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GIS BASED GROUND WATER QUALITY INDEX (WQI) IN SOUTHERN PARTS OF WEST GODAVARI DISTRICT, ANDHRA PRADESH, INDIA

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Abstract- **Due to naturally occurring and anthropogenic activities the quality of ground water has been deteriorating all around world. Though the study area receives heavy rainfall, it faces water quality problems. Hence, a Geographical Information System (GIS) based assessment of spatiotemporal behavior of groundwater quality has been carried out in the southern parts of west godavari district of Andhra Pradesh, India. The water samples were collected across 77 villages of the study area. The samples collected were analyzed for pH, TDS, EC, Total alkalinity, Total hardness, Turbidity, Calcium, Sulphates, Chlorides, Iron and Fluorides. A surface map was prepared using Arc-GIS 10.2.2 (spatial analyst module) to assess the ground water quality in terms of spatial variation. The spatial analysis of groundwater quality index (WQI) of the study area shows seasonal fluctuations and is useful in deciding water use strategies for various purposes. The results show salinity slightly high, which is a clear indication of change in the quality of ground water due to excessive irrigational and aqua cultural activities, cautioning appropriate steps that have to be initiated to maintain the sustainability of the ground water in this region.**

Keywords- **Ground water, GIS, spatial analysis, water quality, sustainability**

I. INTRODUCTION

Water is called elixir of life and is a basic commodity on planet Earth without which life is not perishable. It is difficult to visualize the sustenance of any life forms without this resource. Knowing this fact, the human race continues to pollute this resource both by its actions and deeds. It was estimated that nearly 780 million people in the world lack access to good quality drinking water while around 2.5 billion people lack improved sanitation [1]. In India it was estimated that about 65% of water used for irrigation and 85% of drinking water sources depends on ground water resources. However, it was estimated that within the next 20 years, 60% of groundwater resources will be in a critical state of degradation if current usage of ground water continues. Under natural conditions groundwater is generally fresh, but may not of good chemical quality. India's declining ground water resources both in quality and quantity is a product of many driving factors. Though groundwater contamination is due to natural and anthropogenic activities, ground water pollution is mostly due to knowingly or unknowingly human activities. In most parts of India, groundwater is used intensively for irrigation as well as for industrial purposes, resulting water pollution or degradation of ground water resources [2]. The over-exploitation of ground water is not only causing aquifer contamination but also more mineralization of ground water. Generally near the seacoast marine components dominate while the terrestrial components and anthropogenic activities dominate in arid areas. Human activities have a high impact on water quality in and around highly populated and intensive agricultural area [3]. In India, groundwater is not only used for irrigation but also for drinking and other purposes. People living in those areas where high concentration of different pollutants present in ground water used for drinking will be effected by water borne diseases like cholera, fluorosis, jaundice, typhoid etc,.[4].

II. DESCRIPTION OF THE STUDY AREA

The study area is situated near to east cost of Andhra Pradesh consisting of six mandals of west godavari district namely Mogalthur, Palakollu, Poduru, Achanta, Yelamanchili and

Narsapuram.The area lies between longitudes 82°10' to 82°21' E and latitudes 16°30' to 17°03' N. The monitoring network in the study area consists of ground water resources like bore wells, tube wells, dug wells. A total of 77 water samples were collected from the study area and analyzed during pre and post monsoon seasons of 2016-17 to understand the behavior of ground water quality. The average annual rainfall in the study area is about 312.2 mm during the study period 2016-17 which is below the average rain fall of 720 mm. These areas get most of its seasonal rainfall from the south west monsoon. The main dominant occupation of the people is agriculture and aqua culture the main crops grown are paddy, sugarcane, groundnut etc. During last few decades, though the study area is an agriculture based area, intensive fish and prawn culture starts causing groundwater pollution which results water contamination. Therefore, the present study is to draw attention towards taking necessary steps to minimize the adverse impacts likely to occur due to ground water pollution. The description of study area is shown in Fig. 1.The study area is plotted using survey of India toposheet 65H7,65H10,65H11,65H14,65H15 and using ArcGis 10.2.2.

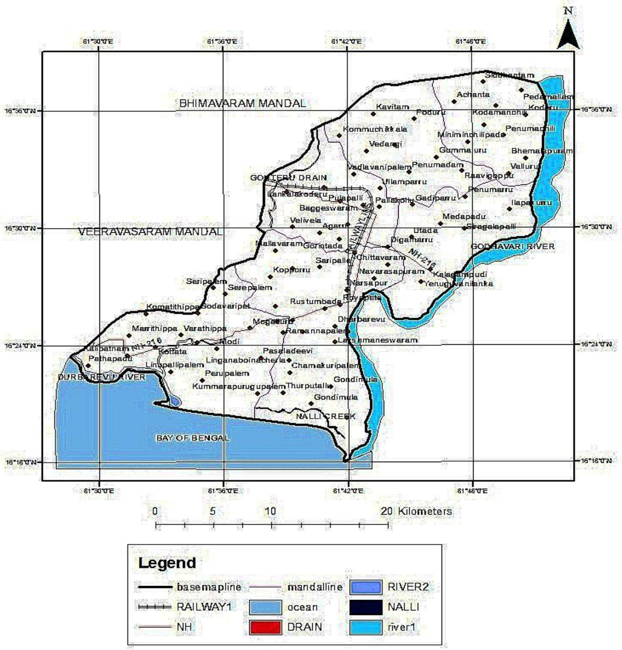

Fig. 1. Study area map with sampling locations

III. MATERIALS AND METHODS

In order to study the physico-chemical characteristics of ground water, samples were collected during 2016-17 following the standard methods prescribed for sampling. The standard methods and procedures were used for quantitative estimation of water quality parameters. All the chemicals of AR grade were used for this purpose. The standards prescribed by APHA were used for the calculation of water quality indices [5].

