Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

Advances in Applied Science Research, 2013, 4(1):244-253

Pelagia Research Library

ISSN: 0976-8610
CODEN (USA): AASRFC

An integrated approach to assess the quality of groundwater in part of Cheralapally area, Rangareddy District, Andhra Pradesh, India

Narsimha. A*, Sudarshan. V*, Srinivasulu. P, Anitha. N* and Parameshwar. V***

**Department of Applied Geochemistry Osmania University, Hyderabad - 500 007*
***Department of Geology, Osmania University, Hyderabad - 500 007*

ABSTRACT

In the current study, 12 groundwater samples were collected from parts of Cheralapally area to assess water quality and investigate by analyzing the major cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and anions (HCO_3^-, Cl^-, SO_4^{2-} and CO_3^{2-}) besides some physical and chemical parameters (pH, electrical conductivity and total hardness). Also, geographic information system-based groundwater quality mapping in the form of visually communicating contour maps was developed using ArcGIS-9.2 to delineate spatial variation in physicochemical characteristics of groundwater samples. All the parameters analysed are in adherence to desirable limits of Indian Standards for drinking water except few locations. From the obtained data, it can be concluded that the water quality profile was good and useful for drinking purpose.

Key words: Groundwater quality, GIS, Cheralapally area

INTRODUCTION

The [23] has clearly stated that the quality of drinking water is a powerful environmental determinant of health. Drinking-water quality management has been a key pillar in the prevention and control of waterborne diseases. Water is essential for life, but it can and does transmit disease in all countries of the world from the poorest to the wealthiest. Safe drinking water therefore is a basic need and hence, an internationally accepted human right [22], and reducing the number of people without access to sustainable safe drinking water supply has been enlisted as one of the ten targets of the millennium development goals (MDGs). Even though urban aquifers are the only natural resource for drinking water supply, they are often perceived as of lesser relevance for the drinking water supply, leading toward crisis in terms of drinking water scarcity, becoming increasingly polluted thereby decreasing their potability [8]. Once contamination of groundwater in aquifers occurs by means of agricultural and industrial activities and urban development, Environ Monit Assess, it persists for hundreds of years because of very slow movement of water in them [13] and prompts investigations on their quality [2]. Since physicochemical composition of groundwater is a measure of its suitability as a source of water for drinking, agriculture (irrigation), and industrial purposes [5], an attempt has been made in the current study to assess the effects of natural and anthropogenic activities and increased human population on groundwater quality and their variation by defining the principal hydrochemical nature of the groundwater.

GIS is a vector based software package capable of handling spatial and non-spatial data. GIS found to be a suitable tool for making spatial distribution maps of various hydro-chemical parameters of constituents. The spatial variation in groundwater chemical quality in the industrial and agricultural areas is mapped using GIS in various regions [3; 4; 18 and 11].

MATERIALS AND METHODS

The sampling bottles soaked in 1:1 HCl for 24 h were rinsed with distilled water followed by deionized water. At the time of sampling, the bottles were thoroughly rinsed two or three times, using the groundwater to be sampled. The chemical parameters viz. pH and electrical conductivity (EC) were measured, using digital instruments immediately after sampling. 12 groundwater samples were collected in 1000-ml polyethylene bottles from hand pump/bore holes in the study area. The bottles were labeled, tightly packed, transported immediately to the laboratory, and stored at 4°C for chemical analyses.

The samples were analyzed for total hardness (TH) as $CaCO_3$, calcium (Ca^{2+}), sodium (Na^+), potassium (K^+), bicarbonate (HCO_3^-), chloride (Cl^-) and sulfate (SO_4^{2-}) following the standard water quality methods [1]. The evaluation of chemical characteristics of groundwater and suitability for drinking, irrigation and industrial purposes have been carried out. Total dissolved solids (TDS) were computed as per [12 and 14] from EC values multiplied by 0.64 and magnesium (Mg^{2+}) was calculated, using the values of TH and Ca^{2+} [1].

The flamephotometer (Systronics, 130 India), concentrations of sodium (Na^+) and potassium (K^+) in the groundwater were measured. Electrical conductivity (EC) and pH were measured by conductivity meter (Systronics, 304) and digital pH meter (Systronics, 802) respectively.

