Monitoring the quality of groundwater in Kushaiguda area Ranga Reddy District, Andhra Pradesh

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ABSTRACT

Groundwater quality and its suitability for domestic purpose were examined by various physico-chemical parameters such as pH, electrical conductivity, total dissolved solids, total hardness, calcium, magnesium, sodium, potassium, bicarbonate, carbonate, sulfate, and chloride. These parameters were used to assess the suitability of groundwater for domestic purpose by comparing with the WHO and Indian standards. The sample analysis reveals that the groundwater is not entirely fit for drinking with respect to EC, TDS, TH, Ca^{2+}, Mg^{2+} and Cl^{-}. In some of the collected samples, the concentrations of these parameters exceed the permissible limits of WHO and ISI standards.

Keywords: Groundwater quality, Kushaiguda area Ranga Reddy District

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INTRODUCTION

Groundwater and surface water are the main sources of water supply for agriculture, industrial and domestic use. The quality of water is of vital concern for mankind, since it is directly linked with human welfare. Poor quality of water adversely affects the plant growth and human health [23, 19, 21, 9, 20, 10, 24, 6 and 13]. Quality of groundwater is equally important to its quantity owing to the suitability of water for various purposes. Water quality analysis is an important issue in groundwater studies. Variation of groundwater quality in an area is a function of physical and chemical parameters that are greatly influenced by geological formations and anthropogenic activities [1]. Groundwater quality data give important clues to the geologic history of rocks and indications of groundwater recharge, movement and storage [22]. The knowledge of hydrochemistry is essential to determine the origin of chemical composition of

groundwater [26]. The hydrology and geochemistry of waters have been further discussed in the classic works of [17, 6, 3 and 4]. Determination of physical, chemical quality of water is essential for assessing its suitability for various purposes like drinking, domestic, agricultural and industrial uses.

MATERIALS AND METHODS

In order to evaluate the quality of groundwater in study area, groundwater samples were collected from 16 in Kushaiguda area Ranga Reddy District, Andhra Pradesh. The samples were collected after 10 min of pumping and stored in polyethylene bottles. Immediately after sampling, pH and electrical conductivity (EC) were measured in the field using a portable pH meter. Water sample collected in the field were analyzed in the laboratory for cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and anions (HCO_3^{-}, CO_3^{2-}, SO_4^{2-}, Cl^{-}) using the standard methods. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) were determined titrimetrically using standard EDTA. Chloride (Cl^{-}) was determined by the standard AgNO3 titration method. Carbonate CO_3^{2-} and bicarbonate (HCO_3^{-}) were determined by titration with HCl. Sodium (Na^{+}) and potassium (K^{+})were measured by flame photometry, and sulfate SO_4^{2-} by spectrophotometric turbidimetry [14].

RESULTS AND DISCUSSION

The groundwater samples were collected in Kushaiguda area Ranga Reddy District, Andhra Pradesh. The physico-chemical characteristics are determined. The data are presented in the Table 1 and Groundwater samples of the study area exceeding the permissible limits prescribed by [25 and 10] for drinking purpose is shown in Table 2. Classification of groundwater based on TDS is presented in Table 3 and distribution maps shown in Fig 1, 2, 3, 4, 5 and 6.

pH has no direct impact on consumers and WHO does not issue a value for pH health-based guideline, the pH of water does affect the effectiveness of water disinfection and clarification, and inappropriate levels can cause corrosion of water mains and pipes in household water systems. Failure to minimize corrosion can result in the contamination of drinking-water and adverse effects on its taste and appearance. The EPA recommends a pH of 6.5 to 8.5 [25 and 5].

