	48.5	Good
2		6.88	1270	390	89	83	825	480	61	6	46	1.42	65.38	Poor
3		6.91	1770	510	160	120	1120	710	70	5	46	2.28	89.06	Very poor
4		6.7	1605	340	227.2	62	898	570	104	2	94	0.661	141.39	U.drinking
5		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
6		7.1	845	180	114	52	540	350	30	3	19	0.818	46.4	Good
7		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
8		6.89	1325	415	110	58	850	510	59	4	44	0.891	80.46	Poor
9		7.38	535	120	64	52	340	200	29	2	18	0.77	31.7	Good
10		7.64	1120	250	178	34	725	450	43	8	28	1	105.99	Poor
11		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
12		6.85	1430	350	153	128	910	500	86	7	44	4.07	75.68	Very poor
13		6.84	2075	400	288	160	1360	860	75	10	115	1.97	96.87	Very poor
14		7.75	635	260	32	15	410	250	27	3	12	0.726	64.31	Poor
15		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
16		8.07	937	175	148.26	58	605	280	46	13	41.5	1.02	70.89	Poor

17		7.51	1245	225	178	160	800	460	78	5	65	2.9	43.1	Good
18		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
19		7.68	554	140	50	52	350	200	67	3	18	1.9	27.1	Good
20		7.98	524	150	50	160	325	190	28	3	17	2.4	31.8	Good
21		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
22		7.27	615	130	49.7	120	345	250	27	2	15.5	0.43	128.71	U.drinking
23		7.41	1950	230	49	140	805	240	26	4	34	0.59	26	Good
24		6.95	945	285	75	58	600	350	48	11	41	0.75	35.8	Good
25		7.7	1200	250	199	2	775	300	150	12	65	1.96	104.4	U.drinking
	SOMARA JUPALLI													
1		6.89	1150	290	114	116	736	460	63	6	37	1.18	23.9	Excellent
2		7.65	775	210	105	27	505	240	51	30	14.6	1.48	35.4	Good
3		6.25	3900	545	408	268	978	1160	120	17	115	0.7	53.35	Poor
4		6.52	463	140	49.7	24	295	190	17	2.5	17	0.759	80.79	Very poor
5		7.43	1195	440	98	26	793	450	77	5	17.5	2.75	134.8	U.drinking
6		6.89	1150	290	114	116	736	460	63	6	37	1.18	23.9	Excellent
7		7.81	645	387	89	10	410	280	17	3	18.5	2.6	32.3	Good
8		6.69	2575	340	277	600	1628	760	168	120	93	1.01	64.1	Poor
9		7.82	875	119	107	160	520	310	56	2	39	1.41	90.5	Very poor
10		7.7	495	170	49	8.6	325	200	19	3	15	0.537	37.1	Good
11		6.89	1150	290	114	116	736	460	63	6	37	1.18	23.9	Excellent
12		7.09	995	380	49	22	635	220	56	3	35.5	4.49	223	U.drinking
13		6.89	1150	290	114	116	736	460	63	6	37	1.18	23.9	Excellent
14		6.89	1150	290	114	116	736	460	63	6	37	1.18	23.9	Excellent
15		7.14	1435	275	231	72	930	460	100	20	68	1.5	74.07	Poor
16		6.89	1150	290	114	116	736	460	63	6	37	1.18	23.9	Excellent
17		7.89	575	160	56	13	335	210	20	3	18	0.73	48.9	Good
18		7.14	880	330	56	21	545	280	186	2	21	4.23	151	U.drinking
19		6.89	975	200	71	88	630	380	44	4	26	1.62	77.9	Very poor
20		6.89	1150	290	114	116	736	460	63	6	37	1.18	23.9	Excellent
21		8.11	565	170	71	20.5	365	180	45	4	8	0.733	49.64	Good
22		6.95	1168	370	191.7	61	709	350	101	2.3	48	1.04	44.9	Good
23		6.98	4950	265	266	290	1330	560	209	18	180	2.7	74.02	Poor
24		7.78	1430	230	213	360	862	560	71	4	65	0.44	86.5	Very poor
25		6.89	1150	290	114	116	736	460	63	6	37	1.18	23.9	Excellent
	KALIKI VAYA													
1		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
2		6.86	1065	375	89	11	685	480	49	2	26	0.5	28.79	Good
3		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
4		8	465	130	56.8	56	285	180	22	2.5	18.5	1.15	65.17	Poor
5		6.81	1860	500	153	90	1054	700	96	9	133	3.63	72.56	Very poor
6		7.03	1260	190	121	290	795	500	56	2	42	1.84	110	U.drinking
7		7.15	1550	215	149	535	1010	460	190	2	44	3.12	133.2	U.drinking
8		7.12	1415	450	124	50	910	440	117	4	43	4.83	90.67	Very poor
9		6.95	1232	332.5	134.19	17.95	845	660	110	2	63.5	3.9	62.18	Poor
10		6.68	1665	360	284	304	1070	700	56	11	52	0.64	43.37	Good
11		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
12		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
13		8.07	390	130	42.6	58	260	160	19	2.5	16	0.603	41.95	Good
14		6.74	1018	200	142	104	647	420	35.5	2.5	38	1.01	63.73	Poor
15		7.52	1420	460	117	67	920	500	95	4	36	3.01	44.7	Very poor
16		6.93	1075	250	140	148	690	390	61	1	38	0.506	116	U.drinking
17		7.71	359	130	43	0.6	216	100	31	2	17	0.6	38.2	Good
18		7.61	1535	400	178	320	1350	500	110	6	64	2.73	58.4	Poor
19		7.51	1190	420	25	25	770	380	105	16	124	2.23	48.3	Very poor
20		7.56	878	220	85	44	520	300	49	35	43	1.6	114	U.drinking
21		7.28	470	140	50	1	290	160	29	2	17	0.87	45.86	Good
22		7.1	954	332.5	57.51	216	745	400	81	1.5	57	0.98	50.99	Good
23		7.51	1190	350	92	216	745	400	81	2	57	0.67	51.1	Poor
24		7.76	462	140	57	0.2	305	160	36	2	19	0.6	38.79	Good
25		7.69	495	140	70	15	315	200	19	3	8.5	0.583	45	Good