Water Quality Index (WQI) of ground water samples was calculated using the methods proposed by Horton [6] and modified by Tiwari and Mishra [7]. According to the role of various parameters on the basis of importance and incidence on the overall quality of drinking water, the rating scales were fixed in terms of ideal values of different physico-chemical parameters. For calculating WQI, the following equations were used:

$WQI = \Sigma\, q_i\, w_i$

here q_i (water quality rating)

$q_i = \{[(V_a - V_i) / (S_i - V_i)]*100\}$

$W_i = K / S_i$ Here w_i(unit weight)

v_a = actual value present in the water sample.

v_i = ideal value(0 for all parameters except pH and DO, for pH and Dissolved oxygen 7.0 and 14.6 mg/l respectively)

On the basis of a number of water pollution studies, the following assumptions were made with reference to assess the extent of contamination or the quality of drinking water as shown in Table1.

TABLE 1: Water Quality Scale with reference to WQI

Water Quality Index (WQI)	Quality Of Water
0-50	Fit for human consumption
51-80	Moderately contaminated
81-100	Excessively contaminated
>100	Severely contaminated

IV. RESULTS AND DISCUSSIONS

In this study the spatial distribution of 12 parameters are calculated and compared with ISO 10500 [8] (Table-3). The spatial distribution of the different water quality parameters are shown in figure 2 to figure 13. The spatial distribution of water quality index (WQI) is shown in figure 14. From figure 2 it is very clear that there is no problem with pH of ground water because in all 77 samples the pH is between 6.5 – 8.5 except one or two locations. The Electrical conductivity is (Figure-3) high at Nallipeta, Seetharamapuram South and Digamarru. The spatial distribution of the Total Dissolved Solids (TDS) shown in Figure-4. According to the findings, few locations namely Nallipeta, Seetharamapuram South, Digamarru, Utada have beyond the maximum permissible limit of 2000 mg/l. Alkalinity shows moderate at centre part of the study area, (Figure-5) high at Ilapakuru, Kavitam, Kalagampudi, Pathapadu etc. The high Turbity (Figure-6) of water makes the water less acceptable by the public and also interfere with disinfection mechanism and reduce the disinfection efficiency especially of chlorination. The Total hardnes parameter (Figure-7) is high at one or two places remaining locations are maintain uniformly throughout the study. The spatial distribution of the calcium is shown in the Figure 8. Almost all locations shows the value of calcium between 75-200mg/l. Water quality index has been calculated based on 12 important water quality Parameters (pH, TDS, EC, Turbidity, Alkalinity, Chlorides, Fluorides, Hardness, Calcium, Magnesium, Sulphate and Iron). Figure 14 shows spatial distribution of WQT index. Only one location namely Siddhantam fall under Excellent category. Few areas like Perupalem, Poduru, Gondimula, Kavitam, Sagamcheruvu, Baggeswaram are having a very high water quality index and unfit for drinking.

V. CONCLUSIONS

In this study the water quality parameters were analysed and water quality index (WQI) has been calculated and the results were interpreted in terms of spatial distribution maps. The analysis of the results drawn at various stages of the work revealed that integration of Remote Sensing and GIS are effective tools for the preparation of various digital thematic layers and maps showing spatial distribution of various water quality parameters. Out of 77 only two locations contain ground water in 'excellent' category and more locations shows unfit for drinking as per WQI. The analysis reveals that the ground water of the area needs some degree of treatment before consumption. The outcome of this work can be effectively utilized by the Rural Water Supply and Sanitation Engineering Department, for better management of groundwater as well as supplying protected water to the area.