Table 1. Mean physico-chemical parameters of groundwater concentrations in Kushaiguda area Ranga Reddy District, Andhra Pradesh

Sampling stations	pH	EC	TDS	TH	Ca^{2+}	Mg^{+2}	Na^{+}	K^{+}	SO_4^{-2}	HCO_3^{-}	CO_3^{-2}	Cl^{-}
KW-1	6.48	1730	1107	500	152	29	51	8	39	305	12	213
KW-2	6.98	2530	1619	115	248	29	89	16	91	549	54	845
KW-3	6.61	1556	995	250	712	372	127	12	78	354	48	533
KW-4	7.1	2858	1140	650	240	12	64	12	39	329	48	369
KW-5	7.07	1960	1254	218	112	462	62	9	36	476	60	206
KW-6	6.55	1265	809	102	244	508	89.7	13	91	403	36	497
KW-7	7.06	2380	1523	480	104	54	63	5	32	476	60	198
KW-8	6.77	2120	1356	430	196	15	47	5	36	378	48	256
KW-9	6.78	2130	1363	630	200	32	33	7	39	354	36	263
KW-10	6.64	2240	1433	640	204	32	33	5	41	329	54	312
KW-11	6.75	2525	1616	500	244	27	43	6	45	354	60	533
KW-12	7.18	1364	872	310	184	36	46	4	28	464	30	185
KW-13	6.85	2250	1440	290	80	22	43	6	23	244	66	128
KW-14	6.66	2881	1843	480	164	17	60	5	32	354	30	249
KW-15	6.82	2470	1580	490	180	10	43.7	6	32	464	48	334
KW-16	6.65	1860	1190	460	16	15	38	3	28	561	36	277

The pH of the water samples from Kushaiguda ranged from 6.48 to 7.18, with all sample inside the recommended range and distribution map is shown in Fig No 1.

Electrical conductivity (EC)

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 μmhos/cm [25]. The EC of the groundwater is varying from 1265 and 2881 μmhos/cm with an average value of 2132.43 μmhos/cm (Table 1 & 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 [7]. The EC can be classified as type I, if the enrichments of salts are low (EC <1,500 μmhos/cm); type II, if the enrichment of salts are medium (EC 1,500 and 3,000 μmhos/cm); and type III, if the enrichments of salts are high (EC >3,000 μmhos/cm). According

Table 2. Groundwater samples of the study area exceeding the permissible limits prescribed by WHO (2004) and ISI (1993) for drinking purpose.

S. No	Water quality parameters	Units	WHO 2004		ISI 1993		Range in the study area
			Most desirable limit	Maximum allowable limit	Most desirable limit	Maximum allowable limit	
1	pH	-	6.5	8.5	6.5-8.5	6.5-9.5	6.48-7.18
2	EC	µmhos/cm	1500	-	-	-	1265-2881
3	TDS	mg/l	500	1500	500	2000	809-1843
4	TH	mg/l	100	500	300	600	102-650
5	Ca^{2+}	mg/l	75	200	75	200	16-712
6	Mg^{2+}	mg/l	50	150	30	100	10-508
7	Na^{+}	mg/l	-	200	-	200	33-127
8	K^{+}	mg/l	-	12	-	-	3-16
9	CO_3^{2-}	mg/l	-	-	-	-	12-66
10	HCO_3^{-}	mg/l	-	-	-	-	244-561
11	SO_4^{2-}	mg/l	200	400	200	400	23-91
12	Cl^{-}	mg/l	200	600	250	1000	128-845

to the above classification of EC, 12.5% of the total groundwater samples come under the type I (low enrichment of salts) and 87.5% under type II (medium enrichment of salts) and distribution map of EC is shown in Fig No 2. The effect of saline intrusion may be the reason for medium enrichment of EC in the study area. The effect of pH may also increase the dissolution process, which eventually increases the EC value.

Total hardness (TH)

The total hardness is varying from 102 to 650 mg/l (Table 1). Groundwater of the entire study area lies within the maximum permissible limit prescribed by ISI. [16] classified groundwater, based on TH, as ground water with TH <75, 75–150, 150–300 and >300 mg/l, designated as soft, moderately hard, hard and very hard, respectively. According to the above categorization, 12.5% belongs to moderately hard; 18.75% belongs to hard and the remaining 68.75% comprises very hard water. The analytical result indicates the water in the study area is hard to very hard. The hardness of the water is due to the presence of alkaline earths such as calcium and magnesium. The drinking water quality is evaluated by comparing with the specifications of TH and TDS set by the World Health Organization and Indian standards (Table 2).

