SPATIAL DISTRIBUTION OF GROUND WATER QUALITY INFORMATION AT RAJAHMUNDRY AND IT'S SURROUNDING AREAS – GIS APPROACH

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Abstract— Spatial variations in ground water quality in the corporation area of Rajahmundry and its surrounding areas have been studied using GIS technique. GIS is a tool which is used for storing, analyzing and displaying spatial data and it is also used for investigating ground water quality information. For this study, water samples were collected during pre-monsoon and post-monsoon seasons from 50 wells representing the entire corporation area. The water samples were analyzed for PH, EC, TDS, TH, Ca, Mg, Na, K, CO_3, HCO_3, CL^-, NO_3, SO_4 and fluoride using standard techniques in laboratory and compared with standards. The ground water quality information maps of the entire study area have been prepared using GIS spatial interpolation technique for all the parameters. The results revealed that PH increases from pre-monsoon to post-monsoon. Similarly the TDS values are decreasing from pre-monsoon to post-monsoon. The concentration of cations namely Ca, Mg, Na have recorded an increasing trend. The anions also indicated similar behaviour. It is established that besides the type of formation the ion exchange phenomena and the drainage network activity in the post-monsoon period contributed to the increase of these parameters. The results obtained in this study and the spatial database established in GIS will be helpful for monitoring and managing ground water pollution in the corporation area. Application of GIS is helped in delineating the potential potable ground water zones of the study area.

1. INTRODUCTION

The groundwater aquifer studies leading to the evaluation of groundwater quality has been carried out by a number of workers in different geological environments of Andhra Pradesh. However, no systematic study was attempted to investigate the hydro-geological conditions in Rajahmundry area of East Godavari district. In this study the aquifer conditions in and around Rajahmundry were studied keeping in view various factors that can control the groundwater quality and occurrence. The study employed the standard

hydro-geological methodology including various field and laboratory techniques (ISI 1983, Vogel 1971, Brown *et al.* 1974). Geographic Information System (GIS) presents an important tool in the effective management of groundwater resources. GIS helps in preparing a scientific database of the resource and also facilitates for updating the data. GIS is also an effective tool for integration of various data and hence finds multifarious applications in geological studies. GIS offers unique opportunities to integrate spatial data from different sources with the natural resources management models (Goodchild 1993). GIS has been put to effective use in many earlier groundwater studies and found to be extremely successful (Krishnamurthy *et al*. 1996, Israil *et al.* 2006, Ravindran 1997, Safar and Choudhary 1998, Anbazhagan and Nair 2004, Vittala *et al*. 2005).

The study area is situated on the east bank of the river Godavari. The area lies between the North latitudes 16°55′ – 17°10' and East longitudes 81°45' – 82°00' falling in the Survey of India toposheets 65H/13 and 65G/16 (Fig.1). The area is drained by the perennial river Godavari, originating in the Nasik Thrayambakam of Maharashtra state and entering the district at Devipatnam. The river Godavari flows in the direction from NNW-SSE. The drainage is sub-dendric in general. Most of the streams are ephemeral. Khondalites, charnockites and granites are exposed in Northern half of the district. The Tirupati sandstones represented by sandstones and clays of Upper Jurassic age are the oldest sedimentary units and underlined by Khondalites and Deccan traps overlaying Tirupati sandstone are exposed north of Rajahmundry. The Tertiary rocks represented by Rajahmundry sandstone of unconsolidated to poorly consolidated sediments are exposed NE of Rajahmundry. The strike of the formations is NE-SW and dips about 80SE. The well locations map is shown in Fig.2.

