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Spatial Distribution of Water Quality Parameters with using Gis

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Abstract: ***The present paper describes the application of GIS to study the spatial and temporal variations of some important water quality parameters in the Veeranam tank drainage basin of cuddalore district, Tamil Nadu, South India. The water quality parameters were depicted by various colour combinations for different ranges of concentrations. Twenty four (24) groundwater samples were collected from bore wells for two different seasons, pre monsoon in July 2015 and post-monsoon in January 2016. The collected water samples were analyzed for chemical constituents, such as chloride, sulphate, bicarbonate, carbonate, nitrate, sodium, potassium, calcium and magnesium in the laboratory, by following the standard procedures described by the American Public Health Association (APHA 1998). Spatial distribution map for Electrical conductivity, Hardness, Calcium, Magnesium, Sulphate and Chloride in pre-monsoon and post monsoon samples was generated by ArcGIS 9.3 software. The study implies that the quality of groundwater is generally good and potable in the nearby Veeranam lake and the quality becomes moderate as it passes away from Veeranam tank of the study area.***

Key Words: GIS, Groundwater, Spatial distribution, Veeraam tank

I. INTRODUCTION

Groundwater is the most important source of domestic, industrial and agricultural water supply in the world. Generally, the mineral concentration in the groundwater has high when compare with the surface water. Type of minerals and their concentrations are depend on the environment, movement and source of the groundwater. The suitability of groundwater for irrigation, industrial, municipal and other uses is determined based on the type and concentration of minerals of the groundwater. Generally, water quality standards have been established for every water use. These water quality standards developed by various agencies, serve as guidelines in determining the suitability of water for various uses. GIS is a computer software used in mapping of huge sets of geo referenced information. Geographical Information System is widely used in the analysis of spatial data. GIS provides greater accuracy and speed in handling the spatial data. [1](Burrough, 1986). Analysis of spatial and temporal distribution of groundwater quality parameters using GIS has received advantage in India. Durbude et al (2002)[2] had attempted a study on 'Mapping of groundwater quality parameters in GIS Environment' in Ghataprabha sub basin.

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15 samples were collected from both bore wells and open wells. For mapping of salinity zones, the boundary map was created in the GIS environment using ILWIS GIS software. Nageswara Rao et al (2002)[3] conducted a study on 'Monitoring of Groundwater quality of Hyderabad using GIS'. Monitoring of groundwater level fluctuations plays a significant role in assessing groundwater condition and potential.

II. MATERIALS AND METHODS

A. Study area

The study area of Veeranam tank and its drainage basin is situated in between the Latitude of 11o 15' and 11o 25' N and the Longitude of 79o 30' and 79o 38' E. The tank is irrigating an extent of 44,856 acres of wet lands in this basin. The Drinking water need of Chennai City is also supplemented from this tank. The climate in this area is sub-tropical and the maximum temperature varies from 30 to 38°C. Average rainfall in the study area is 1,025 mm. It is a rural area having small villages. The main occupation of the people of this area is agriculture. They cultivate mainly rice, black gram and green gram.

B. Sampling And Physicochemical Analysis

Twenty four (24) groundwater samples were collected from bore wells for two different periods, pre-monsoon in July 2015 and post-monsoon in January 2016. The samples were collected in a cleaned one-liter PVC bottles. The bottles which are used for the collection of water samples were thoroughly washed with the particular groundwater sample before collecting water sample. The collected samples were tested for physiochemical parameters include pH, EC (electrical conductivity),TDS (total dissolved solids), and important cations such as Ca2+(calcium), Mg2+(magnesium), Na(sodium) and K(potassium) as well as anions such as, bicarbonates, chlorides, nitrates and sulfates.

The global positioning system (GPS) was used to record the geographic location (latitude, and longitude) of each sampling point. Sample location is written on the bottle. All the geographic coordinates of sampling location and sampling attributes were imported in ArcGIS software v9.3 for geospatial analysis.