Geo-database creation-GIS model:
In generating the spatial distribution maps the obtained values of various hydrochemical parameters created as attribute database. These attributes data then transformed into a point layer for GIS analysis. Each sample point was assigned by a unique code and stored in the point attribute table. The database file contains the values of all chemical parameters in separate columns along with a sample code for each sampling station. The water quality data (attribute data) were linked to the sampling stations (spatial data) and maps showing the spatial distribution were prepared to model the variation in concentrations of the parameters using Inverse Distance Weighted (IDW) raster interpolation technique of Spatial Analyst TM module in ArcGIS® software. IDW is an algorithm for spatially interpolating or estimating values between measurements. Each value estimated in an IDW interpolation is a weighted average of the surrounding sample points. Weights are computed by taking the inverse of the distance from an observation's location to the location of the point being estimated [7]. In a comparison of several different deterministic interpolation procedures, [7 and 15] found that using IDW with a squared distance term yielded results most consistent with original input data. In the present study, the geospatial attribute data was utilized for the generation of spatial distribution maps of selected water quality parameters namely pH, EC, TDS, TH, Ca^{2+}, Mg^{2+},Na^+, K^+,HCO_3^-,CO_3^{2-}, Cl^- and SO_4^{2-} (Figs. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12).

RESULTS AND DISCUSSION

The analytical results of chemical analysis of groundwater samples collected from different sampling sites of Cheralapally area, Rangareddy districts is presented in Table 1. Table 2 presents the Variables, symbols and units. The statistical parameters of analyzed components in groundwater along with the prescribed limits of Indian Standards [6] for drinking water are furnished in Table 3. Groundwater quality with respect of fresh and brackish types presented in Table 4.

During the present investigation, pH value ranged between 6.73 and 7.93. Even though pH has no direct effect on human health, its higher range accelerates the scale formations in water heating apparatus and concentration of pH is shown in Fig 1. EC is measured in microsiemens per centimeter and is a measure of salt content of water in the form of ions [14]. In the present study, EC values ranged from 200 to 1800 µS/cm and North part of the study area is recorded more concentration is shown in Fig 2.

Table 1: Result of chemical analysis and statistical parameters of groundwater samples collected from the study area

S. No	pH	EC	TDS	Ca^{2+}	Mg^{+2}	Na^{+}	K^{+}	SO_4^{-2}	HCO_3^{-}	CO_3^{-2}	TH	Cl^{-}
CW1	6.8	1800	1152	353	26.75	294	203	493	116	15	590	833
CW2	6.73	900	576	116	69.56	119	82	161	128	15	315	337
CW3	6.84	1300	832	134	6.08	175	121	186	146	15	360	496
CW4	6.82	1000	640	188	9.73	106	73	261	116	18	510	301
CW5	6.95	900	576	162	20.67	124	86	225	85	9	490	351
CW6	7.02	900	576	178	4.86	114	79	247	73	15	465	322
CW7	6.88	800	512	150	6.08	139	96	208	122	9	400	394
CW8	7.24	500	320	124	8.51	71	49	172	85	15	345	202
CW9	6.98	900	576	160	6.08	60	41	222	134	18	425	170
CW10	7.09	900	576	162	4.86	127	88	225	140	18	425	361
CW11	7.93	200	128	62	4.86	31	21	86	61	24	175	89
CW12	7.25	1000	640	136	3.64	136	94	189	159	15	355	386
Min	**6.73**	**200**	**128**	**62**	**3.64**	**31**	**21**	**86**	**61**	**9**	**175**	**89**
Max	**7.93**	**1800**	**1152**	**353**	**69.56**	**294**	**203**	**493**	**159**	**24**	**590**	**833**

Table 2: Variables, symbols and units

Variable	Symbol	Units
pH	pH	pH units
Conductivity	EC	µS/cm
Total dissolved solids	TDS	mg/L
Sulphate	SO_4^{2-}	mg/L SO_4^{2-}
Carbonate	CO_3^{2-}	mg/L CO_3^{2}
Bicarbonate	HCO_3^{-}	mg/L HCO_3^{-}
Calcium	Ca^{2+}	mg/L Ca^{2+}
Magnesium	Mg^{2+}	mg/L Mg^{2+}
Total Hardness	TH	mg/L CaCO3
Potassium	K^{+}	mg/L K^{+}
Sodium	Na^{+}	mg/L Na^{+}
Chloride	Cl^{-}	mg/L Cl^{-}