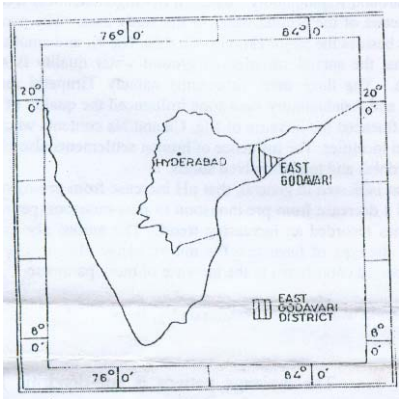


Fig.1: Location map of the study area

Fig.2: Well locations in the study area

2. MATERIALS AND METHODS:

The entire study area was geologically mapped on 1:50,000 scale and 50 observation wells were setup, covering the area and representing all the geological formations. Hydro geological and hydro geochemical studies were carried out mainly to understand the spatial variability in ground water quality. The water samples collected from 50 observation wells during pre-monsoon and post-monsoon periods i.e. in the months of May 1993, December 1993 respectively were analyzed for various chemical parameters. Bottles used for water sample collection are first thoroughly washed with the water being sampled and then were filled. The bottles are then closed leaving only a small air bubble below the stopper. The samples are collected after pumping the well or bore hole for at least an hour. After collection of the samples, the samples are preserved and shifted to the laboratory analysis. Chemical analysis was carried out to determine PH, EC, TDS, TH, Ca, Mg, Na, K, CO_3, HCO_3, Cl^-, NO_3, SO_4 and Fluoride and compared with standard values recommended by ISI, 1983 (Table.1).

GIS Analysis:

Thematic maps like base map and land use map of the study area at 1:50,000 scale were prepared. The drainage, contour maps were prepared from SOI toposheets at 1:50,000 scale. The well location points were digitized and the corresponding location numbers were assigned. The water quality data thus obtained forms the attribute database. It is stored in excel format and was converted into '.dbf' format and linked with the spatial data by join option in ArcMap. The spatial and the attribute database formed are integrated for the generation of spatial distribution maps of the water quality parameters. Spatial interpolation thechnique through Inverse Distance Weighted (IDW) approach in GIS has been used in the present study to delineate the locational distribution of water pollutants.

Table.1: Standards for Drinking water, ISI (1983)

Parameters	Maximum acceptable	Maximum allowable
PH	7.0 – 8.5	6.5 – 9.2
TDS(mg/l)	500	1500
TH(mg/l)	300	600
Ca(mg/l)	75	200
Mg(mg/l)	30	100
Cl^- (mg/l)	250	1000
SO_4 (mg/l)	150	400
NO_3 (mg/l)	45	45
Fluoride (mg/l)	0.6 – 1.2	1.5

3. RESULTS AND DISCUSSIONS:

Results of the geochemical analysis of the study area are presented in Table2.

