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Evaluation of groundwater quality and its suitability for drinking purposes in Gunthakal Area, Ananthapur District, Andhra Pradesh, India

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ABSTRACT

The suitability of groundwater quality for drinking purpose was assessed in the rural areas of Gunthakal area based on the various water quality parameters. Fifteen groundwater samples were collected and analyzed for pH, electrical conductivity (EC), total hardness (TH), total dissolved solids (TDS), anions (F^-, NO_3^-, HCO_3^-, SO_4^{2-}) and cations (Ca^{2+}, Mg^{2+}, Na^+, K^+). Fluoride concentrations ranged up to 2 mg/l, and average concentrations varied from 1.07 mg/L. Nitrate concentrations ranged up to 68.40 mg/l, and average 22.21 mg/l in the study area.

Keywords: Groundwater quality, Suitability for drinking purposes, Gunthakal area

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INTRODUCTION

The importance of water quality in human health has also recently attracted a great deal of interest [17].The importance of the groundwater in the area should not be underestimated because they are sources of water resource for drinking and agricultural purposes, not only for the people living in this area but also for those who live in the surrounding areas [12].

Water quality is extremely important because constant access to good quality water is necessary for life as well as the economy [2]. In recent times, there has been a tremendous increase in demand for freshwater and water shortage in arid and semiarid regions due to population increase, urbanization, industrialization, and intense agricultural activities in many parts of world. Due to inadequate supply of surface waters, most of the people in India are depending mainly on groundwater resources for drinking and domestic, industrial, and irrigation uses. Water is extremely essential for the survival of all living organisms. The quality of water is a vital concern for mankind since it is directly linked with human welfare. Many researchers have focused on hydrochemical characteristics and contamination of groundwater in different basins as well as in urban areas that resulted due to anthropogenic intervention mainly by agricultural activities and industrial and domestic wastewater [31, 19, 24, 25, 16, 20, 26 and 27].

MATERIALS AND METHODS

Sampling and geochemical analysis to assess the groundwater quality of Guntakal area in Ananthapur district, a systematic sampling was carried out in April 2009. Fifteen groundwater samples were collected in prewashed polyethylene narrow-mouth bottles from the hand pumps, which are in regular use. Groundwater was collected after pumping the wells for 5–10 min and rinsing the bottles for two to three times with water to be sampled. Electrical conductivity (EC) and pH values were measured on site using a portable conductivity and pH meter (Systronics) after recalibration with standard buffer solutions. The Groundwater samples were preserved at 4°C and all the geochemical analysis has been completed within a week of sampling. Acid titration method was used to determine the concentration of bicarbonate (HCO_3^-) in groundwater as prescribed by the American Public Health Association [1] and other parameter methods are described in table 1.

Table 1. Instrumental and volumetric methods used for chemical analysis of groundwater in the Gunthakal area, Anthapur District, Andhra Pradesh, India

Chemical parameters	Units	Method, instrument (make)	Reagents	Reference
pH	–	pH meter (Systronics)	pH 4, 7, and 9.2 (buffer solutions)	APHA (1992)
EC	µS/cm	EC meter (Systronics)	Potassium chloride	APHA (1992)
TDS	mg/L	EC×conversion factor (0.55 to 0.75)	–	Hem (1991)
TA	mg/L	Volumetric	Hydrochloric acid (HCl) and methyl orange	APHA (1992)
TH	mg/L	Volumetric	Ethylenediaminetetraacetic acid (EDTA), ammonia and eriochrome black-T	APHA (1992)
Ca^{2+}	mg/L	Volumetric	EDTA, sodium hydroxide and murexide	APHA (1992)
Mg^{2+}	mg/L	Calculation	–	APHA (1992)
Na^+	mg/L	Flame photometer	Sodium chloride (NaCl), KCl and calcium carbonate ($CaCO_3$)	APHA (1992)
K^+	mg/L	Flame photometer	NaCl, KCl and $CaCO_3$	APHA (1992)
HCO_3^-	mg/L	Volumetric	Hydrosulfuric acid (H_2SO_4), phenolphthalein	APHA (1992)
CO_3^{2-}	mg/L	Volumetric	Hydrosulfuric acid (H_2SO_4), methyl orange	APHA (1992)
Cl^-	mg/L	Argentometric	Silver nitrate, potassium chromate	APHA (1992)
F^-	mg/L	(Orion 4 star meter bench top pH/ISE meter)	TISAB	APHA (1992)