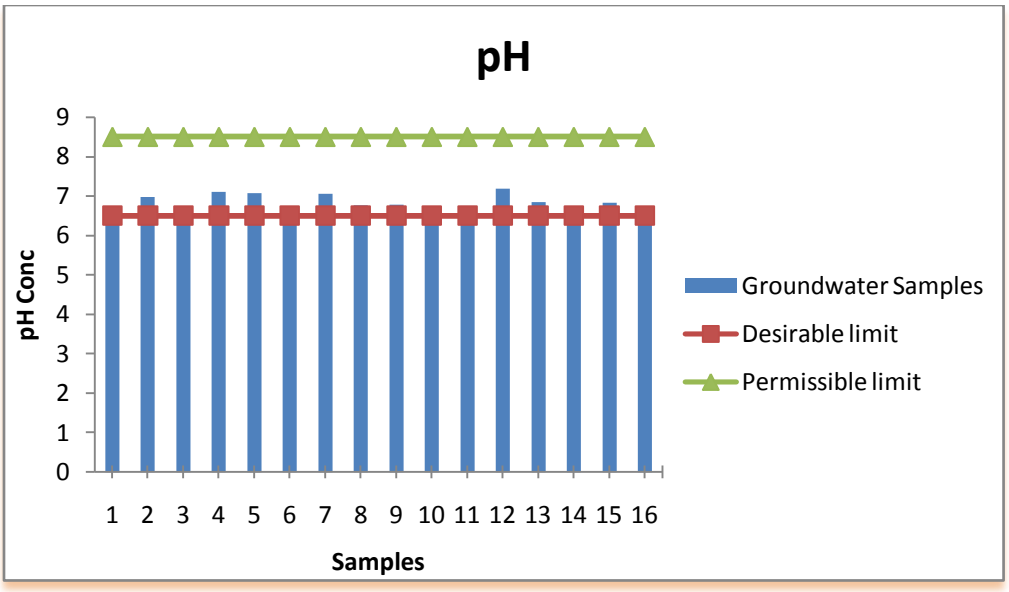

Fig.1 Distribution of pH

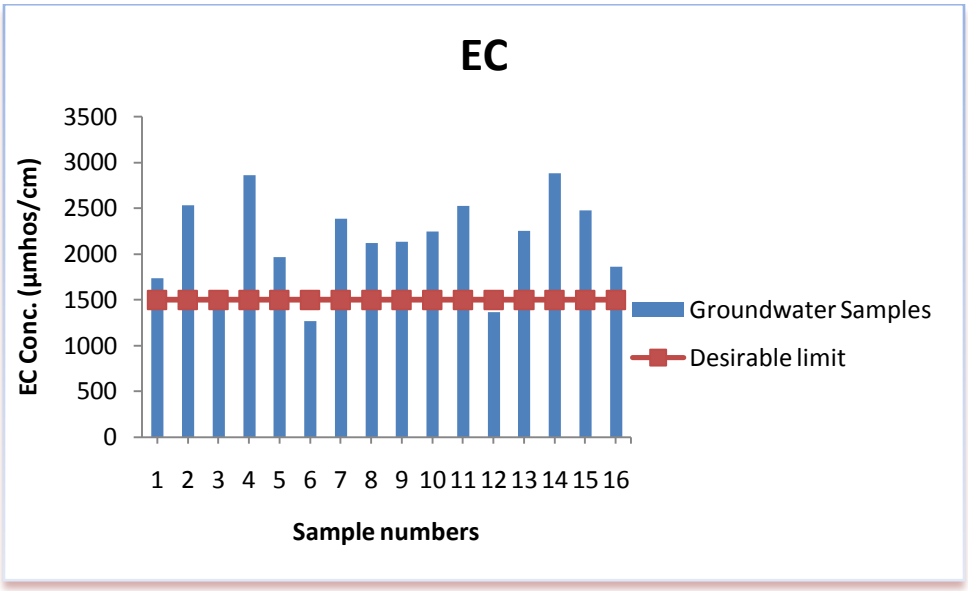

Fig.2 Distribution of EC

Total dissolved solids (TDS)

TDS include inorganic salts, such as calcium, magnesium, potassium, and organic matter that are dissolved in water. The concentration of TDS in drinking water can vary based on local geology and geography. 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 809 mg/l and a maximum of 1,843 mg/l, indicating that most of the groundwater sample lies within the maximum permissible limit. According to the [2] (Table 3) classification of groundwater based on TDS, 18.75% permissible for drinking (500–1,000 mg/l) and 81.25% is suitable for irrigation purposes. High concentration of TDS in the groundwater sample is due to leaching of salts from soil and also domestic sewage may percolate into the groundwater, which may lead to increase in TDS values [15] (Fig No 3).

