Research Article

Quality Characterization of Ground Water Using Water Quality Index In Visakhapatnam City

L. Vaikunta Rao[1], P. Pavitra[1]*, CH. Ramakrishna[2], D. Mallikarjuna Rao[2] and Y. Satyanarayana[2]

[1]Department of Chemistry, Institute of Science, GITAM University, Visakhaptanam, Andhra Pradesh, India.
[2]Department of Environmental Studies, Institute of Science, GITAM University, Visakhaptanam, Andhra Pradesh, India.

ABSTRACT

Ground water quality parameters of North coastal district of Andhra Pradesh, Visakhapatnam were assessed in this study. Visakhapatnam is fast growing metropolitan city, increasing human population and industrial processes were accelerating urbanization. The analysis of the water quality is important to preserve and protect the natural ecosystem. In order to appreciate the impacts of ground water and to discuss its suitability for human consumption from the water quality index values. The ground water samples collected from boreholes and subjecting the samples to a comprehensive physico-chemical analysis. For calculating the WQI, The following parameters like p^H, EC, Total hardness, TDS, Calcium, Magnesium, Nitrate, Sulphate, Alkalinity, Iron have been considered. The results of analysis have been used to suggest model for predicting the water quality. The WQI for these samples ranged between “24 to 60”. The analysis revealed that the groundwater of some areas are excellent and some areas good. But it also needs to be protected from the perils of contamination by giving some degree of treatment.

Keywords: Groundwater, physicochemical parameters, water quality index.

INTRODUCTION

Water is an elixir to life which contains minerals, rocks and it is called as ubiquitous solvent[1]. Ground water is the major source of water for drinking, agricultural, Industrial desires. Expansion of human population is exceeding necessitate fresh water but only 1% of water available from river, ponds, lakes[2,3]. The quality of ground water depends upon geology of a particular region, climate change, and combination of dissolved salts depending on the source and from soil superficial interaction[5]. Ground water quality declined due to rapid increase in population,industrial development, increasing mining and petroleum consumption and use of fertilizer ,Pesticides in agriculture[4]. Infiltration of irrigation water, septic tanks and sewage treatment plants, pits, lagoons and ponds used for storage[5]. The change in groundwater quality depends on variation in physical, chemical and biological environment through which it passes. It is observed that the groundwater resources getting deteriorated due to anthropogenic activities.[6] admitting many uses the organic and inorganic compound from Textiles, dying, chemical and other industries effluents are toxic involves and cause environmental contamination that as serious worldwide problem. Organic compounds may cause skin cancer due to photosensitization and photodynamic damage[7]. The sustainable development, over exploitation, rapid industrialization and highest growth population leads to fast degradation of our environment[8,9]. Once ground water is contaminated its quality cannot be renovate by stopping the pollutants from the surface[8]. Determination of water quality is very important for knowing the suitability of water for various purposes. In this view total thirteen physicochemical parameters considered PH, temperature, EC, TDS, TH Ca, Mg, phosphates, Sulphates, Nitrates, Aluminum, Iron. The objective behind the study was to develop an overall picture of the groundwater quality using WQI, assessment of groundwater quality suitability of groundwater for different purposes and contamination causes.

Experimental Methods

Sampling area

The study area is located between 17.41.35.59 to 17.466.00.75N latitude and 83.17.45.9 to83.21.02.14E longitude. It is situated in the middle of Chennai-Kolkata Coromandal Coast. The sampling stations are Seethammadhara, Aarilova, Gurudwara, Rtc Complex, Maddilapalem, Law sons bay colony, Akkayyapalem, Railway New colony, Ushodaya, Ramnagar

Water samples without any air bubbles were collected in polythene bottles as per standard procedure. The data and time of collection were recorded and samples were analyzed for 14 parameters.

Physico-Chemical Parameters

The parameters studied are temperature, pH, conductivity, TDS, TH Ca, Mg, phosphates, Sulphates, Nitrates, Aluminum, Iron.

Physical Parameters Measurement

The p^H, Temperature, electrical conductivity and total dissolved solids of the water were measured on the spot . p^H ,electrical conductivity were determined by using ELICO L1615 Model P^H meter, ELICO CM180digital conductivity meter in the laboratory.