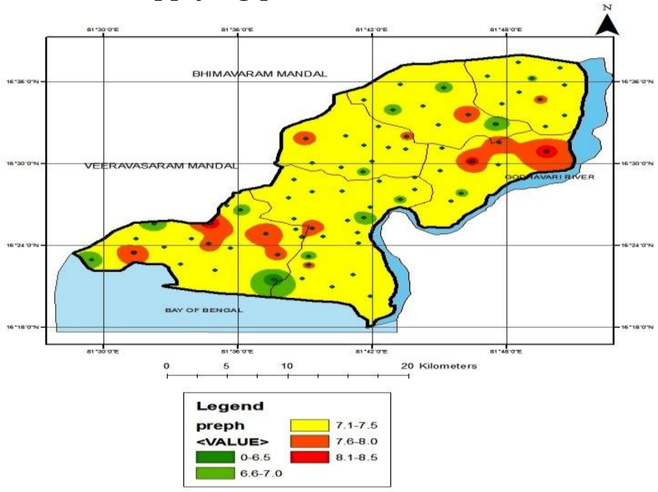

Fig. 2: The spatial distribution of pH

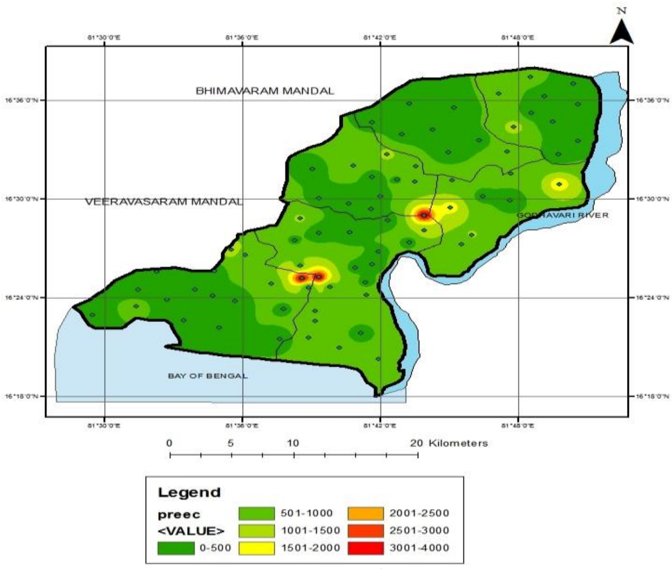

Fig. 3: The spatial distribution of electrical conductivity

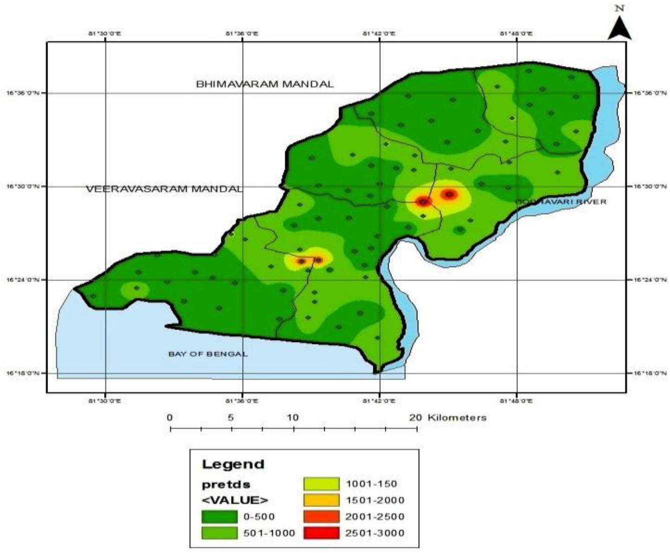

Fig. 4: The spatial distribution of total dissolved solids (TDS)