Table 3. Classification of groundwater based on TDS (Davis and De Wiest 1966)

TDS (mg/l)	Water type	% of samples
<500	Desirable for drinking	-
500–1,000	Permissible for drinking	18.75
<3,000	Useful for irrigation	81.25
>3,000	Unfit for drinking and irrigation	-

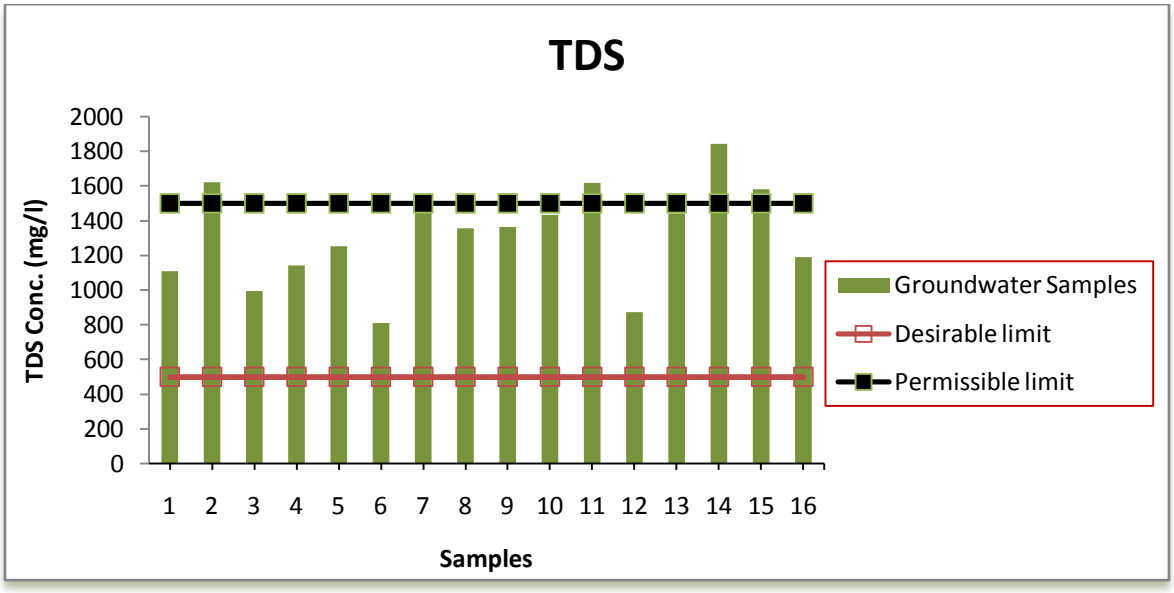

Fig.3 Distribution of TDS

Bicarbonate (HCO_3^- and CO_3^{2-})

The value of HCO_3^- is observed from 244 to 561 mg/l, which is recorded in the Kushaiguda area (Table 1). The higher concentration of HCO_3^- in the water points to the dominance of mineral dissolution [17]. The bicarbonate ion has no known adverse health effects on human beings. The

value of CO_3^{2-} is recorded in the range of 12 to 66 mg/l. The highest carbonate is observed station KW-13 and lowest in KW-1.

Calcium and magnesium (Ca^{2+} and Mg^{2+})

The values of calcium and magnesium are recorded in the range of 16–712 mg/l and 10–508 mg/l, respectively, in groundwater samples (Table 1). The calcium and magnesium values are within the permissible limit of [25] (200 and 150 mg/l) for most of the groundwater samples. But the calcium values are high at stations KW-3, KW-2, KW-4, KW-6 and KW-11. High values of magnesium are found at stations KW-6, KW-5, and KW-3. The low values may be due to the reverse cationic exchanges with sodium, i.e., sodium ions replace calcium and magnesium ions thereby reducing their concentrations [18] and distribution map of calcium and magnesium is shown in Fig No 4 & 5 respectively.