Table.2: Chemical composition of Groundwater in the study area

Sample No.	Location	Ph	EC (mohs/cm)	TDS mg/l	TA mg/l	TH mg/l	HCo3 mg/l	Cl mg/l	So4 mg/l	F mg/l	Na mg/l	K mg/l	Ca mg/l	Mg mg/l
1	Rajahmundry	7.12	562	359	126	200	154	40	144	0.10	34	3	56	15
2	Rajahmundry	7.17	860	550	226	220	276	117	140	0.10	99	39	40	29
3	Morampudi	7.80	621	398	164	260	200	28	225	0.20	48	3	52	51
4	Punyakshetram	7.40	385	246	99	120	121	20	125	0.40	25	2	40	5
5	Bhupalapatnam	7.60	388	248	243	680	297	660	140	0.40	45	250	120	92
6	G.Errampalem	8.15	517	331	162	200	198	45	135	0.40	42	3	40	24
7	P.Tungapadu	7.80	785	502	198	200	242	60	145	0.20	73	10	48	19
8	Mallampudi	7.40	309	198	91	100	112	30	160	0.10	28	2	32	5
9	P.Ramachandrapuram	7.40	430	275	99	120	121	50	209	0.20	38	2	32	10
10	Mukkinada	7.80	349	223	84	120	102	30	210	0.10	13	4	24	15
11	Kapavaram	7.59	539	345	131	220	160	35	150	0.10	34	3	48	24
12	Balabhadrapuram	7.50	1435	918	178	460	218	205	121	0.20	96	15	84	61
13	Bommuru	6.93	569	364	118	240	145	19	180	0.10	25	3	56	24
14	Sampathnagar	6.53	905	579	164	300	200	123	145	0.20	65	7	80	24
15	Kesavaram	6.79	399	255	97	140	119	42	150	0.20	27	4	40	10
16	Dwarapudi	7.40	604	357	191	220	233	30	130	0.10	35	3	56	19
17	Lalacheruvu	7.00	916	586	145	180	177	140	160	0.70	61	35	88	15
18	Tokada	7.00	712	456	99	260	121	70	120	0.10	38	4	10	56
19	Atchutapuram	7.14	320	205	98	120	120	23	145	0.10	20	3	32	10
20	Central Jail	7.05	700	446	225	285	275	19	165	0.20	39	4	55	36
21	Lalacheruvu	7.50	1192	763	141	220	172	195	178	0.10	136	28	47	25
22	R.V.Nagar	8.00	275	175	96	80	69	10	150	0.10	24	5	24	5
23	C.T.R.I	7.34	1325	846	258	460	315	123	145	0.10	94	14	145	25
24	Alcotgardens	6.70	1404	897	272	500	332	164	160	0.10	114	5	120	48
25	Gandhipuram	6.80	1400	921	24	500	30	20	124	0.50	114	1	45	5
26	Fortgate	6.40	1443	925	196	400	240	136	126	0.10	110	125	73	53
27	Pidumgoyya	6.90	638	404	101	200	124	93	140	0.50	50	5	49	19
28	Danavaipeta	7.80	498	319	159	220	195	48	120	0.50	49	4	40	29
29	Dowlaiswaram	8.10	939	600	232	300	283	75	160	0.10	76	5	64	34
30	Ramaswamipeta	7.00	2620	1676	602	660	735	400	140	1.00	385	2	80	113
31	Kondagunturu	7.80	484	309	114	150	140	55	120	1.00	42	5	28	19
32	Rajanagaram	7.50	4640	2972	118	1400	144	92	100	1.00	40	3	224	204
33	Divancheruvu	7.50	251	160	58	80	71	32	130	0.10	27	4	15	10
34	Hukumpeta	7.01	1524	974	296	500	362	215	135	0.50	115	20	128	4
35	Butchampeta	7.13	773	495	183	240	224	130	160	0.50	88	11	72	15
36	Kalvacherla	6.93	4279	2733	397	1462	485	1048	148	0.10	435	2	135	272
37	Gandapalli	7.65	1926	1234	314	360	383	258	120	1.50	312	3	24	73
38	Palacherla	7.25	968	620	295	320	360	70	160	0.20	68	1	72	32
39	Konthamuru	8.20	1234	790	274	420	335	120	140	0.20	115	6	87	49
40	Burugupudi	7.80	3890	2490	83	640	102	780	135	0.50	343	4	112	88
41	Madurapudi	7.43	910	581	176	340	215	80	154	0.70	46	7	88	29
42	Torredu	7.43	3980	2547	306	440	368	903	123	0.70	758	4	48	78
43	Hundeswarapuram	7.41	3975	2543	299	435	365	900	115	0.50	754	3	46	75
44	Murari	7.90	402	256	83	140	102	18	125	0.50	23	1	40	10
45	Nandarada	6.90	4278	2731	396	1450	484	1035	154	0.10	434	2	134	273
46	Dosakayalapalli	7.12	772	494	182	235	223	132	123	0.59	86	10	71	14
47	Gadala	7.80	1190	763	362	440	442	60	160	0.20	69	1	80	56
48	Narendrapuram	7.60	1290	823	323	442	2395	150	125	0.20	90	4	48	78
49	Velugubanda	7.30	1218	780	247	320	302	170	143	0.80	28	3	56	44
50	Ramadaspeta	7.80	972	623	203	400	248	80	121	0.50	48	2	80	49

GIS zonation maps prepared for each element is self-explanatory and help in future management of water resources in the area. The spatial distribution of PH values (Fig.3(a)) ranges from 6.4 to 8.2. In majority of samples the PH ranges from 7.0 to 7.5. The higher range of PH is 7.5 to 8.2 is observed in central wells of central, eastern and western parts of the area. Maximum PH of more than 8.0 is encountered in localized pockets, where the soil constitutes kankar, ferrusions fractions and thick clay zones which occur in places like Morampudi, G.Errapalem and Dowleswaram. According to ISI (1983), the permissible limit for PH is 6.5 – 9.2. According to ISI standards all water samples were found to be within limit. The spatial distribution of TDS (Fig.3(b)) shows a