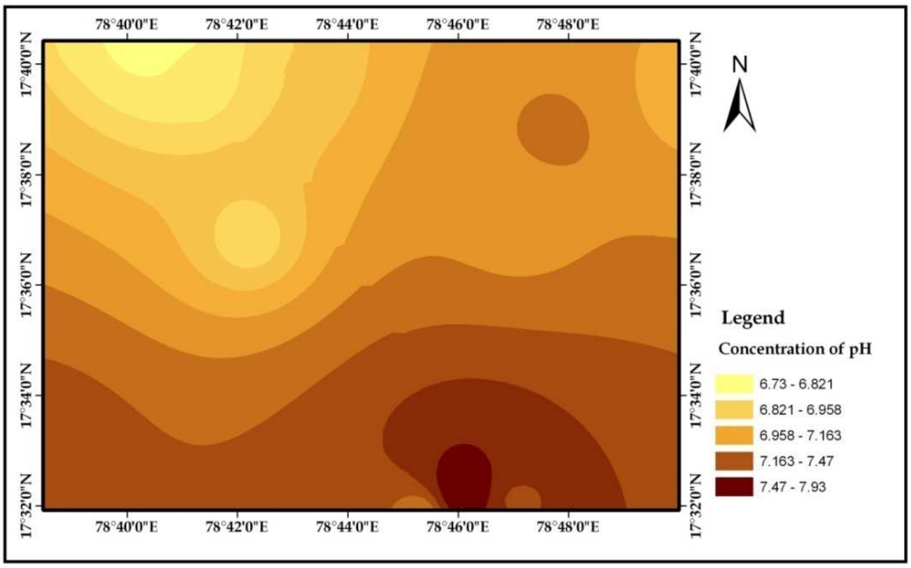

Fig No 1. Concentration of pH

The TDS varies from 128 to 1,152 mg/L, which indicates a variation of degree of water quality due to an entering of foreign matter into the groundwater system. The majority of groundwater samples (92%; Table 4) come under fresh water type, as the value of TDS in them is less than 1,000 mg/L [9] and concentration of TDS is shown in Fig 3.

Table 3: Groundwater samples of the study area exceeding the desirable and permissible limits prescribed by BIS for drinking purposes

Parameters	BIS 2003		No. of samples exceeding desirable limit	No. of samples exceeding permissible limit
	Desirable limit	Permissible limit		
pH	6.5-8.5	8.5-9.2	-	-
EC (µS/cm)	-	-	-	-
TDS (mg/L)	500	2,000	10	-
Ca^{2+} (mg/L)	75	200	11	1
Mg^{2+} (mg/L)	30	100	1	-
SO_4^{-2} (mg/L)	200	400	7	1
Cl^- (mg/L)	250	1,000	9	-
$*Na^+$ (mg/L)	50	200	12	1
TH (mg/L)	300	600	11	-

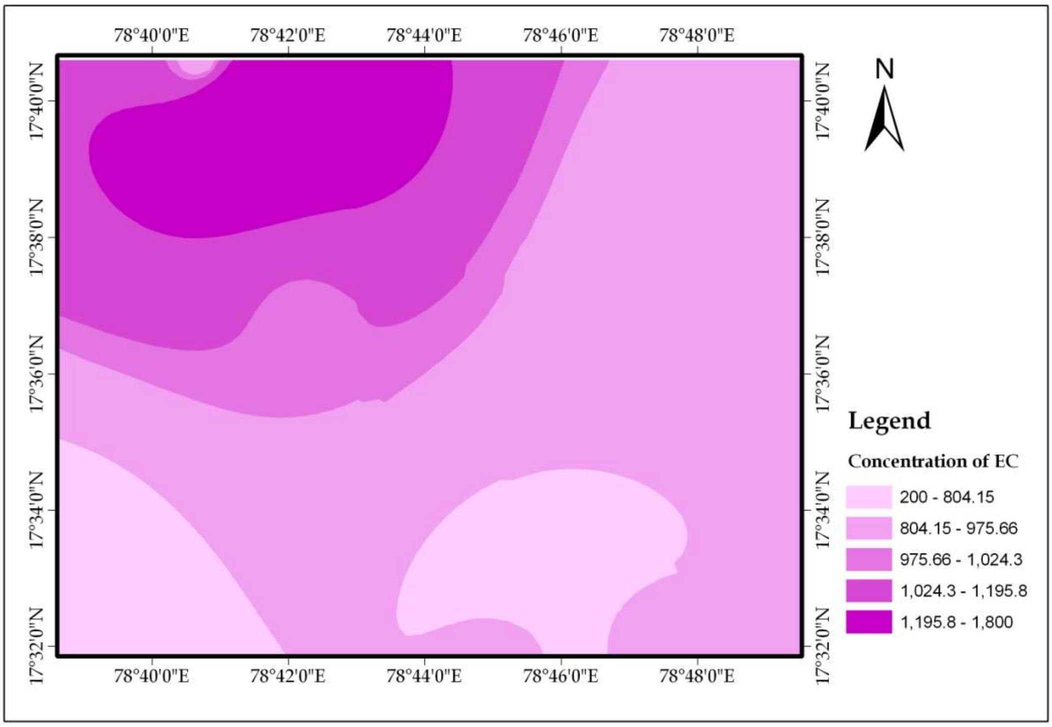

Fig No 2. Concentration of EC

Table 4: Groundwater quality with respect to fresh and brackish types

TDS (mg/L)	Sample numbers	Percentage of samples	Water type
<1,000	2–12	92	Fresh
>1,000	1	8	Brackish

In the present study, total hardness values ranged from 175 to 590 mg/L; thus, all the samples are below the maximum permissible limit of 600 mg/L for drinking water. The high amount of total hardness, calcium, and magnesium contents makes the groundwater of very low quality generally hard, although these are also attributed to geological formations encountered in the flow history.