RESULTS AND DISCUSSION

The analytical results of hydrogeochemical analysis of groundwater samples collected from different sampling sites of Gunthakal area, Ananthapur district. Table 2 presents the hydrogeochemical characteristics of groundwater in Gunthakal Area, Ananthapur District.

Table 2. Hydrogeochemical characteristics of groundwater in Gunthakal Area, Ananthapur District

Sample NO	pH	EC	TDS	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	HCO_3^-	NO_3^-	F^-
		µS/cm	mg/L								
W1	7.87	1140	729.6	199	110	211	160	40	115	22.1	0.84
W2	8.50	816	522.24	153	55	238	200	52	120	12.2	1.74
W3	8.43	1294	828.16	260	75	449	200	21	60	12.4	1.9
W4	8.48	1054	674.56	120	70	119	140	23	121	5.08	1.4
W5	7.99	2026	1296.64	277	80	476	110	18	90	26.6	0.38
W6	8.09	1729	1106.56	136	80	132	160	16	80	26.5	0.24
W7	8.181	482	308.48	168	85	198	165	20	100	18.9	1.57
W8	8.45	2981	1907.84	159	60	238	140	25	90	4.19	0.881
W9	7.76	346	221.44	156	60	231	120	48	70	44.6	0.18
W10	8.29	680	435.2	277	60	528	140	43	88	68.4	0.3
W11	8.05	926	592.64	144	35	264	110	20	27	8.91	1.36
W12	8.85	1463	936.32	148	60	211	95	26	55	27.4	1.18
W13	8.53	815	521.6	154	58	231	329	35	162	12	0.95
W14	7.82	1593	1019.52	111	40	172	340	26	60	7.53	2
W15	8.46	852	545.28	327	45	687	320	20	60	36.4	1.07
Min	**7.76**	**346.00**	**221.44**	**111.00**	**35.00**	**119.00**	**95.00**	**16.00**	**27.00**	**4.19**	**0.18**
Max	**8.85**	**2981.00**	**1907.84**	**327.00**	**110.00**	**687.00**	**340.00**	**52.00**	**162.00**	**68.40**	**2.00**
Average	**8.26**	**1213.13**	**776.41**	**185.93**	**64.87**	**292.33**	**181.93**	**28.87**	**86.53**	**22.21**	**1.07**

pH is a measure of the balance between the concentration of hydrogen ions and hydroxyl ions in water. The pH of water provides vital information in many types of geochemical equilibrium or solubility calculations [9]. The limit of pH value for drinking water is specified as 6.5–8.5 [32 and 11]. The pH value of most of the groundwater samples in the study area varies from 7.56 to 8.85 and average is 8.26, which clearly shows that the groundwater in the study area is alkaline in nature. Even though pH has no direct effect on human health, its higher range accelerates the scale formations in water heating apparatus. Distribution map of pH is shown in Fig.1.