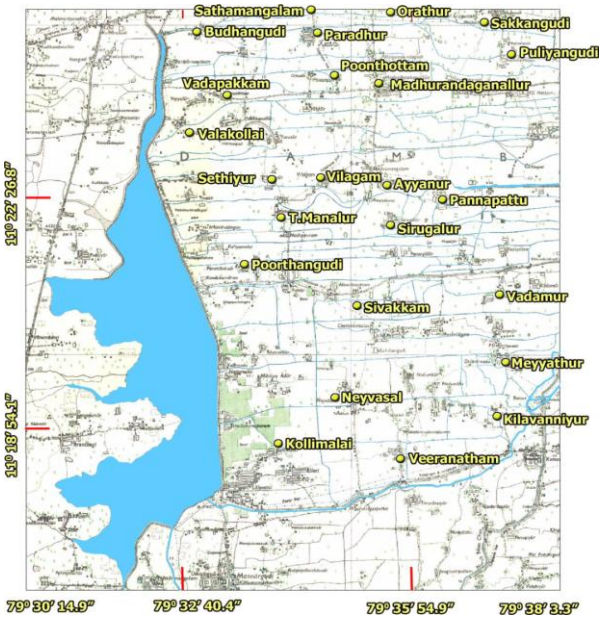

Figure 1: Study area with locations of sampling villages

III. RESULT AND DISCUSSION

A. Physicochemical Parameters of Groundwater

Table 1 and table 2 shows the hydrochemical properties of groundwater quality in pre-monsoon and post monsoon periods respectively.

B.GIS Analysis

Spatial distribution study is an important tool to understand the spatial distribution of ionic concentrations of hydro-chemical parameters. Spatial distribution provides pictorial representation of the spread of ionic concentration. The sample locations are represented as point feature layer. Each location is attributed with location identity, physical and chemical content concentrations. Spatial distribution map of groundwater was generated by ArcGIS v9.3 software. The study implies that the quality of groundwater is generally good and potable in the nearby Veeranam lake and the quality becomes moderate as it passes away from Veeranam tank of the study area. Geostatistical relationships of known borehole points used Arc-GIS 10.3 software to interpolate physicochemical parameters of groundwater in the study area and represent their distribution in maps.

The spatial distribution of Electrical conductivity, Hardness, Calcium, Magnesium, Sulphate and Chloride in pre-monsoon and post monsoon samples were shown in figure 2 and figure 3 respectively.

C. Electrical Conductivity

Electrical Conductivity (EC) is the measurement the dissolved ions present in the water. EC of water will increase or decrease based on the ion concentrations. Electrical Conductivity is used to find the suitability of water for agriculture utilization, If the electrical conductivity is higher than 2,250 µS/cm, then the water is not suitable for irrigation.(Richards (1954)) [4].

According to Hem TDS can be calculated from EC. He derived an equation to find TDS.

TDS = K*EC where K is multiplying constant from 0.55 to 0.75 and EC in micro Simen/cm [5],

From the EC spatial distribution diagram, it was understood that some scattered areas of south and central part of the study area, contains low value of EC during pre monsoon season The spatial distribution diagram of EC showed that the middle and southern part of Veeranam drainage basin, contains low value of EC during post monsoon season.

D.Total Hardness (Th)

Hardness of water is the amount of dissolved Calcium and Magnesium in the water. Hardness produces scales in boiler When water is evaporated in boilers[6] (Camp, 1963). Total Hardness may also be divided in to carbonate (temporary) and non-carbonate (permanent) hardness. Total hardness (mg/l as $CaCO_3$) = Carbonate hardness + Non-carbonate hardness

The groundwater of very good quality is present over southern part of veeranam tank drainage basin with respect to TH during pre monsoon season. From the spatial distribution diagram, it is understood that the groundwater from considerable scattered part in north east side of Veeranam tank drainage basin have groundwater of poor quality with respect to TH during post monsoon season. The western side of Veeranam tank drainage basin, the TH of groundwater is found low during post monsoon season.

E .Calcium (Ca)

Calcium is dissolved in all types of solids and rocks, mainly from limestone, dolomite and gypsum. When groundwater moves through the rocks the solubilities of minerals are added in groundwater.

Groundwater of poor quality with respect to Calcium during pre monsoon season was found in some scattered areas at central north, west and south part of the Veeranam tank drainage basin. From the spatial distribution diagram, it is understood that the groundwater in small southern part of Veeranam tank drainage basin contain groundwater of poor quality with respect to Calcium during post monsoon season.

F. Magnesium (Mg)

In groundwater Calcium and Magnesium are heavily present. Calcium and Magnesium are very essential mineral to human wellbeing

From the spatial distribution diagram, it is understood that the some scattered areas of south and central part of Veeranam tank drainage basin, contains low magnesium value during both pre and post monsoon season.