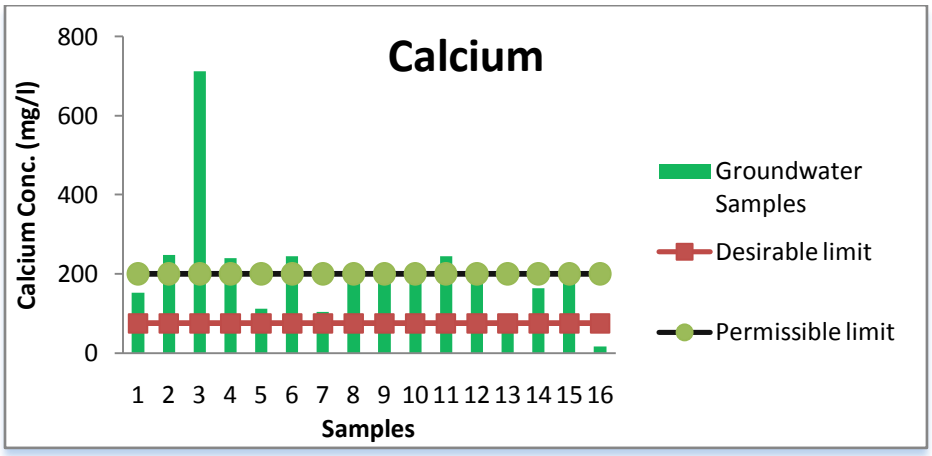

Fig.4 Distribution of Calcium

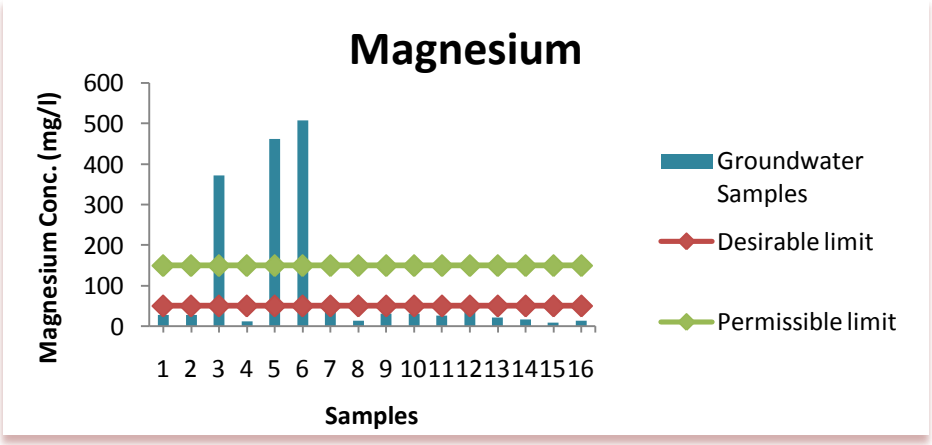

Fig.5 Distribution of Magnesium

Potassium (K^+) and Sodium (Na^+)

The values of potassium are recorded between 3 and 16 mg/l for groundwater samples (Table 1). The values of potassium exceed permissible limit of 12 mg/l in most of the groundwater samples. The values of potassium in groundwater samples vary station wise. High concentration in groundwater is due to the presence of silicate minerals from igneous and metamorphic rocks [12]. The maximum value is observed at station KW-2, which is surrounded by agricultural field. The excessive potassium fertilizers and manures used for the cultivation might have percolated into the groundwater. Sodium ranks sixth among the elements in order of abundance and is present in most of natural waters. Sodium is generally found in lower concentration than Ca^{2+} and Mg^{2+} in freshwater. The concentration of Na^+ is varied from 33 to 127 mg/l (Table 1). The maximum permissible limit of sodium is 200 mg/l and it reveals that few samples are exceeding the permissible limit of WHO and ISI (Table 2). The intake of high level of Na^+ causes increased blood pressure, arteriosclerosis, oedema and hyperosmolarity. Groundwater with high Na content is not suitable for agricultural use as it tends to deteriorate the soil.

Sulfate (SO_4^{2-})

Sulfate is one of the major anion occurring in natural waters. The upper limit for sulfate concentration for drinking water is 400 mg/l [11]. The sulfate concentration in the study area ranges between 23 and 91 mg/l with an average value of 44.379 mg/l indicating that all samples fall within the desirable limit and distribution map of sulfate is shown in Fig No 6.