Chemical Parameters Analysis

The samples were analyzed chemically using UV-Spectrophotometer SHIMAD2U UV-1800 Model. Sulphates, Phosphates, Nitrates, Iron, were determined. Sodium and potassium were determined by using Flame photometer ELICO CM-378 Model. Using titrimetric method Alkalinity, Total hardness, calcium hardness, chlorides were determined for samples[10].

WATER QUALITY INDEX

Water quality index was calculated for average values of parameters for 10 samples. Water quality index is commonly used for the detection and evaluation of water pollution and may be defined as a rating, reflecting the composite influence of different quality parameters on the overall quality of water[8]. Water quality and its suitability for drinking purpose can be examined by determining its quality index. The standards of World health organization, BIS (2012) standards have been considered for calculating of WQI. Recommended and unit weight are given in table. The quality rating q_i for I^{th} water quality parameter i= (1, 2, 3…..n) was obtained from the relation.

$Q_i=100(v_i/s_i)$ – (1)

Where v_i = value of the i^{th} parameter at a given sample

S_i = standard permissible value of Ith parameter.

The equation ensures that q_i = 0 when a pollutant is absent in water while q_i = 100 if the value of this parameter is equal to its permissible value for drinking water

Quality rating for ph and DO requires special handling the permissible range of ph for drinking water is 7-8.5 quality rating for p^H may be

$q_P{}^H= 100[V_{pH} -7.0/8.5-7.0]$ — (2)

In case of DO is slightly complicated because the quality water is in enhanced if it contains more DO

$q_{DO}= 100[(14.6- v_{DO})/14.6-5)]$---(3)

So the weights for various water quality parameters are assume med to be inversely proportional to the standard for the corresponding parameters

$w_i = k/s_i$ --- (4)

w_i = unit weight for i^{th} parameter i=(1,2,3….n)

k= constant proportionality which is determined from the condition and k = 1

$^{12}\Sigma_{j=1}\ w_i =1$----- (5)

To calculate the WQI, first the sub index (SI) corresponding the Ith parameter calculated. These are given by the product of the quality rating Qi and unite weight of the i^{th} parameter

$Si= q_iw_i$ ---- (6)

This overall water quality index was calculated by aggregating the sub index (SI) this could be written as

$WQI = [^{12}\Sigma_{j=1}q_iw_i/ 12\Sigma j_{=1}]$ ----- (7)

$WQI=^{12}\Sigma_{j=1}q_iw_i$------ (8)

RESULT AND DISSECTION

p^H

p^H is one of the most important parameter of the water quality. The p^H values in the ground water at all the areas of Visakhapatnam are mostly confined within the range 7.32 at Gurudwara to 8.1 at Railway new colony. The pH values for most of the samples are well within the limits prescribed by BIS (2012) for various uses of water including drinking and other domestic supplies.

EC

Conductivity is mesure to capacity of water to carry electrical current due to presence of dissolved dissociated substance in water. Electrical conductivity in water is affected by different factors like geology and soils, land use, flow, runoff, groundwater inflows, temperature, evaporation and dilution. The conductivity values in the present ground water samples varied widely from 1000µs/cm at Gurudwara to 1900µs/cm at RTC complex. Conductivity range not suggetioned by BIS (2012)

TDS
The TDS values were found in between 460-710mg/l this might be due to the natural and percolation of minerals, landfill leachates, Feedlots, salts in to the ground water table. The desirable limit for TDS in drinking water is 500 mg/l and permissible limit is 2000 mg/l. The observed values for TDS at 50% locations were found below the desirable limit.