Table 1 Chemical Analysis of groundwater samples for Pre-Monsoon season (All parameters are in mg/l except pH &EC (µS/cm))

Location	pH	E C	Mg	Ca	K	Na	SO_4	Cl^-	HCO_3	TDS	TH	NO_3
V1	7.7	1190	57	33	7	106	3	296	356	862	288	20
V2	7.5	3200	63	82	6	109	32	740	740	2240	432	54
V3	7.7	1090	55	24	10	109	2	212	332	698	252	21
V4	7.8	1360	54	50	26	109	3	272	380	842	260	25
V5	7.7	840	50	60	32	109	6	320	420	538	315	14
V6	7.9	1400	70	44	41	109	3	496	460	896	343	22
V7	8.2	1660	51	23	24	113	40	272	300	1062	208	28
V8	7.7	3300	120	77	10	113	150	796	788	1980	546	55
V9	7.8	3300	132	80	7	113	175	824	824	2112	590	51
V10	8	1080	58	36	2	108	58	200	388	691	288	18
V11	7.4	1270	62	18	2	113	40	224	340	812	240	20
V12	7.6	1020	48	37	13	92	15	420	316	653	252	18
V13	7.8	1650	53	44	16	113	60	280	356	1014	292	28
V14	7.5	2800	81	58	30	113	140	280	516	1792	409	47
V15	7.1	1950	53	40	40	113	58	244	348	1248	245	33
V16	7	1240	53	75	9	294	35	236	264	794	342	21
V17	7.5	700	30	20	2	95	15	92	168	448	153	12
V18	7.1	2700	80	139	3	406	15	800	740	1728	527	45
V19	7.2	2700	78	123	15	436	58	704	712	1512	545	41
V20	7.4	1090	48	32	5	106	15	224	292	698	248	18
V21	7.3	2900	51	190	6	585	10	800	704	1756	482	48
V22	6.3	870	41	33	4	98	8	164	284	647	211	15
V23	7.7	1182	56	30	9	108	3	257	342	756	208	20
V24	7.8	2400	66	68	28	109	18	620	604	1536	362	40

Table 2 Chemical Analysis of groundwater samples for Post Monsoon season (All parameters are in mg/l except pH & EC (µS/cm))

Location	pH	E C	Mg	Ca	K	Na	SO_4	Cl^-	HCO_3	TDS	TH	NO_3
V1	7.4	1103	52	39	6	128	15	345	356	706	245	15
V2	7.3	2981	70	98	11	142	27	836	740	1908	457	35
V3	7.5	1017	50	22	12	132	6	183	332	611	224	15
V4	7.3	1272	48	55	24	92	12	226	380	714	296	17
V5	7.4	781	56	66	30	97	14	265	420	500	345	13
V6	7.5	1256	62	40	37	101	9	322	460	654	285	12
V7	7.7	1445	50	21	26	126	32	245	300	925	241	19
V8	7.5	3622	134	91	18	118	124	572	788	2156	632	40
V9	7.4	2584	148	87	22	123	142	746	824	1654	682	30
V10	7.6	1020	56	39	5	102	49	160	388	653	253	15
V11	7.1	1306	55	17	3	133	32	198	340	836	225	18
V12	7.2	969	44	45	11	124	13	473	316	620	270	17
V13	7.4	1494	46	40	14	132	45	253	356	926	238	20
V14	7.3	2554	72	68	36	126	122	331	516	1635	372	30
V15	7	1769	46	45	36	121	86	231	348	1132	242	23
V16	7	1137	50	81	12	330	42	208	264	728	346	16
V17	7.3	762	27	21	5	86	11	146	168	488	154	13
V18	7	2469	74	149	2	436	12	920	740	1580	578	24
V19	7.1	2522	71	140	13	462	40	775	712	1614	535	29
V20	7.2	1036	45	30	4	125	28	264	292	663	221	15
V21	7.1	2752	44	198	9	642	42	964	704	1856	544	31
V22	6.9	831	37	35	5	91	12	154	284	532	211	15
V23	7.4	1058	50	36	9	128	11	262	352	678	258	18
V24	7.5	2085	72	82	24	128	24	464	554	1334	405	28