	MULAGU													
	NTAPADU													
1		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
2		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
3		8.08	505	130	84	9	310	200	17	4	11.5	0.569	38	Good
4		7.24	699	320	245	14	350	480	110	4	32	0.962	39	Good
5		7.76	495	140	35	12	295	140	50	4	9.5	0.507	42	Good
6		7.09	1418	180	149	500	870	380	58	8	92	0.85	102.3	U.drinking
7		6.75	1010	230	142	64	615	410	56	3	54	0.34	56.5	Poor
8		7.19	1063	323	114.85	96	564	420	81	2	64.5	1.07	56	Poor
9		7.41	435	160	21	14	285	150	31	3	24.5	0.54	34	Good
10		8.01	685	360	112	72	417	200	57	4	9	0.46	36.3	Good
11		6.82	810	470	92	500	500	970	122	27	50	0.36	55.5	Poor
12		8.02	485	160	91	12	315	220	19	4	9.5	0.46	36.3	Good
13		8.07	1005	250	134.9	58	645	460	46	7.5	33.5	0.646	70.08	Very poor
14		8	728	170	84	62	460	200	76	4	10.5	0.55	39	Good
15		8.01	705	150	140	5.2	472	310	19	4	9	0.494	29	Good
16		7.54	1300	310	142	84	845	470	67	3	67	1.4	104	U.drinking
17		7.23	1465	150	107	240	940	550	73	8	92	1.2	53.9	Poor
18		7.44	1155	300	154	53	747	440	41	21	20	0.513	25.7	Good
19		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
20		7.15	1420	325	174	116	925	540	65	15	58	1.3	67.23	Poor
21		6.93	1145	115	131	292	750	380	68	30	50	0.41	23.9	Excellent
22		6.85	815	220	85.2	52	508	320	35.5	2.5	38	1.96	89.49	Very poor
23		7.2	1075	250	128	344	685	630	50	2	35	0.4	130	U.drinking
24		6.7	1218	315	117	102	785	420	80	6	50	1.2	69.17	Poor
25		6.74	1375	290	135	204	890	530	75	9	53	1.3	73.58	Poor

WQI: Water Quality Index, **WQR:** Water Quality Rating **U. drinking:** Unfit for drinking



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