According to the TH classification [17], about 8% of the total groundwater samples fall in the category of hard (150–300 mg/L) and the rest of the water samples (92%) in the category of very hard (>300 mg/L; Table 3; Fig 4).

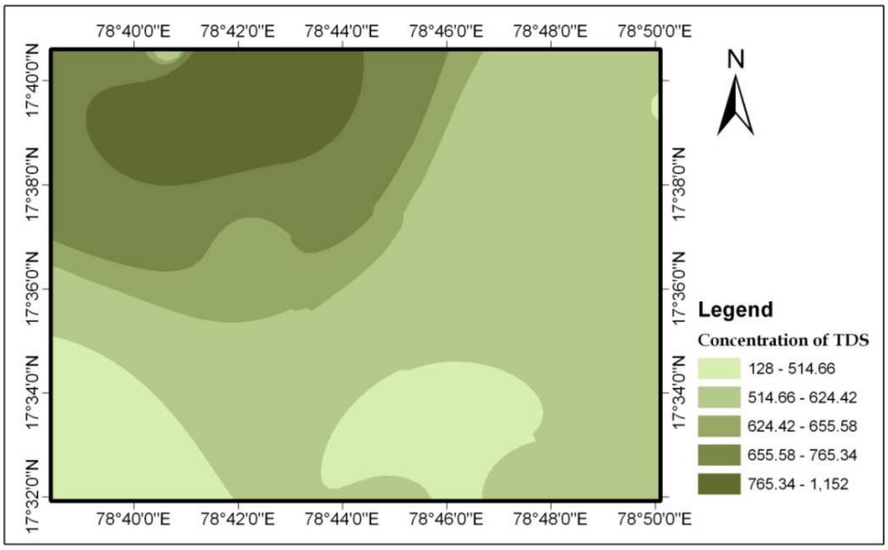

Fig No 3. Concentration of TDS

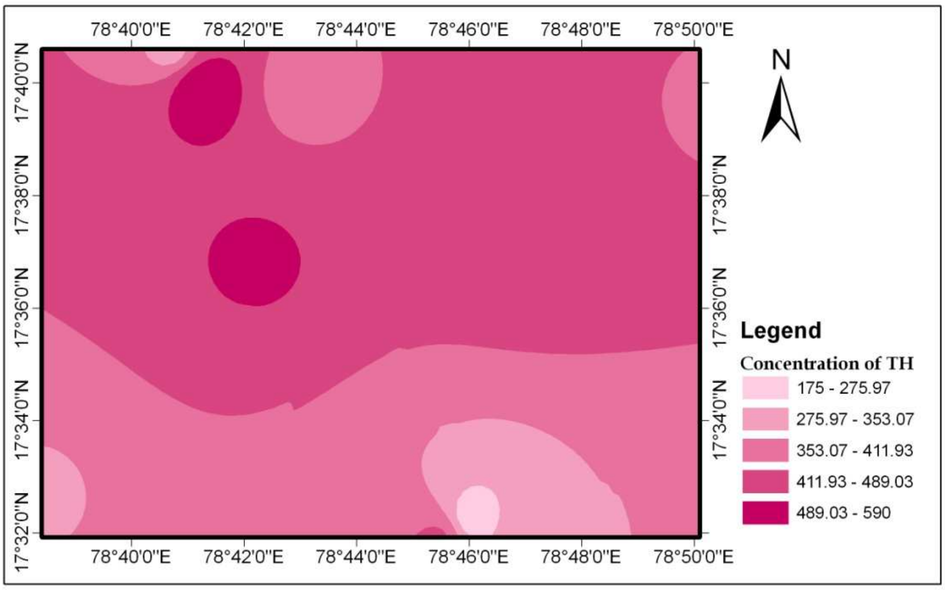

Fig No 4. Concentration of TH

The Ca^{2+} is an important element to develop proper bone growth. The concentration of Ca^{2+} observed from the study area is varied from 62 to 353 mg/L (Table 1), which is below the standard limit of 200 mg/L (Table 3) in all the groundwater samples, except one groundwater location and concentration of Ca^{2+} map is shown in Fig 5. Mg^{2+} is an essential ion for functioning of cells in enzyme activation, but at higher concentration, it is considered as laxative agent [10]. In the present study, Mg^{2+} values ranged from 3.64 to 69.56 mg/L (Table 1; Fig 6).