Calcium
Calcium is one of the most important parameter to assessing the water quality. In the present study area calcium value ranged between 67mg/l at Gurudwara to 165mg/l at Railway new colony. A limit of 75mg/l Calcium has been recommended as desirable limit and 200 mg/l as the permissible limit prescribed by BIS (2012)

Magnesium
In the present study area magnesium value ranged between 36 mg/l at Aarilova to 75mg/l at Ushodaya. A limit of 30mg/l Magnisium has been recommended as desirable limit and 100 mg/l as the permissible limit prescribed by BIS (2012)

Chloride
Chlorides are widely distributed in nature as salts of sodium (NaCl), potassium (KCl), and calcium Chloride ($CaCl_2$) in water may be considerably increased by treatment a process in which chlorine or chloride is used .The concentration of chloride varies from 79mg/l to 183 mg/L. Most of the samples are within the desirable limit of 250 mg/L. A limit of 250 mg/L chloride has been recommended as desirable limit and 1000 mg/L as the permissible limit for drinking water (BIS, 2012). The maximum chloride concentration value of 183 mg/l observed at Ushodaya and minimum chloride concentration value of 79mg/l observed at Seethammadhara

Total alkalinity
Alkalinity in water due to presence of some basic dissolved salts like Carbonate, bicarbonate, Borates, phosphates, silicates. In the present study area TA value ringed from126mg/l observed at Gurudwara to 226mg/l at Maddilapalem. The desirable limit for TA in drinking water is 200 mg/l and permissible limit is 600 mg/l prescribed by BIS (2012).

Total hardness
Total hardness is ability of the water to cause precipitation of insoluble Calcium and magnisium salts of higher fatty acids from soap. It is due to metallic ions dissolved in the water. Known as concentration of calcium carbonate its derived from dissolved limestone, Groundwater can be divided into soft water (TH<150mg/L), moderately hard water (150<TH<300mg/L), hard water (TH>300 mg/l) extremely hard water (TH>450mg/l) water. in the present study area TH value ringed from 220mg/l to 520mg/l .More than 95% of the samples are above the desirable limit of 200 mg/l. A limit of 200 mg/l Total hardness has been recommended as desirable limit and 600 mg/l as the permissible limit prescribed by BIS (2012). The maximum Total hardness concentration value of 520mg/l observed at Seethammadhara and minimum Total hardness concentration value of 220mg/l observed at Maddilapalem and Ramnagar.

Sulfate
Sulfate concentration result from saltwater intrusion, mineral dissolution and domestic or industrial waste the concentration of sulfate in the cities varied from 99 to 186mg/L. Bureau of Indian standard has prescribed 200 mg/L as the desirable limit and 600 mg/L as the permissible limit for sulfate in drinking water. The maximum Sulfate concentration value of 186mg/l observed at Akkayapalem and minimum Sulfate concentration value of 99 mg/l observed at Aarilova.

Nitrate
Nitrate occurs in mineral deposits, soils, seawater, Fresh water, atmosphere of high levels of nitrate in ground water is a prominent problem in many parts of the country. The nitrate content in the present study area varied from 1.7 mg/l at Lawsons bay colony to 2.9 mg/l at Aarilova. Permissible limit of nitrate concentration 45 mg/L has been prescribed by WHO and BIS 2012 for drinking water supplies. Its concentration above 45 mg/, nitrate may produce a disease known as methaemoglobinaemia (blue babies) which generally affects bottle-fed infants. Repeated heavy doses of nitrates on ingestion may also cause carcinogenic diseases.

Phosphates
The range of phosphate varied from 0.2mg/l observed at Aarilova to 1.4mg/l at Railway new colony, which is very low because Phosphorous is an essential plant nutrient and is extensively used as fertilizers. Phosphate gets adsorbed or fixed as aluminum or iron phosphate in acidic soils or as calcium phosphate in alkaline or neutral soils.

Iron

Iron is a common constituent in soil and ground water. It is present in water either as soluble ferrous iron or the insoluble ferric iron as a mineral from sediment and rocks or from mining, industrial waste, and corroding metal. In high concentration it causes scaling in plumbing fixtures.

Correlation among parameters was determined. The value of correlation coefficient greaterthan or equal to -0.5 or +0.5 . A strong +ve correlation was found between Aluminum and p^H, phosphate and calcium, chloride and iron. Some parameters show +ve correlation with magnesium, sulfate, electrical conductivity, phosphate, iron, chloride.