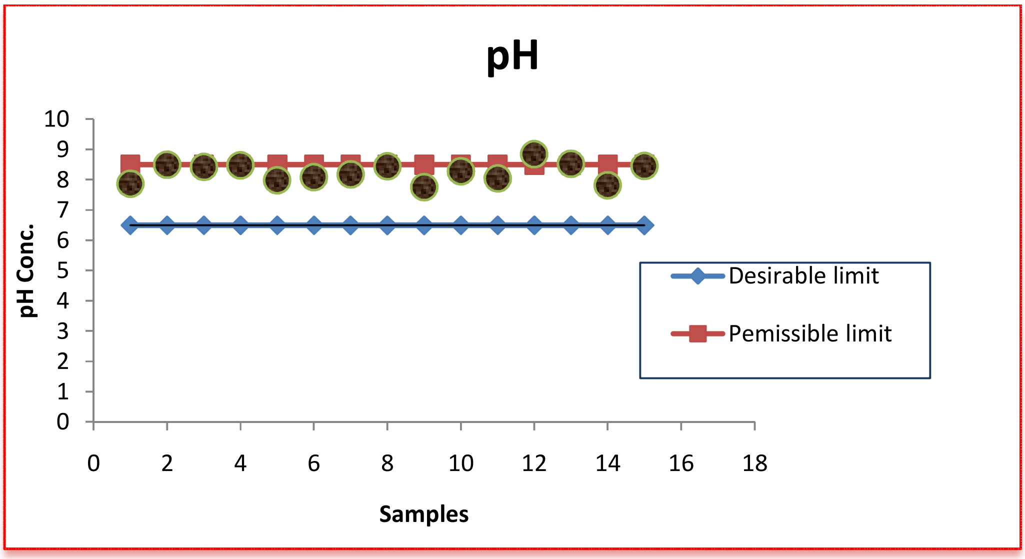

Fig.1 Distribution of pH

Electrical conductivity is a measure of water capacity to convey electric current. The most desirable limit of EC in drinking water is prescribed as 1, 500 µS/cm [32]. The EC of the groundwater is varying from 346 and 2981 µS/cm with an average value of 1213.13 µS/cm and distribution map of EC is shown in Fig.2. Higher EC in the study area indicates the enrichment of salts in the groundwater. The value of electrical conductivity may be an approximate index of the total content of dissolved substance in water. It depends upon temperature, concentration and types of ions present [9]. EC values are a good measure of the relative difference in water quality between different aquifers [22].

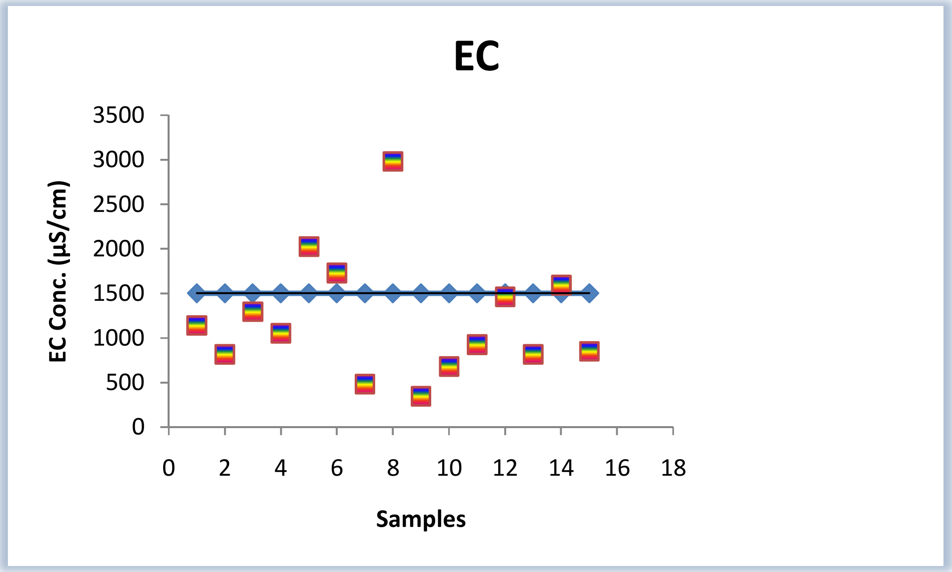

Fig.2 Distribution of EC

According to WHO specification TDS up to 500 mg/l is the highest desirable and up to 1,500 mg/l is maximum permissible. In the study area the TDS value varies between a minimum of 221.44 mg/l and a maximum of 1907.84 mg/l, indicating that most of the groundwater samples lies within the maximum permissible limit. According to the [6] classification of groundwater based on TDS, 20% of the total groundwater samples are desirable for drinking

(TDS <500 mg/l), 54% permissible for drinking (500–1,000 mg/l) and 26 % is suitable for irrigation purposes (<3000 mg/l).