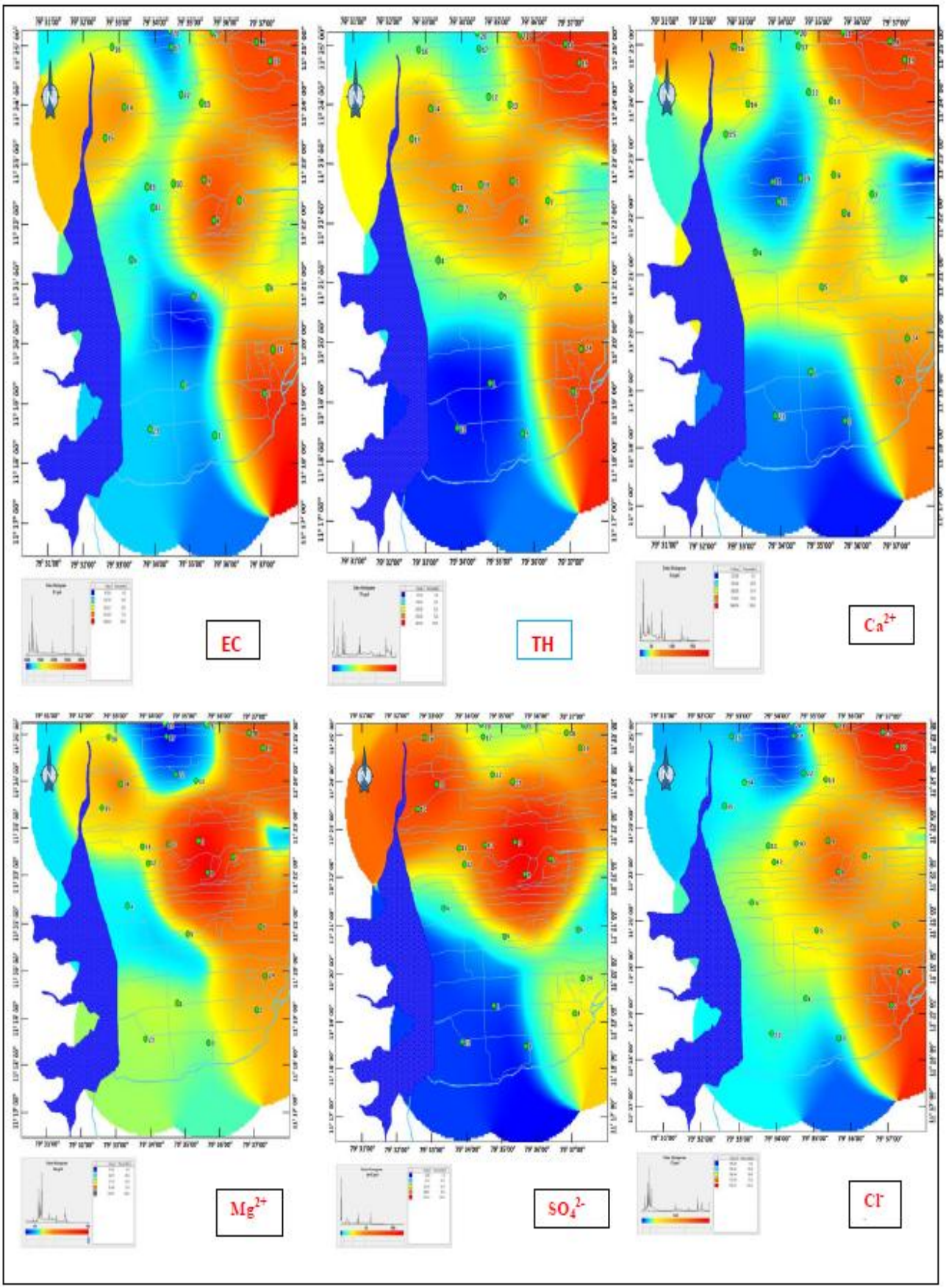

Figure 2 Spatial distribution of Electrical conductivity (EC,), Hardness (TH,). Calcium (Ca^{2+}) , Magnesium (Mg^{2+}), Sulphate (SO_4^{2-}) and Chloride (Cl^-) during pre- monsoon samples