CONCLUSION

The analysis of the water quality parameters of groundwater from the 10 different wells in Visakhapatnam shows that pH, TDS, sodium, potassium, calcium, magnesium, chloride, bicarbonate, nitrate, sulphate are within permissible limits but above desirable limits. The WQI has been calculated for the groundwater samples of Visakhapatnam which is ranged from 24 to 60. ground water quality at almost all the locations fit for drinking purposes.

ACKNOWLEDGMENT

Our thanks are due to the University Grants Commission, New Delhi, India for providing the funding for carry out the research work.

Table 1: Latitudes and longitudes of the study area

S.No	Sampling Station	Latitude	Longitude
1	Seethammadhara	17.44.33.81	83.18.21.19
2	Aarilova	17.46.00.75	83.18.30.47
3	Gurudwara	17.44.11.84	83.18.30.43
4	Rtc Complex	17.43.28.85	83.18.17.68
5	Maddilapalem	17.44.14.88	83.19.17.35
6	Law sons bay colony	17.43.58.2	83.20.12.68
7	Akkayyapalem	17.43.58.59	83.17.58.10
8	Railway New colony	17.43.24.05	83.17.45.9
9	Ushodaya	17.44.12.44	83.20.08.33
10	Ramnagar	17.41.35.59	83.21.02.14

Table 2: Water quality classification based on WQI value

WQI Value	Water Quality
<25	Excellent
25-50	Good water
50-100	Poor water
100-200	Very poor water

Table 3: Physico-chemical analysis of water quality parameters in the Visakhapatnam area

S.No	Sample code	Tem p(^{0}C)	p^H	EC (µs/cm)	TDS (mg/l)	TH (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Cl^- (mg/l)	TA (mg/l)	SO_4^{2-} (mg/l)	NO_3^- (mg/l)	PO_4^{3-} (mg/l)	Fe^{2+} (mg/l)	Al^{3+} (mg/l)
Seetammadhara	S1	28	7.6	1.8	570	520	83	67	79	167	138	2.6	0.8	0.001	0.003
Aarilova	S2	27	7.8	1.7	710	290	72	36	89	168	99	2.9	0.2	0.003	0.12
Gurudwara	S3	27.5	7.3	1	460	310	67	47	140	126	146	2.6	0.16	0.003	0.18
Rtc Complex	S4	27.9	7.8	1.9	525	320	85	73	133	143	185	1.9	0.15	0.004	0.16
Maddilapalem	S5	27.6	7.8	1.4	638	220	125	36	98	226	103	1.8	0.26	0.003	0.19
Law sons bay colony	S6	28.2	7.7	1.6	465	295	87	58	126	201	110	1.7	1	0.002	0.2
Akkayyapalem	S7	28.6	7.8	1.5	475	240	139	60	138	193	186	1.9	1.2	0.004	0.18
Railway New colony	S8	28.9	8.1	1.8	486	326	165	73	170	197	168	2.6	1.4	0.005	0.19
Ushodaya	S9	26.9	7.7	1.7	575	385	111	75	183	186	146	2.7	0.8	0.003	0.23
Ramnagar	S10	27.8	7.6	1.8	576	220	106	58	143	202	164	2.1	0.4	0.002	0.25

Table 4: Summary of physical and chemical parameters

Parameter	Min	Max	Mean	S.D	C.V
Temp	26.9	28.9	27.9	0.6346	0.0227
p^H	7.32	8.1	7.71	0.207	0.026
EC	1	1.9	1.45	0.265	0.164
TDS	460	710	585	82.1	0.149
Total Hardness	220	520	370	89.28	0.285
Ca^{2+}	67	465	116	31.489	0.302
Mg^{2+}	36	75	55.5	14.57	0.25
chloride	79	183	131	33.45	0.257
Alkalinity	126	226	176	30.04	0.166
Sulfates	99	186	142.5	32.18	0.222
Nitrates	1.7	2.9	2.3	0.441	0.193
iron	0.001	0.005	0.003	0.001	0.384
Phosphates	0.15	2.2	1.175	0.609	1.02
aluminum	0.003	0.23	0.265	0.068	0.40