The threshold limit of TH for drinking water is 300 mg/l [4]. Accordingly, the groundwater in 56% of the total water samples is not suitable for drinking. The higher concentration of TH in potable water causes to develop gall bladders, urinary stones and arthritis [7]. Further, such water quality also develops scales in water heaters, distribution pipes and well pumps, boilers and cooking utensils, and requires more soap for washing clothes [29, 9 and 14]. Distribution map of Total hardness is shown in Fig.3.

Magnesium content is varying from 119 to 687 mg/l with an average value of 292.22 mg/l. The maximum permissible limit of Mg^{2+} Concentration of drinking water is specified as 100 mg/l [11] and 150 mg/l [32]. Sample number W4 and W6 below the WHO limit as it shows a value of 119 and 132 mg/l respectively.

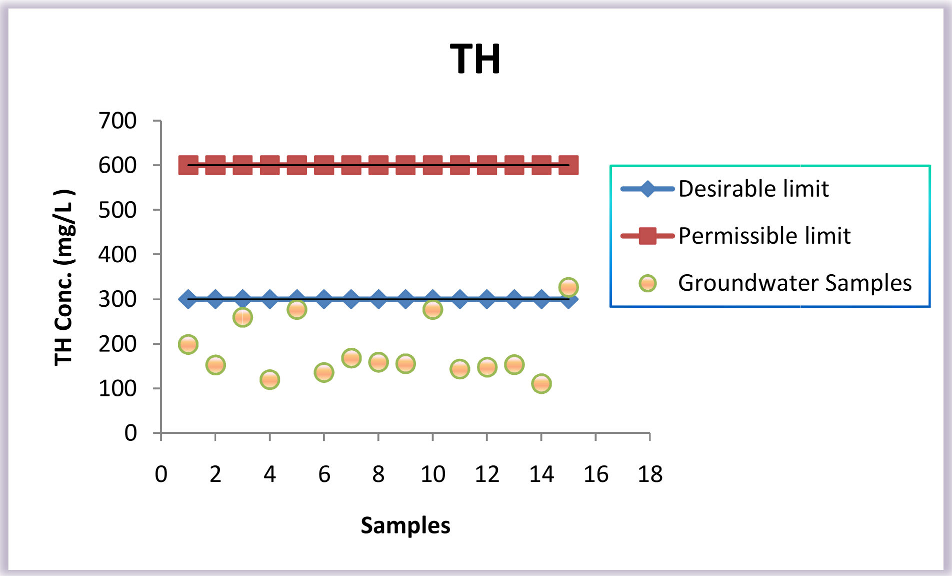

Fig.3 Distribution of Total Hardness

Calcium is an essential nutritional element for humans. Thus, the optimum concentration of Ca^{2+} is required to prevent cardiac disorders and for proper functioning of metabolic processes. Calcium concentrations are varying from 35 to 110 mg/l with an average value of 64.87 mg/l. The desirable limit of calcium concentration for drinking water is specified as 75 mg/l [11] which shows that one groundwater samples fall beyond the permissible limit. Magnesium is a constituent of bones, which is essential for normal metabolism of Ca^{2+} and its deficiency leads to protein energy malnutrition and distribution map of calcium is shown in Fig.4.

Potassium is a naturally occurring element; however, its concentration remains quite lower compared with Ca, Mg and Na. Its concentration in drinking waters seldom reaches 20 mg/l. The concentration of K^{+} is observed between 16 and 52 mg/l from the groundwater. The maximum permissible limit of potassium in the drinking water is 12 mg/l and it was found that all the samples are above the permissible limit of WHO, 2004.