range of 160 to 2972 mg/l. In almost all the formations of the study area, the TDS values are less than 500mg/l with lowest concentration of 160mg/l recorded at Divancheruvu. Higher range of 100-1000 mg/l is observed in the central, western and eastern parts of the study area. The next higher range of TDS with 1000-1500mg/l is of local nature confining to topographic depressions and ayacut areas. The maximum values of TDS more than 1500mg/l occur at a few isolated patches underlain by clay. Permissible limit for TDS is 500-1500mg/l according to ISI (1983). The TDS values ranges from 160 to 1600mg/l except in well nos. 33, 43, 46 and 48 which are located in thick clayey beds. The spatial distribution of TH (Fig.3(c)) varies from 80 to 1462 mg/l. Minimum and maximum was reported from R.V.Nagar and Kalvacherla respectively. ISI recommended safe permissible limit for hardness is 300-600 mg/l. In groundwater, hardness is mainly due to carbonates, bicarbonates, sulphates and chlorides of Ca and Mg. Ca content (Fig.3(d)) in the study area ranges from 10-224 mg/l. Ca was within permissible limit in 25% samples whereas 75% samples contained below than limit. Mg content (Fig.4(a)) in the study varies from 4-273 mg/l. Mg was below than limit in 52% samples and 40% samples showed Mg within optimum limit. Total hardness was higher in 8% samples, below than limit in 52% samples whereas 40% samples contained TH within optimum limit. Cl^- is the second dominant ion in the groundwater. It varies (Fig.4(b)) from 10-1048 mg/l. Minimum was reported from R.V.Nagar and maximum was observed from Kalvacherla samples. The Chloride content was higher than permissible limit in 8% samples whereas lower in 76% samples. Only 16% samples were within optimum limit. Higher content of chloride gives salty taste to water. Sulphate (SO_4) concentration (Fig.4(c)) range from 120-225 mg/l which is less than the groundwater of east coast of Andhra Pradesh which are reported in the range of 3-1053mg/l (Vinoda rao 1985 ravi Prakash 1986, sathibabu 1990). Fluoride content (Fig.4(d)) varied from 0.1-1.5 ppm. Minimum and maximum concentration of Fluoride was observed from Rajahmundry and Gandapalli samples respectively. Permissible limit for Fluoride concentration is 0.6-1.2 ppm according to ISI (1983). The data revealed that 80% samples are affected with low concentration of Fluoride, whereas 20% samples contained optimum limit of Fluoride.