TDS – Total dissolved solids in mg/l, TH – Total Hardness in mg/l, Ca – Calcium Hardnessin mg/l, Mg – Magnesium Hardness in mg/l, Fe – Iron in mg/l, F – Fluoride in mg/l, NO3 –Nitrate in mg/l, Cl – Chloride in mg/l, SO4 – Sulphate in mg/l, K–Potassium in mg/l, S.D – Standard deviation, C.V – Coefficientof variation %, Min. – Minimum, Max-maximum

Table 5: Correlation coefficient for physico chemical parameters

Paramater	Temp (^{0}C)	pH	EC (µs/cm)	TDS (mg/l)	TH (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Cl^- (mg/l)	TA (mg/l)	SO_4^{2-} (mg/l)	NO_3^- (mg/l)	PO_4^{3-} (mg/l)	Fe^{2+} (mg/l)	Al^{3+} (mg/l)
Temp(^{0}C)	1													
p^H	0.404	1												
EC(µs/cm)	0.988	0.645	1											
TDS(mg/l)	-0.646	0.121	0.263	1										
TH(mg/l)	-0.0749	-0.17	0.282	-0.032	1									
Ca^{2+}(mg/l)	0.6027	0.722	0.195	-0.204	-0.265	1								
Mg^{2+}(mg/l)	0.3757	0.352	0.56	-0.496	0.4975	0.31	1							
Cl^-(mg/l)	0.143	0.266	0.026	-0.507	-0.15	0.471	0.5923	1						
Alkalinity	0.244	0.482	0.212	0.2047	-0.393	0.651	-0.113	0.0372	1					
SO_4^{2-} (mg/l)	0.494	0.245	0.238	-0.561	0.0012	0.375	0.6886	0.5577	-0.2534	1				
NO_3^- (mg/l)	-0.409	-0.12	0.023	0.3284	0.5136	-0.18	0.0304	0.0577	-0.4188	-0.128	1			
PO_4^{3-} (mg/l)	0.694	0.47	0.243	-0.492	0.195	0.687	0.5365	0.3905	0.42425	0.2858	-0.04	1		
Fe^{2+} (mg/l)	0.348	0.642	-0	-0.245	-0.369	0.596	0.1914	0.5292	-0.0224	0.4693	-0.001	0.238	1	
Al^{3+} (mg/l)	-0.034	0.168	-0.16	-0.221	-0.7164	0.359	0.0262	0.7248	0.36309	0.1816	-0.333	0.034	0.3701	1

Table 6: Water quality index (WQI)

parameters	WHO standards	Unit weight (Wi)	S1 qiwi	S2 qiwi	S3 qiwi	S4 qiwi	S5 qiwi	S6 qiwi	S7 qiwi	S8 qiwi	S9 qiwi	S10 qiwi
P^H	6.5-8.5	0.133	5.32	7.0	6.3	7.89	7	6.20	0	9.75	7	6.02
TDS	500	0.002	0.22	0.28	0.1	0.21	0.25	0.18	0.38	0.19	0.23	0.230
Total hardness	200	0.003	0.57	0.31	0.34	0.35	0.22	0.29	0.26	0.35	0.16	0.22
Calcium	75	0.013	1.43	1.24	1.16	1.53	0.02	1.50	2.40	2.86	2.06	1.83
Magnesium	30	0.02	2.68	1.44	1.88	2.92	1.44	2.32	2.4	2.92	3	2.32
Chloride	250	0.004	0.12	0.14	0.28	0.21	0.52	0.20	0.22	0.27	0.29	0.22
Alkalinity	200	0.005	0.41	0.36	0.29	0.35	0.36	0.32	0.30	0.39	0.46	0.50
Sulphates	200	0.005	0.34	0.34	0.20	0.46	0.25	0.27	0.46	0.42	0.36	0.41
Nitrate	45	0.022	0.12	0.12	0.12	0.09	0.08	0.08	0.09	0.01	0.13	0.102
Iron	0.3	3.3	3.3	1.09	3.3	4.4	0.02	3.3	2.2	4.4	5.5	3.3
ΣWi		3.907										
ΣQiWi		0.189	9.292	10.282	6.036	11.491	11.395	6.144	4.648	9.665	11.366	9.87
ΣQiWi/ΣWi			**49.16**	**54**	**31.9**	**60.85**	**60**	**32.5**	**24.5**	**50**	**59**	**52**