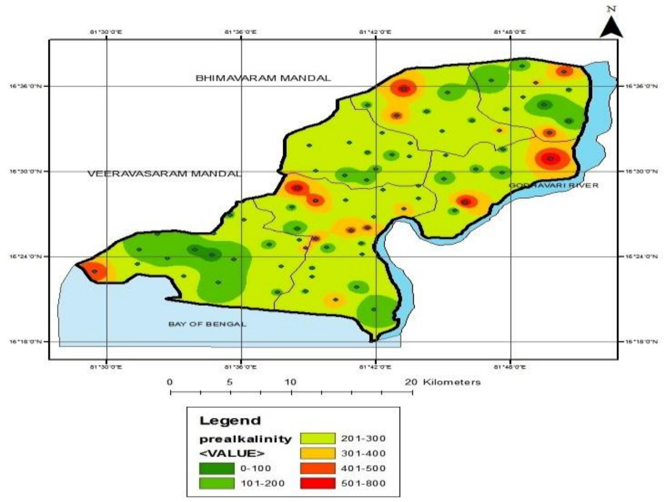

Fig. 5: The spatial distribution of alkalinity

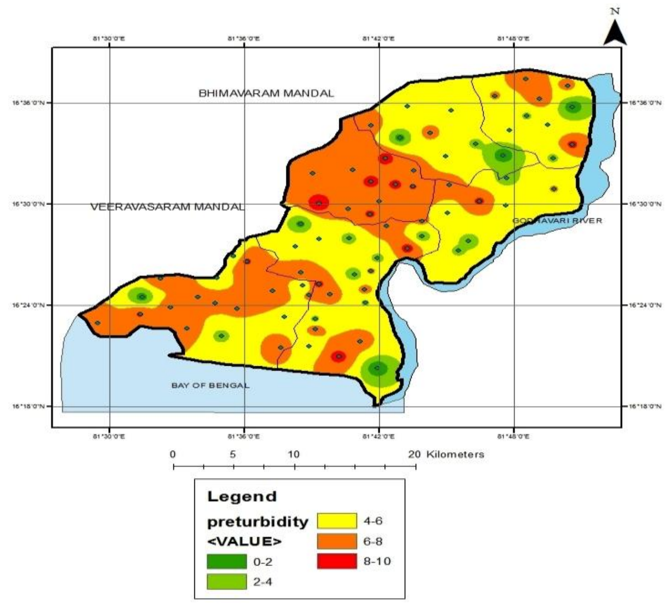

Fig. 6: The spatial distribution of turbidity

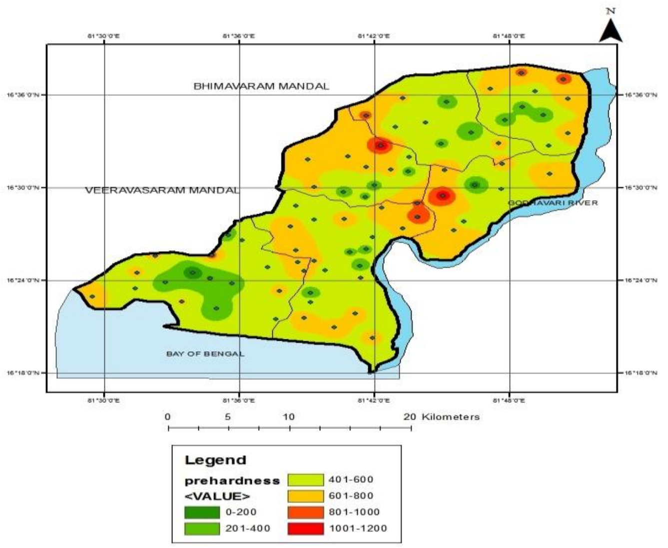

Fig. 7: The spatial distribution of total hardness

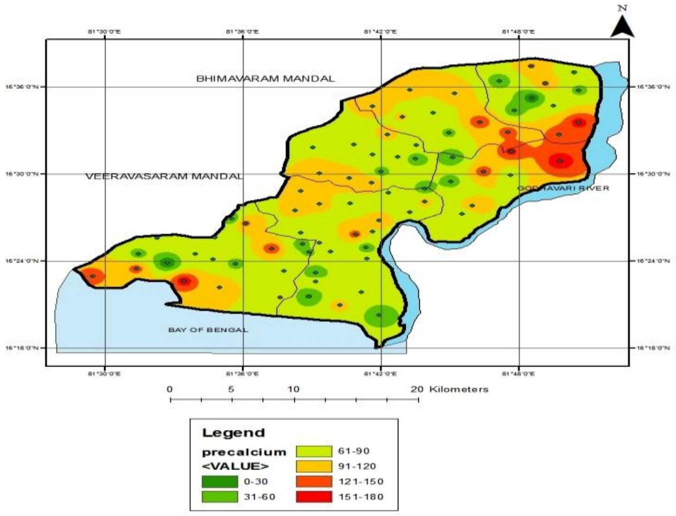

Fig. 8: The spatial distribution of calcium

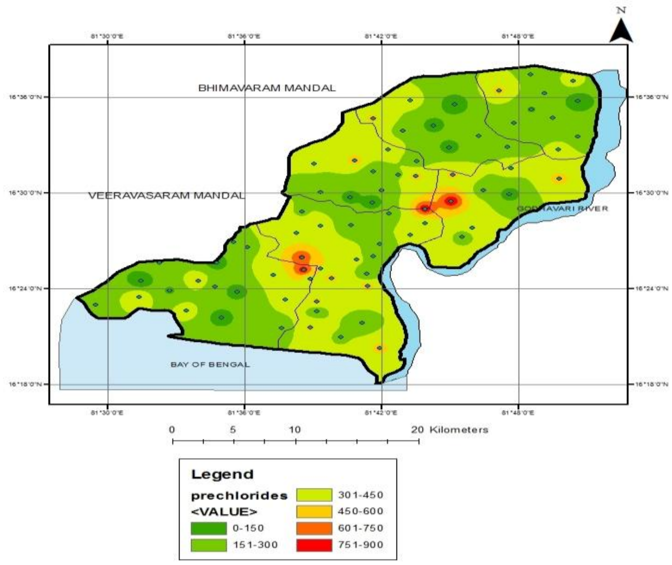

Fig. 10: The spatial distribution of chlorides

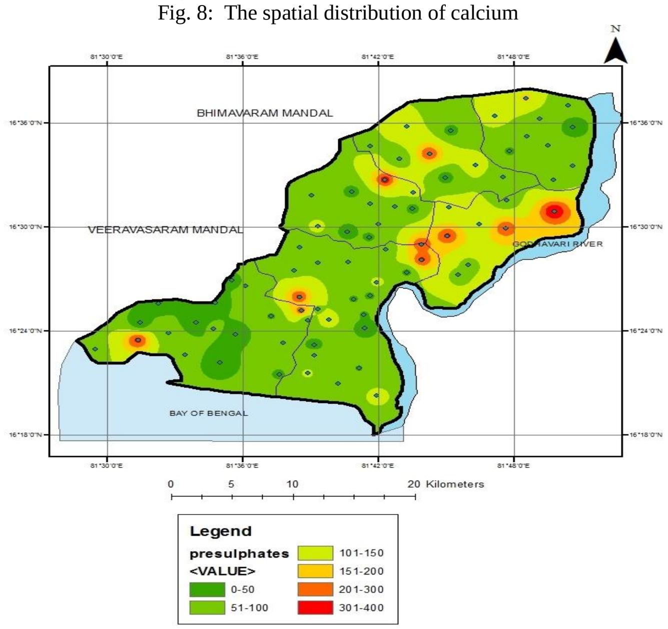

Fig. 9: The spatial distribution of sulphates

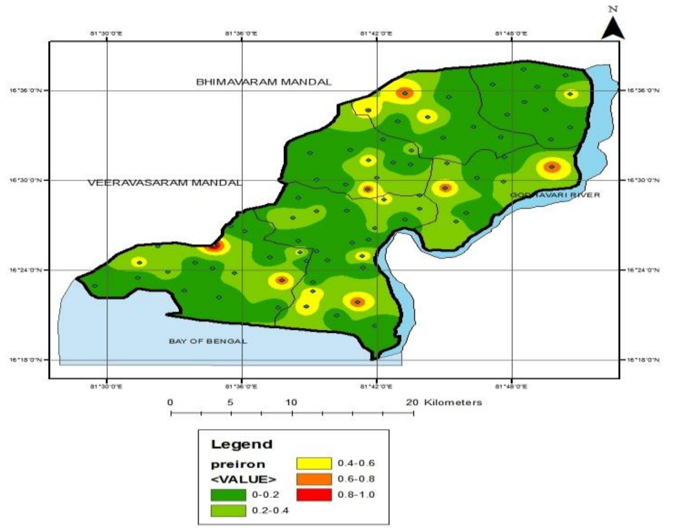

Fig. 11: The spatial distribution of iron

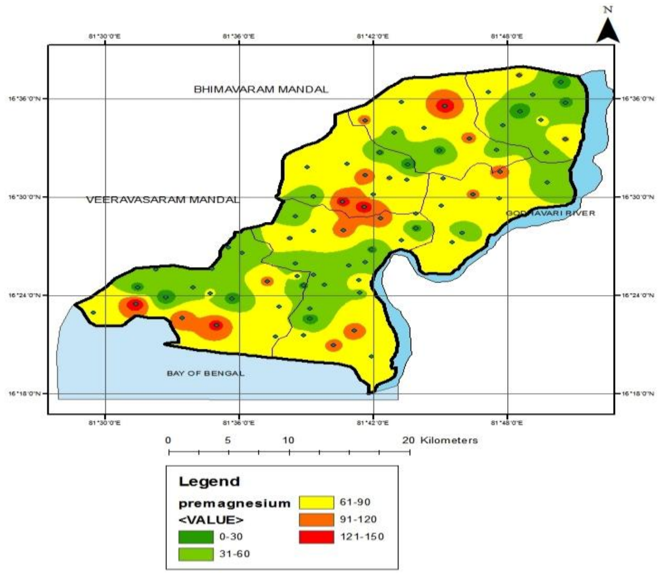

Fig. 12: The spatial distribution of magnesium

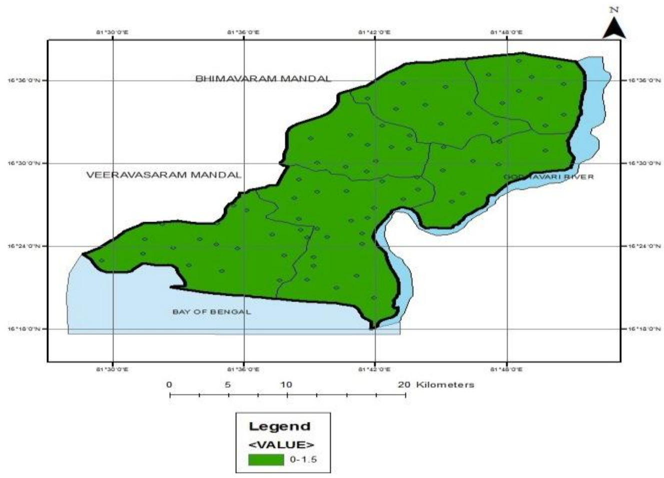

Fig. 13: The spatial distribution of fluoride

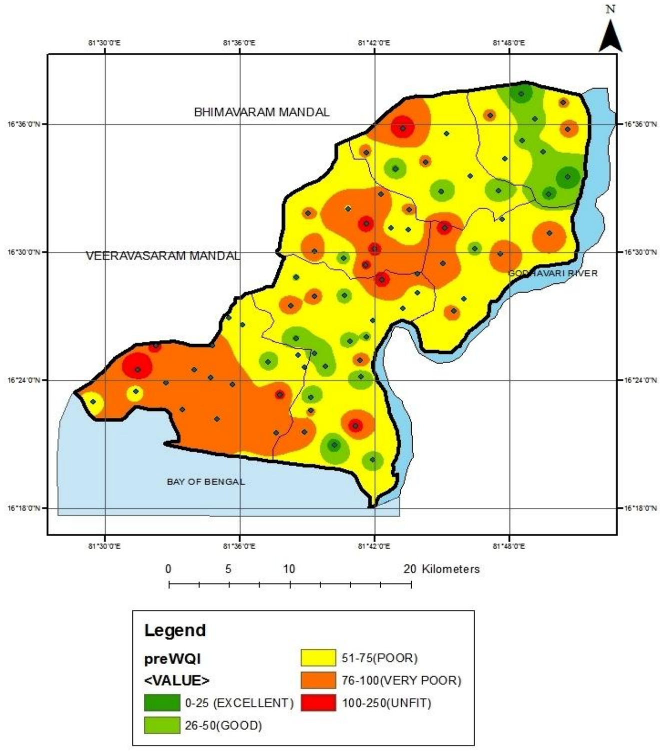

Fig. 14: Spatial distribution of Water Quality Index (WQI) in the study area

Table 3: Spatial location and water quality parameters of study area

S.NO.	Location	Longitude E	Latitude N	pH	Alkalinity	Hardness	Turbidity	Calcium as Ca^{2+}	Magnesium as Mg^{2+}	Sulphates	Chlorides as CI	Iron as Fe	TDS	E. C.	Flouride
1	Perupalem	81.583069	16.369969	7.62	309	140	1.7	109.2	102.4	18	78	0.1	331	420	0
2	Poduru	81.753742	16.592502	7.2	334	154	2.6	110.4	110.3	27	49	0.1	421	431	0
3	Gondimula	81.685751	16.364332	7.31	351	243	3.1	61.8	84.6	34	161	0.7	523	612	0
4	Dharbarevu	81.689681	16.415653	7.35	367	139	3	42.6	61.5	33	142	0.6	510	625	0.01
5	Thurputallu	81.647921	16.359441	7.29	381	273	2.1	31.7	54.3	59	415	0.6	937	1029	0.01
6	Vemuladeevi	81.698684	16.338067	7.46	291	237	0.7	44.7	59.4	61	419	0.1	952	1023	0.01
7	Nallipeta	81.643295	16.419724	7.51	394	253	2.1	36.4	58.6	112	726	0.5	2543	3218	0.01
8	Lakshmaneswaram	81.689873	16.402783	7.5	435	241	1.9	76.5	49.3	20	435	0.1	1102	1204	0.01
9	Linganaboinacherla	81.652822	16.386621	7.01	376	126	1.8	38.2	49.7	19	427	0.1	964	1109	0