The concentration of Na^{+} is varied from 31 to 294 mg/L (Table 1) and the recommended limit of 200 mg/L (Table 3). This is because of the silicate weathering and/or dissolution of soil salts stored by the influences of evaporation and anthropogenic activities [19; 16 and 21], in addition to the agricultural activities and poor drainage conditions and concentration of Ca^{2+} map is shown in Fig 7.

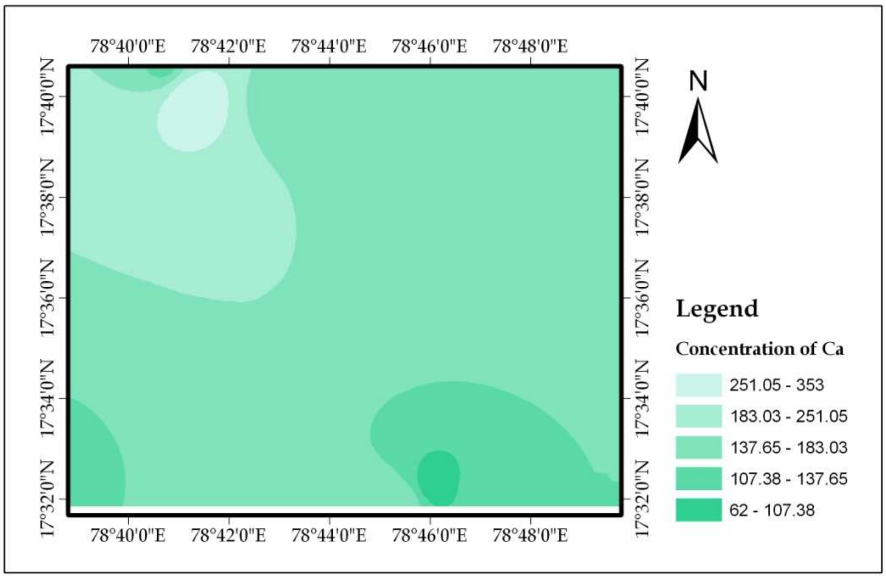

Fig No 5. Concentration of Ca^{2+}

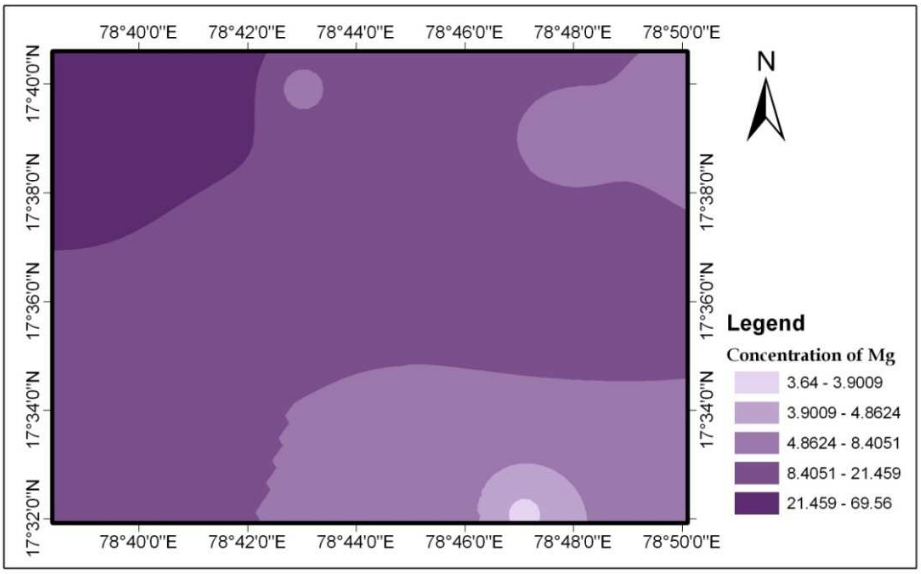

Fig No 6. Concentration of Mg^{2+}

Generally, the concentration of K^+ is less than 10 mg/L in the drinking water. It maintains fluids in balance stage in the body. The K^+ exceeds 10 mg/L in approximately 100% of the total groundwater samples. The concentration of K^+ is varied from 21 to 203 mg/L (Table 1; Fig 8).