The prescribed safe limit of Na^{+} is 200 mg/L for drinking water [10]. The Na^{+}, which is more than the recommended limit of 200 mg/L in potable water, causes hypertension or congenial heat diseases and also kidney problems. So, the people, who suffer from the hypertension, should be taken only sodium-restricted food [28]. None of the groundwater samples exceeds this limit so that the water is potable. Potassium is essential to maintain the fluid in balance stage in the body. Generally, it is less than 10 mg/L in water. In the study area, Na^{+} varying from 95 to 340 mg/L (average 181.93 mg/L), indicating that only three groundwater locations are exceeding recommended limit of 200 mg/L.

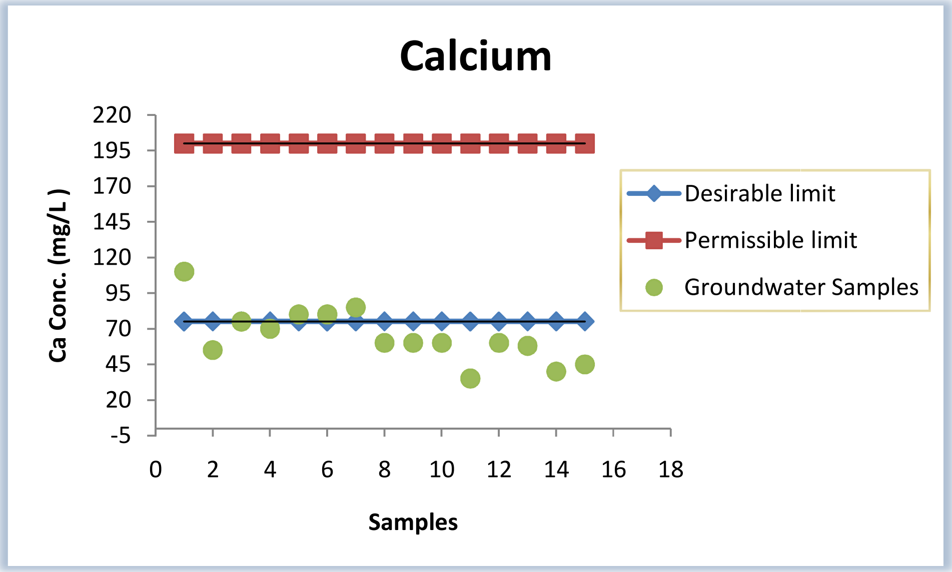

Fig.4 Distribution of Calcium

The NO_3^- has also a non-lithological source [21], reflecting a man-made pollution. The concentration of NO_3^- does not exceed 10 mg/L in water under natural conditions [5]. Since the concentration of NO_3^- varies from 4.19 to 68.40 mg/l (average 22.21 mg/l) in the study area (Table 1), the higher NO_3^- than that of 10 mg/l is indicative of anthropogenic contamination; hence only one groundwater (w10) location is recorded more than the maximum permissible limit of 45 mg/l [4, 32 and 33].

The usage of waters with a high nitrate level for drinking purpose reduces the oxygen carrying capacity of the blood and can lead to ‘‘blue disease’’ (methemoglobinaemia) in babies. Because babies younger than 6 months have relatively low levels of gastric acid, nitrate is reduced to nitrite, which reacts with hemoglobin in blood, forming methemoglobin. The blood loses its ability to carry oxygen and as a result breathing difficulties may be observed in babies [15, 33, 30, 12 and 13]. Distribution map of nitrate is shown in Fig.5.