10	Yenuguvanilanka	81.758679	16.454023	7.43	341	259	1.9	76.1	71.6	51	245	0.3	642	781	0
11	Saripalle	81.677792	16.466322	7.39	406	261	1.6	75.3	89.6	39	163	0.1	351	442	0
12	Pasaladeevi	81.630177	16.388949	7.81	467	253	2.7	83.6	61.7	38	274	0.7	549	621	0.12
13	Chamakuripalem	81.653029	16.376556	7.79	473	197	3.1	74.2	10.4	58	176	0.6	756	904	0
14	Chittavaram	81.732206	16.468626	7.6	396	353	1.5	92.5	21.4	125	342	0.4	1250	1432	0
15	Narsapur	81.699142	16.446622	7.42	406	225	1.7	93.7	23.4	61	238	0.3	543	723	0.01
16	Rustumbada	81.681654	16.430899	7.36	619	167	1.3	125.3	29.4	32	287	0.1	487	613	0.02
17	Royapeta	81.693907	16.434171	7	617	161	2.9	85.2	41.7	31	241	0.1	583	614	0
18	Mallavaram	81.641991	16.480339	7.29	743	193	1	93.4	29.8	41	263	0.1	1069	1289	0.02
19	Likhithapudi	81.655561	16.465585	7.36	698	209	2.3	91.3	59.4	54	327	0.3	329	412	0
20	Kopporru	81.637859	16.458271	7.51	357	283	2.4	92.7	73.4	52	399	0.4	651	719	0
21	Siragalapalli	81.793739	16.498809	7.49	346	186	2.5	59.5	61.4	118	82	0.3	369	432	0
22	Modi	81.594998	16.397135	7.53	351	143	2.9	48.6	15.6	19	67	0.4	354	429	0.13
23	Marrithippa	81.524391	16.408258	7.46	369	251	0.9	51.6	21.7	15	35	0.5	432	529	0.11
24	Mutyalapalli	81.578808	16.402536	7.84	195	119	2.9	69.4	52.9	41	154	0.1	469	647	0.11
25	Kottata	81.545645	16.398185	7.39	376	137	3.1	11.2	9.4	46	135	0.3	621	657	0
26	Kalipatnam	81.523082	16.391399	8.01	387	183	3.6	120.6	112.5	125	397	0.1	982	984	0.01
27	Medapadu	81.774518	16.502931	8.15	375	94	3.7	127.6	76.2	61	196	0.1	562	627	0
28	Mogalturu	81.621416	16.414417	8	368	206	3.3	134.2	82.4	32	314	0.1	919	887	0
29	Seripalem	81.592211	16.448811	7.57	364	128	1.9	35.7	30.4	29	236	0.1	1253	1549	0.01
30	Ramannapalem	81.648029	16.410521	7.64	547	286	2.8	52.7	21.5	36	314	0.1	643	643	0.01
31	Serepalem	81.601918	16.443479	7.01	496	237	3.7	119.4	33.5	35	232	0.2	978	983	0
32	Seetharamapuram South	81.655605	16.420881	8.03	654	251	3.8	85.6	32.4	51	386	0.1	2594	3214	0.01