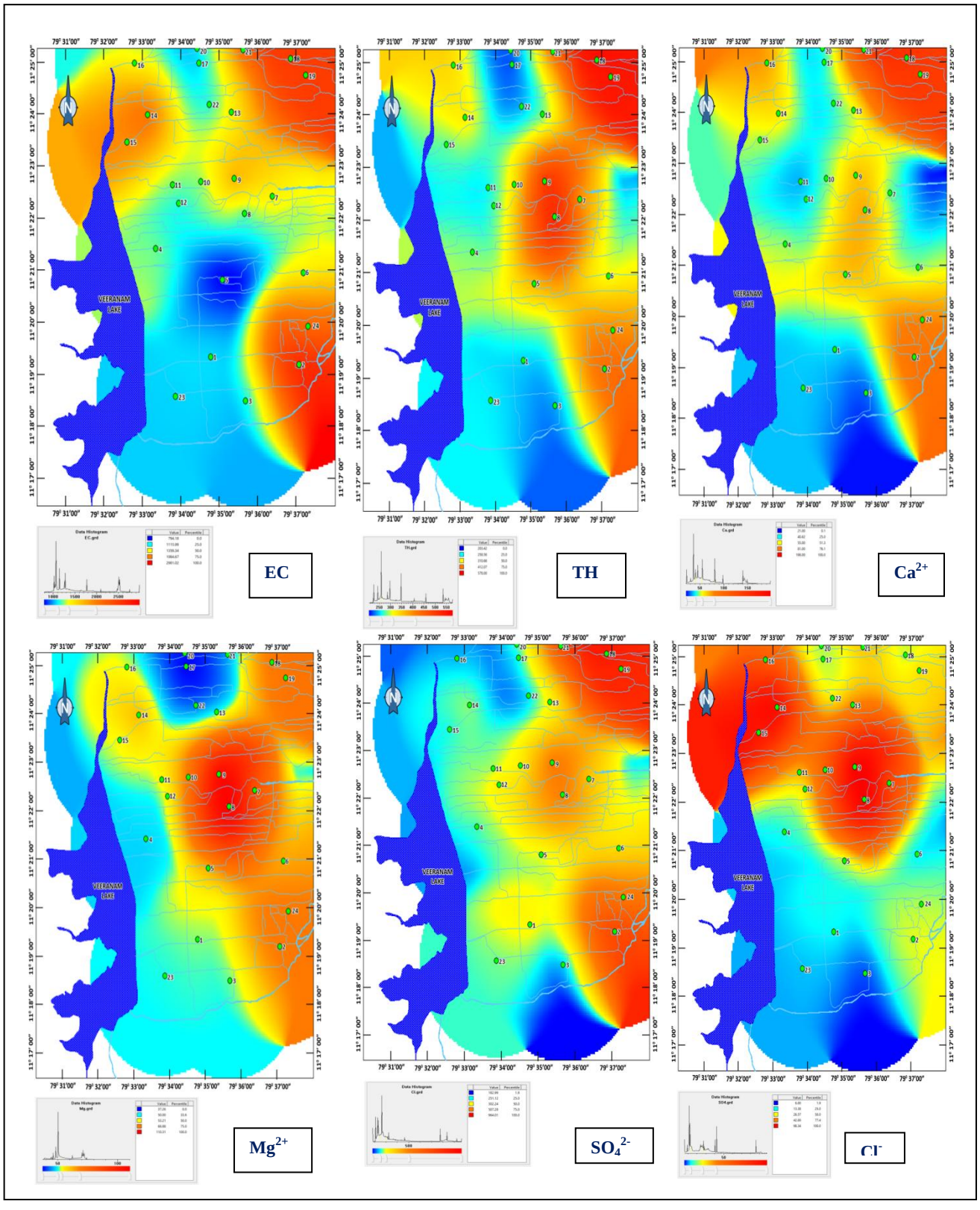

Figure 3 Spatial distribution of of Electrical conductivity (EC,), Hardness (TH,). Calcium (Ca^{2+}) , Magnesium (Mg^{2+}), Sulphate (SO_4^{2-}) and Chloride (Cl^-) during post monsoon samples

G. Sulphate (So_4^{2-})

Groundwater receives sulphate when it moves through sedimentary rocks that contain sulphate minerals like Gypsum, anhydride Sometime high value of sulphate is present in groundwater. It may be due to oxidative weathering of pyrite [7](Lowson et al., 1993).

$$CaSO_4.2H_2O \text{ (Gypsum)} \rightarrow Ca^{2+} + SO_4^{2-} + 2\,H_2O$$

$$2FeS_2 \text{ (Pyrite)} + 7O_2 + 2H_2O \rightarrow 2Fe^{2+} + 4SO_4^{2-} + 4H^+$$

From the spatial distribution diagram, we can find that the groundwater in south and central part of the study area are of very good quality with respect to SO_4 during both pre and post monsoon season.

High concentration of sulphates was found in northern parts of study area.

H. Chloride (Cl^-)

Chloride in groundwater may occur naturally and human caused sources such as road salts, agriculture runoff containing fertilizers, effluents from septic tank, seawater intrusion and industrial wastewater.

The spatial distribution of chloride indicates that the chloride concentration was less over entire area in both pre and post monsoon season. Only in post monsoon, some small portion of northern side had high amount of chloride.

IV. CONCLUSION

This study has demonstrated the utility of GIS combined with analytical data to assess and mapping of groundwater quality. The spatial distribution map of Electrical conductivity (EC,), Hardness (TH,). Calcium (Ca^{2+}) , Magnesium (Mg^{2+}), Sulphate (SO_4^{2-}) and Chloride (Cl^-) during pre-monsoon and post monsoon samples shows that, the spatial variation of these parameters in the study area.. These maps imply that the quality of groundwater is generally good and potable in the nearby Veeranam lake and the quality becomes moderate as it passes away from Veeranam tank of the study area.

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