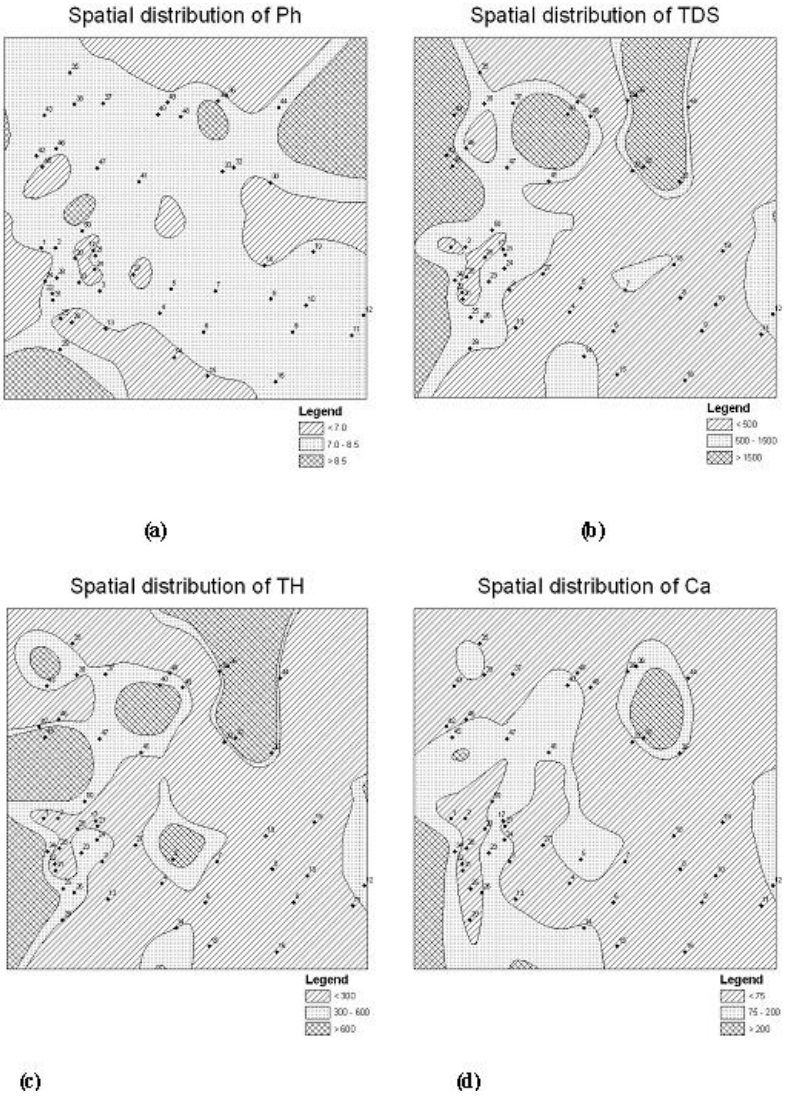
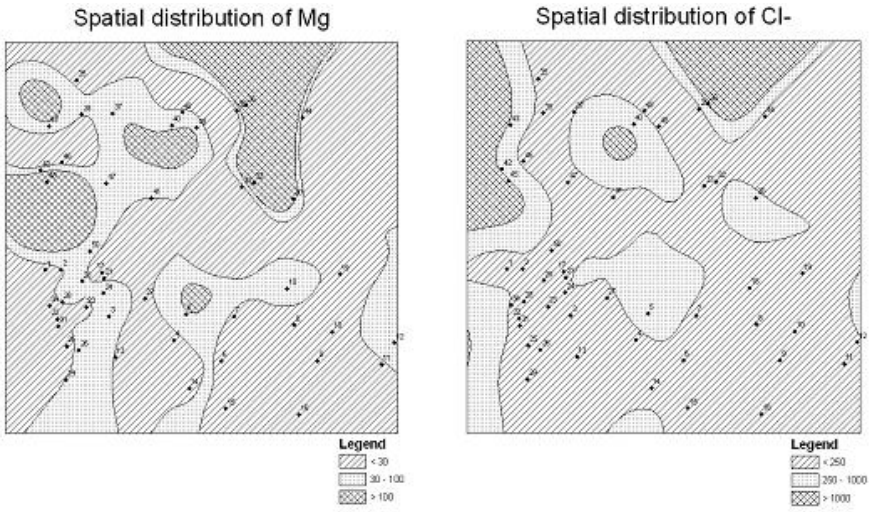
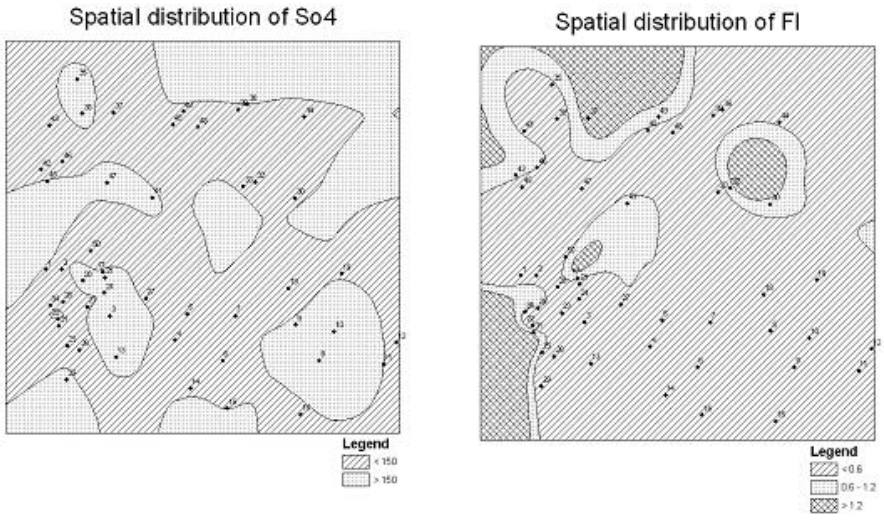


Fig.3: Spatial Distribution of groundwater quality Parameters.



1. (b)



(c) **(d)**

Fig.4: Spatial Distribution of groundwater quality Parameters.

4. CONCLUSIONS

Due to lithological influence the instance of man made pollution have increased the TH values at well Nos.33, 35 enormously. Similarly the increase in TDS values due to the influence of clay, encountered in certain clay zones can't be ruled out. The general high concentration of Mg, Ca and Na content in the well Nos. 33, 40 and 43 suggests the influence of basic composition of trap rocks. It is observed that the wells 29 and 33 directly fall in trap rock lithology, whereas the wells 40, 43 fall in tirupati sand stones. It is well established that intercalations of trap rocks within the tirupati sand stone is a common phenomena in the study area. Since the tirupati sand stones are overlain by trap rocks in the geological succession. It is observed that the well no.29 has recorded similar concentration of Ca, Mg in comparison with wells of trap rocks Na content is much lower than these wells. This can be explained that the higher concentrations of Ca, Mg may be due to the fact that this well is located near the town Dowaleswaram which is influenced by river Godavari which might be source for anomalous concentration of Ca and Mg since Godavari has a catchments area of high grade metamorphic and trap rocks has a natural supply of Mg and Ca. Hence it is well established the ion exchange play a major role in concentration of Mg, Ca and Na. The GIS maps clearly brings out the areal extent of each parameter in the study area.

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