33	Seetharamapuram North	81.641866	16.432909	7.56	257	291	3.4	73.5	29.4	125	665	0.1	1012	1069	0.09
34	Yeramsettypalam	81.663588	16.411167	7.51	293	210	3.1	81.6	43.8	71	412	0.1	653	986	0.02
35	Varathippa	81.566047	16.408565	7.36	243	69	2.8	82.6	40.6	14	419	0.2	684	659	0
36	Komatithippa	81.537765	16.426906	7	294	245	3.5	83.4	49.7	21	236	0.3	383	391	0.01
37	Kummarapurugupalem	81.627152	16.358671	6.59	381	219	3.1	87.5	71.6	32	183	0.1	429	512	0
38	Navarasapuram	81.721262	16.456508	7.21	548	241	3.9	86.2	59.4	28	273	0.1	549	632	0
39	Pathapadu	81.491454	16.383005	7.16	681	268	3.2	121.6	51.8	51	241	0.1	586	659	0.01
40	Agarru	81.677467	16.495672	7.61	313	146	2.8	110.3	104.2	20	81	0.1	335	418	0
41	Gorintada	81.693521	16.490298	7.18	347	164	3.7	112.7	112.5	30	52	0.7	419	452	0.12
42	Baggeswaram	81.694041	16.522372	7.29	381	253	3.8	62.8	87.6	38	164	0.6	521	601	0
43	Chandaparru	81.700385	16.502727	7.34	376	143	3.4	43.6	63.5	37	147	0.4	512	621	0
44	Gadiparru	81.751893	16.519391	7.28	392	294	3.1	32.9	59.4	62	421	0.3	947	1020	0.01
45	Achanta	81.786038	16.607079	7.43	301	254	2.8	45.7	62.7	64	425	0.1	981	1012	0.02
46	Digamarru	81.731973	16.483601	7.46	419	297	2.9	39.7	62.9	120	732	0.4	2941	3215	0
47	Lankalakoderu	81.680847	16.534112	7.49	461	263	3.1	82.9	52.1	25	452	0.1	1053	1187	0.01
48	Pallakollu	81.725342	16.517455	7.51	397	138	3.6	41.6	51.6	21	439	0.1	987	1062	0.01
49	Pulapalli	81.712335	16.519432	7.39	354	271	3.7	81.6	73.4	53	261	0.1	639	749	0
50	Sagamcheruvu	81.705526	16.478527	7.37	457	283	3.3	79.2	94.2	42	185	0.5	384	435	0.01
51	Sivadevunichikkala	81.650768	16.530399	7.76	482	281	3.5	85.6	63.7	43	284	0.1	545	619	0.09
52	Ullamparru	81.726051	16.533399	7.73	491	213	3.1	75.3	12.5	60	195	0.3	765	897	0.02
53	Vadlavanipalem	81.705184	16.545356	7.51	412	399	3.9	94.8	25.4	132	354	0.1	1247	1387	0.02
54	Velivela	81.655561	16.500642	7.39	453	246	4.3	95.7	27.3	62	241	0.1	591	657	0