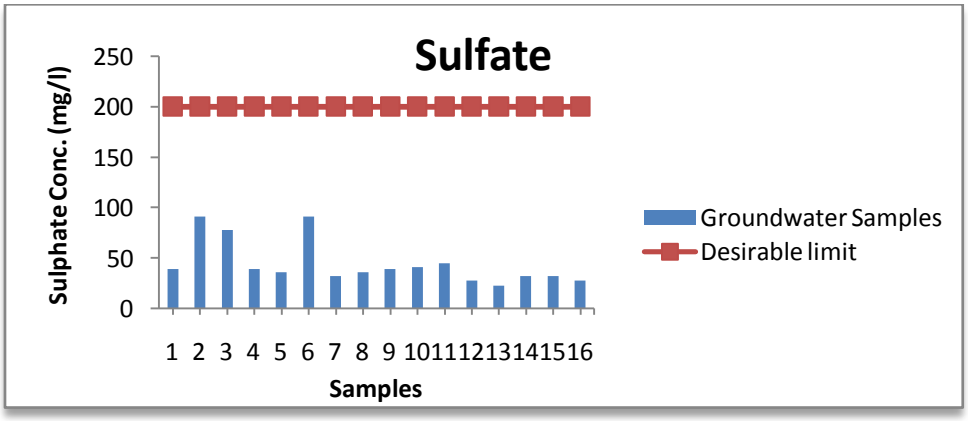

Fig.6 Distribution of Sulfate

Chloride (Cl^-)

High concentration of Cl^- in drinking water causes the salty taste and has a laxative effect on people not habituated to it. The origin of chloride in groundwater may be from diverse sources such as weathering, leaching of sedimentary rocks and soils, intrusion of saltwater, windblown salt in precipitation, domestic and industrial waste discharges, municipal effluents, etc. [12]. In the study area, the concentration of chloride is between 128 and 845 mg/l (Table 1; Fig No 7). The permissible limit of chloride for drinking water is specified as 600 mg/l [25] (Table 2) and highest value of chloride is recorded station KW-2. The excess of chloride in the water is usually taken as an index of pollution and considered as tracer fro groundwater contamination.