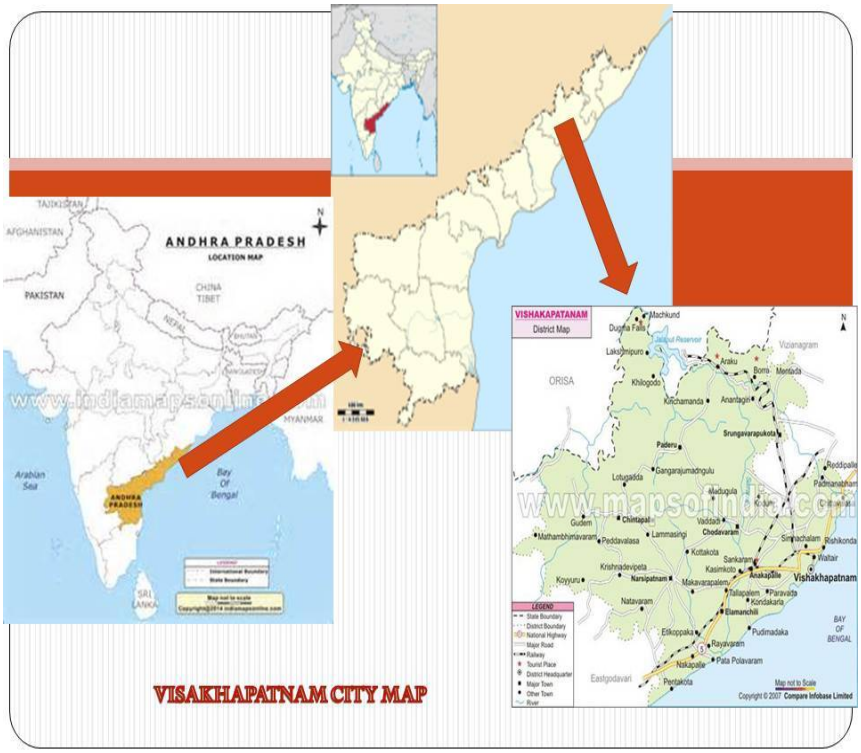

Fig. 1: Visakhapatnam study area map

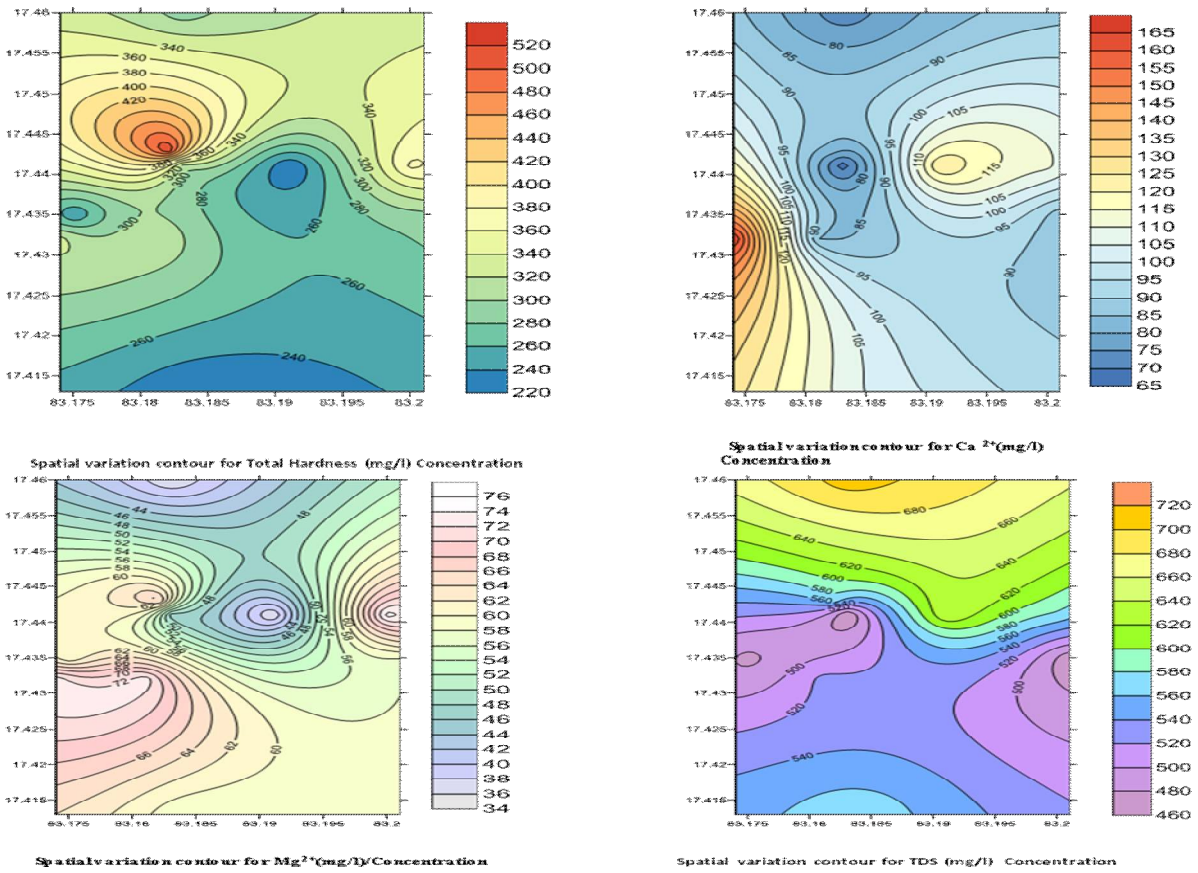

Fig. 2: Spatial Variation Contour Maps for Different Physico- Chemical Parameters

REFERENCES

1. Bhuvana Jagadeswari P and Ramesh K. Water Quality Index for Assessment of Water Quality In South Chennai Coastal Aquifer, TamilNadu, India. International Journal of Chem Tech Research. ISSN: 0974-4290. 4(4):1582-158.
2. Bhattacharya T, Chakraborty S and Tuck Neha. Physico chemical Characterization of ground water of Anand district, Gujarat, India. International Research Journal of Environment Sciences. 2012;1(1):28-33.
3. Ishaku JM, Nur A and Matazu HI. Interpretation of groundwater. International journal of earth sciences and Engineering. ISSN 0974-5904. 2012;5(3):373-382.
4. Talabi Abel O. Geostatistical Assessment of Groundwater Quality from coastal aquifers of Igbokoda, Southwestern Nigeria IOSR Journal of Environmental Science, Toxicology And Food Technology ISSN: 2319-2402, ISBN: 2319-2399. 2012;2(2):18-24.
5. Amaliya NK and Sugirtha P Kumar. Emphasizing the Quality of Some Selected Ground Water Samples of Kanyakumari District, India Using Quality Index Assessment International Research Journal of Environment Science ISSN 2319–1414. 2(9):76-82,
6. Amadi AN, Olasehinde PI, Yisa J, Okosun EA, Nwankwoala HO and Alkali YB. Geostatistical Assessment of Groundwater Quality from Coastal Aquifers of Eastern Niger Delta, Nigeria Geosciences. 2012;2(3):51-59
7. Rajankar PN, Wate SR, Tambekar DH and Gulhane SR. Assessment of ground water quality using Water Quality Index. Journal of Environmental Science and Sustainability. 1(2):49-54. ISSN: 2321-5577.

8. Srinivas Kushtagi and Padaki srinivas. Studies on water quality index of ground water. International journal of applied biology and pharmaceutical technology. ISSN: 0976-4550. 2: 252.
9. Ishaku JM. Assesment of ground water quality index ,Journal of Geology and Mining research. 2011;3(9):219-231. ISSN 2006-9766@2011 Acadamic Journals.
10. APHA, Standard methods for analysis of water and wastewater.18th Edition. American Public Health Association, Inc., Washington DC. 1992.