55	Kodamanchili	81.819318	16.603931	7.25	510	212	3.5	115.6	31.8	51	272	0.1	498	608	0
56	Valluru	81.829305	16.545734	7.31	632	183	1.9	127.6	34.5	35	301	0.1	502	546	0
57	Vedangi	81.715626	16.565402	7.15	625	176	0.9	87.3	45.2	33	255	0.1	592	601	0
58	Kalagampudi	81.766561	16.464001	7.21	753	216	1.7	97.8	32.5	49	281	0.1	1186	1235	0
59	Pedamallam	81.839991	16.616815	7.53	645	306	2.9	59.7	24.3	41	321	0.2	653	652	0
60	Kavitam	81.721262	16.596783	7.31	726	238	2.6	93.6	62.8	58	334	0.7	354	397	0
61	Kommuchikkala	81.693893	16.578153	7.49	371	301	3.1	94.2	75.2	54	412	0.6	689	710	0
62	Bolletigunta	81.737728	16.570572	7.43	376	213	3	61.3	65.2	121	86	0.6	382	421	0
63	Penumadam	81.749698	16.547583	7.48	395	163	2.1	52.6	21.5	21	73	0.1	376	412	0
64	Koderu	81.843559	16.596002	7.38	383	273	0.7	53.1	26.3	19	41	0.5	441	456	0
65	Penumachili	81.825278	16.578451	7.72	216	137	2.1	72.3	54.1	43	165	0.1	493	573	0.01
66	Vennapuvaripalem	81.809632	16.587316	7.33	406	158	1.9	12.8	10.5	51	142	0.1	623	643	0.01
67	Gummaluru	81.771461	16.559938	8	381	126	1.9	132.4	81.3	68	201	0.1	583	639	0.01
68	Penumarru	81.794528	16.525992	7.87	376	253	1.6	143.8	84.3	36	326	0.1	912	942	0.01
69	Miniminchilipadu	81.797003	16.572923	7.42	384	158	2.7	41.9	32.5	31	241	0.1	1247	1463	0.01
70	Raavigoppu	81.792119	16.548362	6.87	512	251	0.5	121.4	36.2	42	246	0.1	984	1023	0
71	Siddhantam	81.809042	16.624004	7.36	364	300	3.1	112.8	73.1	80	256	0.1	598	940	0.01
72	Ilapakurru	81.829627	16.515202	8.2	773	278	2.8	160.7	37.2	140	431	0.7	970	1851	0.01
73	Utada	81.751081	16.491635	7.4	334	395	2.4	46.5	62.7	124	756	0.7	2789	1851	0.01
74	Gondimula	81.67011	16.349647	7.28	571	245	3.9	97.8	78.2	40	260	0.1	563	872	0.01
75	Godavaripet	81.579731	16.427462	8.32	466	313	2.6	65.8	45.7	22	55	0.9	418	587	0.01
76	Linupallipalem	81.557908	16.377339	7.28	474	243	3.3	152.3	89.2	41	335	0.1	445	587	0
77	Bhemalapuram	81.843263	16.558986	7.39	265	287	3.7	148.7	73.4	48	260	0.1	974	523	0