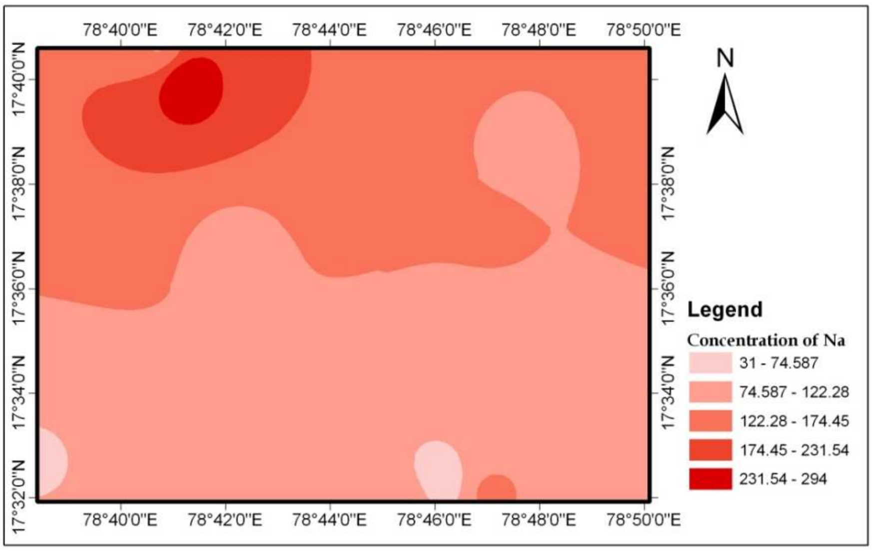

Fig No 7. Concentration of Na^+

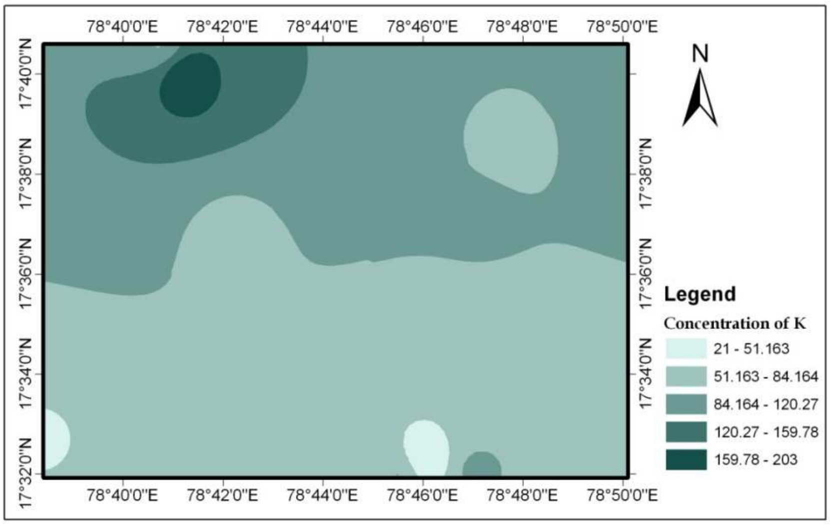

Fig No 8. Concentration of K^+

Bicarbonate is a major element in human body, which is necessary for digestion. When ingested, for example, with mineral water, it helps buffer lactic acid generated during exercise and also reduces acidity of dietary components. It has a prevention effect on dental cavities. In the current study, the concentration of HCO_3^- (61–159 mg/L; Table 1; Fig. 9) was much higher than CO_3^{2-} (9–24 mg/L; Fig. 10). Thus, the carbonates (HCO_3^- and CO_3^{2-}) are the dominated ions in the groundwater. They result from the CO_2 that is released from the decay of organic matter and root respiration in soil zone. The higher content of carbonates indicates an intense weathering of rocks, which favors an active mineral dissolution [20].

$CO_2 + H_2O \rightarrow H_2CO_3$
$H_2CO_3 \rightarrow H_2 + HCO_3^-$
$HCO_3^- \rightarrow H^+ + CO_3^{2-}$