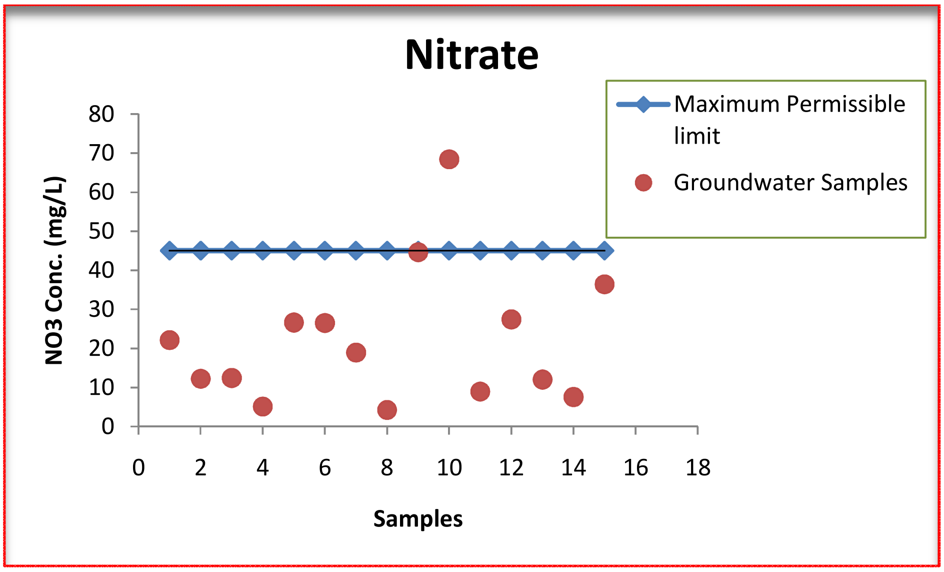

Fig.5 Distribution of Nitrate

The occurrence of F^- in groundwater is mainly due to natural or geogenic contamination and the source of contamination is often unknown [8 and 23]. While the F^- bearing minerals, apatite, biotite, muscovite, hornblende and fluorite, in the country rocks are the principal sources of F^- in the groundwater, the application of agricultural fertilizers, phosphate variety, is the supplementary source of F^- in the water. The concentration of F^- range from 0.18 to 2 mg/L and average is 1.07 mg/L, indicating that only four (w2, w3, w7 and w14) groundwater locations exceeding the maximum permissible limit of 1.5 mg/L and distribution map of fluoride is shown in Fig.6. Consumption of fluoride-contaminated groundwater (>1.50 mg/L) causes dental fluorosis [3].

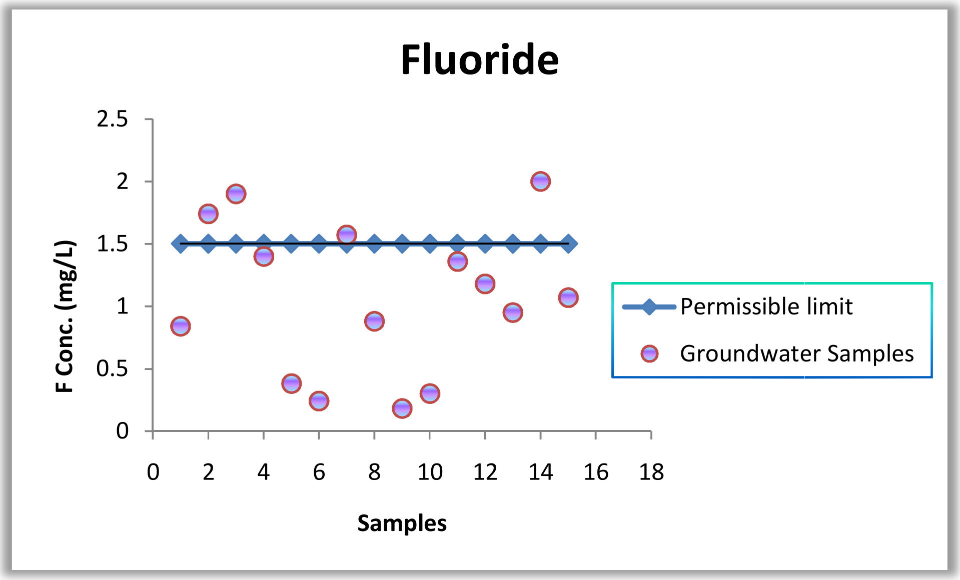

Fig.6 Distribution of Fluoride

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