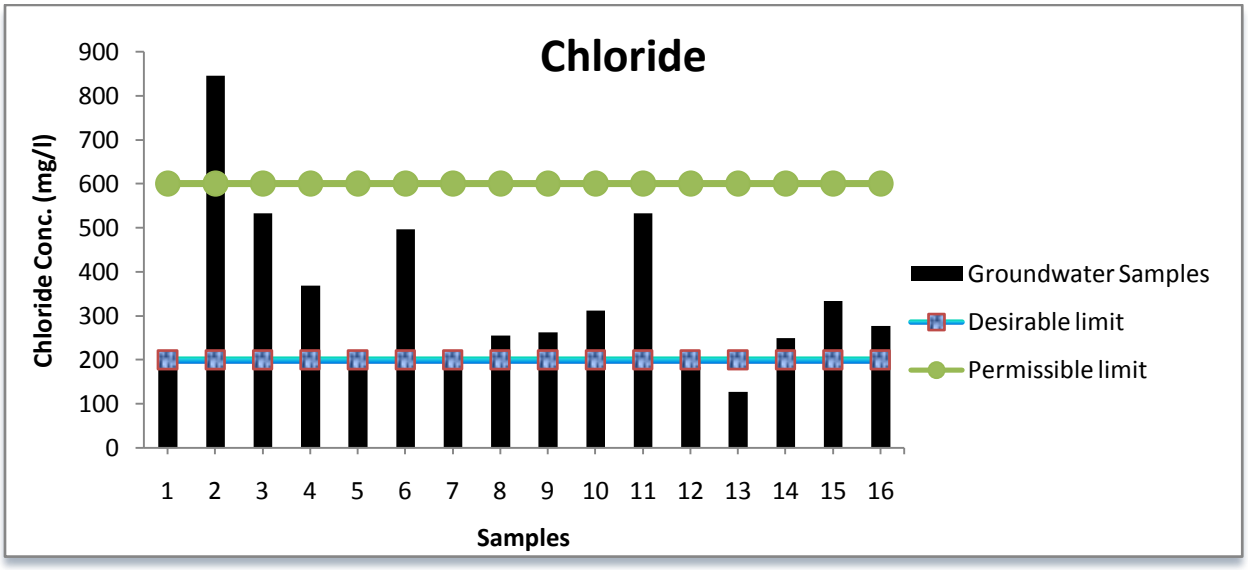

Fig.7 Distribution of Chloride

Conclusion

The groundwater samples were taken in Kushaiguda area Ranga Reddy District, Andhra Pradesh. The water samples were subjected to physico-chemical analysis. The results of the above work show that most of the physico-chemical parameters like Ca^{2+}, Mg^{2+} and Cl^- are above permissible limit.

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Reference

[1] Belkhiri L, Boudoukha A, Mouni L, Baouz T (2010). Application of multivariate statistical methods and inverse geochemical modeling for characterization of groundwater - A case study: Ain Azel plain (Algeria). Geoderma 159:390–398.

[2] Davis SN, De Wiest RJM (1966). Hydrogeology, vol 463. Wiley, New York.

[3] Drever JI (1988). The geochemistry of natural waters, 2nd edn. Prentice-Hall, New York.

[4] Domenico PA, Schwartz W (1998). Physical and chemical hydrogeology, 2nd edn. Wiley, New York, p 506.

[5] EPA (2009). National secondary drinking water regulations. United States Environmental Protection Agency.

[6] Hem JD (1991). Study and interpretation of the chemical characteristics of natural waters, 3rd edn, Book 2254. Scientific Publishers, Jodhpur.

[7] Hem JD (1985). Study and interpretation of the chemical characteristics of natural waters, 3rd edn. USGS Water Supply Paper. 2254, pp 117–120.

[8] Hem JD (1991). Study and interpretation of the chemical characteristics of natural waters, 3rd edn, Book 2254. Scientific Publishers, Jodhpur.

[9] HoldenWS (1971)Water treatment and examination. Churchill, London.

[10] ISI (1983). Indian standard specification for drinking water. IS: 10500. Indian Standard Institute, India.

[11] ISI (1993). Indian standard specification for drinking water. ISI 10500, New Delhi

[12] Karanth KR (1987). Groundwater assessment, development and management. Tata McGraw Hill publishing Company Limited, New Delhi.

[13] Karanth KR (1997). Groundwater assessment, development and management. Tata McGraw-Hill, New Delhi.

[14] Rowell DL (1994). Soil science: methods and applications. Longman and Scientific Technical, New York, p 350.

[15] Sarath Prasanth SV, Magesh NS, Jitheshlal KV, Chandrasekar N and Gangadhar K. (2012). Evaluation of groundwater quality and its suitability for drinking and agricultural use in the

coastal stretch of Alappuzha District, Kerala, India. Appl Water Sci, 2:165–175, DOI 10.1007/s13201-012-0042-5.

[16] Sawyer GN, McCarthy, DL (1967). Chemistry of sanitary engineers, 2nd edn. Mc Graw Hill, New York, p 518.

[17] Stumm W, Morgan JJ (1996). Aquatic chemistry. Wiley, New York, p 1022.

[18] Thomson Jacob, C, Azariah, J., & Viji Roy, AG. (1999). Impact of textile industries on river Noyyal and riverine groundwater quality of Tirupur, India. *Pollution Research, 18*(4), 359–368.

[19] Thorne DW, Peterson HB (1954). Irrigated soils. Constable and Company, London.

[20] Todd DK (1980). Groundwater hydrology. Wiley, New York.

[21] US Salinity Laboratory Staff (1954). Diagnosis and improvement of saline and alkali soils. US Department of Agricultural soils. US Department of Agricultural Hand Book 60, Washington.

[22] Walton WC (1970). Groundwater resources evaluation. McGraw Hill Book Co., New York.

[23] Wilcox LV (1984). The quality of water for irrigation uses. US Department of Agricultural Technical Bulletin 1962, Washington.

[24] WHO (1984). Guidelines for drinking water quality. World Health Organization, Geneva.

[25] WHO (2004). Guidelines for drinking water quality. World Health Organisation, Geneva.

[26] Zaporozec A (1972). Graphical interpretation of water quality data. Ground Water 10(2):32–43.