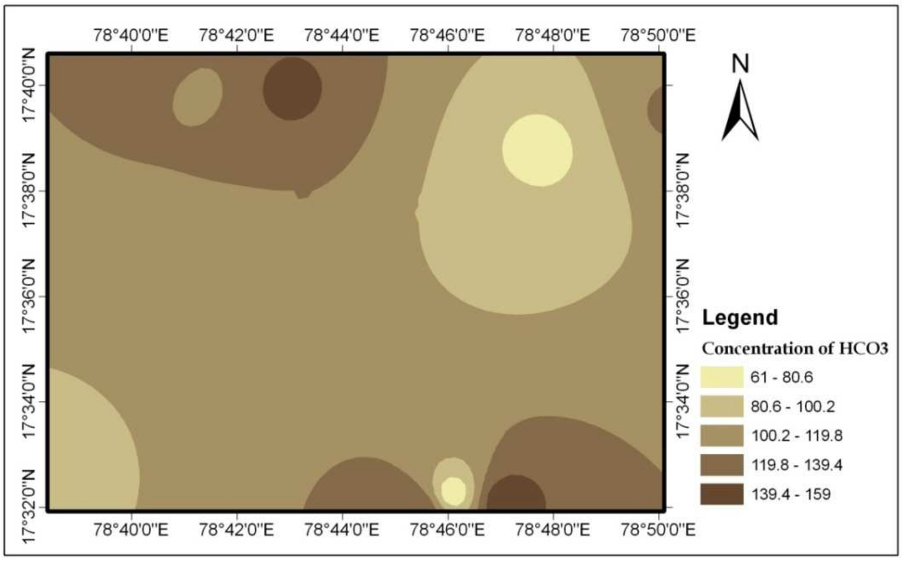

Fig No 9. Concentration of HCO_3^-

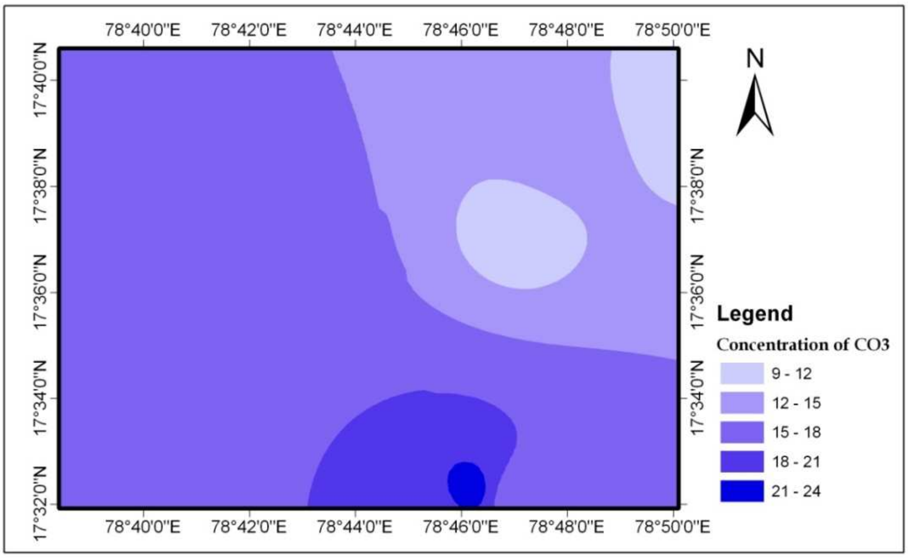

Fig No 10. Concentration of CO_3^{2-}

High chloride in groundwater samples may be due to the pollution from chloride rich effluents of sewage and municipal waste. The Cl^- is derived mainly from a non-lithological source. However, the country rocks may contribute Cl^- to the groundwater. High chloride in groundwater samples may be due to the pollution from chloride rich effluents of sewage and municipal waste. The chloride content varied from 89 to 833 mg/L (Table 1; Fig. 11), indicating that it is well within the permissible limit of 1,000 mg/L (Table 3; [6]).

Sulphate is unsuitable for drinking, when it exceeds the permissible limit of 400 mg/L and causes a bitter taste and laxative effect on humans, together with Na^+ or Mg^{2+} In water [6]. The diarrhea, catharsis, dehydration and gastrointestinal irritations may also be associated with the ingestion of water containing SO_4^{2-} [10]. The groundwater samples of the study area show SO_4^{2-} from 86 to 493 mg/L (Table 1), which are below the recommended limit of SO_4^{2-} for drinking water (Table 3; Fig. 12).