TABLE 4: Water quality index (WQI) of sampling locations in the study area

S.NO.	SAMPLING STATION	WQI VALUE	CLASSIFICATION
1	Perupalem	115	Unsuitable for drinking
2	Poduru	110	Unsuitable for drinking
3	Gondimula	158	Unsuitable for drinking
4	Dharbarevu	141	Unsuitable for drinking
5	Thurputallu	140	Unsuitable for drinking
6	Vemuladeevi	81	Very poor water quality
7	Nallipeta	105	Unsuitable for drinking
8	Lakshmaneswaram	60	Poor water quality
9	Linganaboinacherla	56	Poor water quality
10	Yenuguvanilanka	120	Unsuitable for drinking
11	Saripalle	73	Poor water quality
12	Pasaladeevi	151	Unsuitable for drinking
13	Chamakuripalem	120	Unsuitable for drinking
14	Chittavaram	105	Unsuitable for drinking
15	Narsapur	91	Very poor water quality
16	Rustumbada	77	Very poor water quality
17	Royapeta	84	Very poor water quality
18	Mallavaram	85	Very poor water quality
19	Likhithapudi	125	Unsuitable for drinking
20	Kopporru	130	Unsuitable for drinking
21	Kamsalibethapudi	136	Unsuitable for drinking
22	Modi	140	Unsuitable for drinking
23	Marrithippa	167	Unsuitable for drinking
24	Mutyalapalli	133	Unsuitable for drinking
25	Kottata	140	Unsuitable for drinking
26	Kalipatnam	106	Unsuitable for drinking
27	Medapadu	74	Poor water quality
28	Mogalturu	70	Poor water quality
29	Seripalem	96	Very poor water quality
30	Ramannapalem	106	Unsuitable for drinking
31	Serepalem	103	Unsuitable for drinking
32	Seetharamapuram South	57	Poor water quality
33	Seetharamapuram North	56	Poor water quality
34	Yeramsettypalam	76	Very poor water quality
35	Varathippa	138	Unsuitable for drinking
36	Komatithippa	144	Unsuitable for drinking
37	Kummarapurugupalem	24	Excellent water quality
38	Navarasapuram	114	Unsuitable for drinking
39	Pathapadu	112	Unsuitable for drinking
40	Agarru	70	Poor water quality
41	Gorintada	148	Unsuitable for drinking
42	Baggeswaram	164	Unsuitable for drinking
43	Chandaparru	154	Unsuitable for drinking
44	Gadiparru	160	Unsuitable for drinking
45	Achanta	120	Unsuitable for drinking
46	Digamarru	139	Unsuitable for drinking
47	Lankalakoderu	114	Unsuitable for drinking
48	Pallakollu	96	Very poor water quality
49	Pulapalli	103	Unsuitable for drinking
50	Sagamcheruvu	160	Unsuitable for drinking
51	Sivadevunichikkala	115	Unsuitable for drinking
52	Ullamparru	118	Unsuitable for drinking
53	Vadlavanipalem	121	Unsuitable for drinking
54	Velivela	126	Unsuitable for drinking
55	Kodamanchili	76	Very poor water quality
56	Valluru	53	Poor water quality
57	Vedangi	55	Poor water quality
58	Kalagampudi	91	Very poor water quality
59	Pedamallam	118	Unsuitable for drinking
60	Vempa	168	Unsuitable for drinking
61	Matsyapuripalem	116	Unsuitable for drinking
62	Bolletigunta	119	Unsuitable for drinking
63	Penumadam	58	Poor water quality
64	Koderu	127	Unsuitable for drinking
65	Penumachili	83	Very poor water quality
66	Vennapuvaripalem	82	Very poor water quality
67	Gummaluru	88	Very poor water quality
68	Penumarru	109	Unsuitable for drinking
69	Miniminchilipadu	115	Unsuitable for drinking
70	Raavigoppu	67	Poor water quality
71	Siddhantam	35	Good water quality
72	Ilapakurru	136	Unsuitable for drinking
73	Utada	142	Unsuitable for drinking
74	Gondimula	44	Good water quality
75	Godavaripet	130	Unsuitable for drinking
76	Linupallipalem	116	Unsuitable for drinking
77	Bhemalapuram	39	Good water quality

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