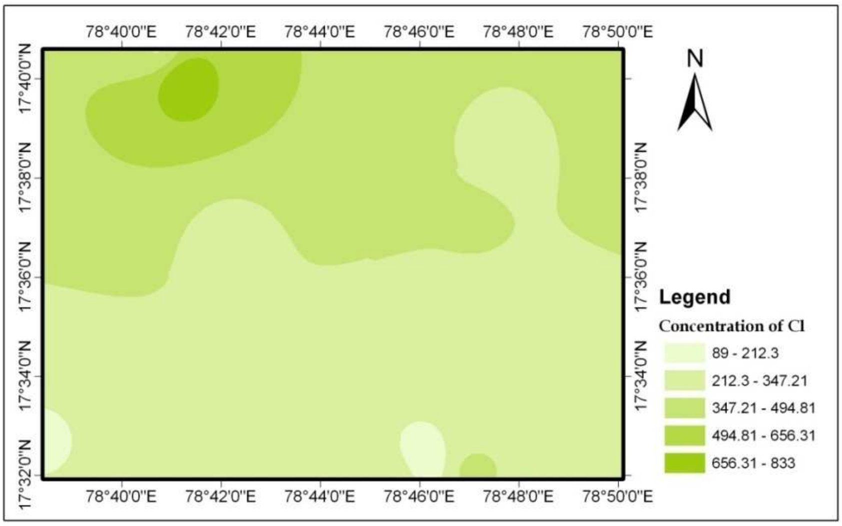

Fig No 11. Concentration of Cl^-

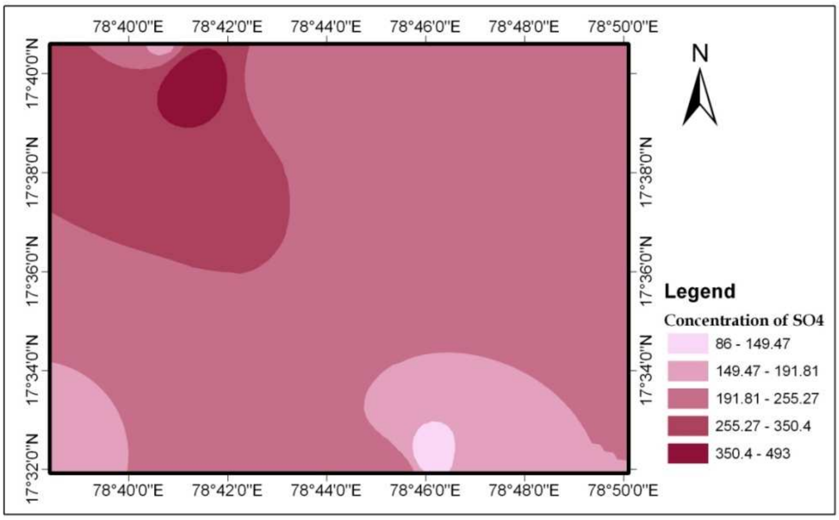

Fig No 12. Concentration of SO_4^{2-}

CONCLUSION

The present study envisages the integrated water quality the application of GIS techniques in the assessment and quantification of the quality of groundwater in Cheralapally area of Rangareddy district, Andhra Pradesh. According to TDS study revealed that 92% of groundwater is in fresh water category and only one groundwater location of calcium and sulphate are exceeding the maximum permissible limit.

Acknowledgments
The author thanks the Head, Department of the Applied Geochemistry, Osmania University, Hyderabad, for permitting to carry out the research project.

REFERENCES

[1] APHA, Standard methods for the examination of water and wastewater. *Washington, DC: American Public Health Association*, **1992,** pp 326.
[2] Aksoy AO, & Scheytt T, *Environmental Geology*, **2007,** *53*, 19–25.
[3] Ahn Hong-II, Chon Hyo-Taek, *Environ Geochem Health*, **1999,** 21, 273–289.

[4] Anbazhagan S, Archana MN, *Environ Geol,* **2004,** 45, 753–761.
[5] Babiker IS., Mohamed MAA, & Hiyama T, *Water Resources Management,* **2007,** *21*, 699–715.
[6] BIS, *Indian standard drinking water specifications IS10500:1991, edition 2.2 (2003–2009). Bureau of Indian Standards*, *New Delhi,* **2003.**
[7] Burrough PA, McDonnell RA, *Principles of geographical information systems for land resources assessment. Oxford University Press*, New York, **1998.**
[8] Dixit S., Gupta, SK, & Tiwari S, *Electronic Green Journal*, **2005**, *21*, 2–6.
[9] Fetter CW, Applied hydrogeology. *CBS Publishers and Distributors, New Delhi***, 1990**.
[10] Garg VK, Suthar S, Singh S, Sheoran A, Meenakshi Garima, Jai S, *Env Geol*, **2009**, 58, 1329–1340.
[11] Goyal SK, Chaudhary BS, Singh O, Sethi GK, Praveen KT, *Environ Earth Sci,* **2010,** 61, 1587–1597.
[12] Hem JD, Study and interpretation of the chemical characteristics of natural water. 2nd edn. *US Geol. Surv. Water supply paper*-2254, **1985**, pp 363.
[13] Jerry AN, Basic environmental technology *(water supply, waste disposal and pollution control,* New York: Wiley, **1986**.
[14] Karanth KR, *Ground water assessment development and management,* **1987,** 217–275.
[15] Mathes ES, Rasmussen TC, *Hydrogeol J,* **2006,** 14, 1493–1507.
[16] Meyback M, *American Journal Science*, **1987**, 287, 401–428.
[17] Sawyer CN, McCarty PL, Chemistry for sanitary engineers, 2nd edn. *McGraw-Hill, New York***, 1967**.
[18] Singh DSH, Lawrence JF, *J Geol Soc India*, **2007**, 69, 1067–1076.
[19] Stallard RF., and Edmond JM, *Journal of Geophysical Research*, **1983**, 88, 9671–9688.
[20] Stumm W, Morgan J.J, *Aquatic chemistry. Wiley-Interscience, New York***, 1996**.
[21] Subba Rao N, *Environmental Geology*, **2002**, 41, 552–562.
[22] WHO, *Water health and human rights*. *World Water Day*. **2001,**
http://www.who.int/water_sanitation_health/humanrights/en/.
[23] WHO, *Water for health: guidelines for drinking-water quality*. **2010,**
http://www.preventionweb.net/english/professional/publications/v.php?id=2034.