

Major ion chemistry of groundwater in rural area of kattanguru, Nalgonda District, Andhra Pradesh, India

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ABSTRACT

Study on chemical characteristics of groundwater and impacts of groundwater quality on human health, plant growth, and industrial sector is essential to control and improve the water quality in every part of the country. The present study was undertaken to assess major ion chemistry of groundwater to understand the groundwater quality for promoting sustainable development and effective management of groundwater resources. A total of 18 water samples were collected from selected parts of the rural area of karangur and the water chemistry of various ions viz. Ca^{2+} , Mg^{2+} , Na^+ , K^+ , CO_3^{2-} , HCO_3^- , Cl^- , SO_4^{2-} , F^- and NO_3^- are carried out. The nitrate appeared as a major problem of safe drinking water in this region. We recorded highest nitrate concentration, i.e., 70 mg/L in four groundwater locations. A comparison of groundwater quality in relation to drinking water quality standards revealed that about major nitrate and fluoride are four groundwater locations are not suitable for drinking.

Keywords Anion and cation chemistry, Groundwater quality, rural area of Kattanguru

INTRODUCTION

Groundwater is a significant water resource in India for domestic, irrigation, and industrial needs. More than 85% of rural and 50% of urban domestic water requirements are being met from groundwater resources, while irrigation accounts for around 92% of groundwater extraction [8]. The [22] 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 [20], 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). Pollution of the groundwater due to geogenic and anthropogenic factors often render the groundwater unpotable as consumption of such water can lead to various health-related complications. The present paper is illustrated that cation, anion and other parameters for drinking water quality.

MATERIALS AND METHODS

The study was conducted in Kattangur area, Nalgonda district, Andhra Pradesh, which is falling in topoheet no 56 O/8/NW. A total number of 18 groundwater samples were collected from representative bore/hand pumps in rural of Kattanguru area, Nalgonda District, Andhra Pradesh, India. The pH and electrical conductivity (EC) of the collected

water samples were measured in the field using portable pH meter and electrical conductivity meter. Other major parameters [Mg^{2+} , Ca^{2+} , Na^+ , K^+ , Cl^- , CO_3^{2-} , HCO_3^- , SO_4^{2-} , NO_3^- and F^-], were analyzed according to the standard procedures described in Standard methods for the examination of water and wastewater [1] immediately after the water samples were transported to the laboratory. Fluoride concentration was measured by ion-selective electrode method using an ion meter (Orion 720A) equipped with combined fluoride ion-selective electrode. Magnesium and calcium were estimated by volumetric titrations using EDTA. Chloride ion concentration was determined by volumetric titrations using AgNO_3 . Sodium and potassium were determined by flame photometry. Sulfate was measured using turbidity meter. Carbonate and bicarbonate ion concentration were measured by volumetric titrations using 0.01 N H_2SO_4 . EC of the water samples is used to obtain the total dissolved solids (TDS) concentration in water by dividing the EC values expressed in $\mu\text{S}/\text{cm}$ by 1.56 [18]. The total hardness (TH, mg/L CaCO_3) of the water samples was determined by using the following equation [18]: $\text{TH} = 2.5\text{Ca}^{2+} + 4.1\text{Mg}^{2+}$

RESULTS AND DISCUSSION

The minimum, maximum, and average concentrations of physicochemical parameters of water quality such pH, EC, TDS, and major anions and major cations are presented in Table 1 and groundwater samples of the study area exceeding the desirable and permissible limits prescribed by WHO for drinking purposes are presented in Table 2.

The pH value of groundwater in the study area ranges from 7.08 to 7.65 (average 7.35, Table 1), indicating an alkaline nature of most of the groundwater samples. The pH values of all the collected samples except four are well within the safe limit as prescribed by [19]. Though pH has no direct effect on human health, but it shows close relations with some other chemical constituents of water [11].

EC is measured in microsiemens per centimeter and is a measure of salt content of water in the form of ions [9]. In the present study, EC values ranged from 600 to 3080 $\mu\text{S}/\text{cm}$. TDS indicate the salinity behaviors of groundwater and in the study area it varies between 384 and 1971.4 mg/L with an average value of 839.47 mg/L . According to WHO [19], the maximum acceptable concentration of TDS in groundwater for a domestic purpose is 500 mg/L and excessive permissible limit is 1,500 mg/L . All groundwater samples have TDS values well within permissible limit of [19], except one groundwater location. [3] classified groundwater on the basis of TDS, up to 500 mg/L (desirable for drinking); 500–1,000 mg/L (permissible for drinking) and 1,000 to 3,000 mg/L (useful for agricultural purposes). Based on this classification, it is observed that out of 18 samples collected, 4 samples (KW-10, KW-11, KW-12 and KW-16) are desirable for drinking, 8 (KW-1, KW-3, KW-5, KW-8, KW-9, KW-13, KW-15 and KW-18) are permissible for drinking and six (KW-2, KW-4, KW-6, KW-7, KW-14 and KW-17) are useful for agricultural purposes.

Hardness is very important property of water from its domestic application point of view. Similarly, hard water causes problem in boilers in industries. The acceptable limit of total hardness (as CaCO_3) is 200 mg/L , which can be extended up to 600 mg/L in case of non-availability of any alternate water source [19]. Total hardness (TH) as CaCO_3 in the study area ranges from 240 to 540 mg/L with an average of 348.89 mg/L . Based on TH, [6] classified water as 0–60, soft; 61–120, moderately hard; 121–180, hard and >180 very hard water. Based 100% of samples belong to very hard type water.

Anion chemistry

The major anions analyzed include bicarbonate, chloride, sulfates, nitrate, fluoride, and carbonate. The origin of Cl^- derives mainly from the non-lithological sources and can also be contributed, especially, from the surface sources through the domestic wastewaters, septic tanks, irrigation-return flows and chemical fertilizers [18 and 7].

Table 1. Chemical data of groundwater sampling silts

S. No	pH	EC	TDS	TH	F ⁻	SO ₄ ²⁻	NO ₃ ⁻	CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺
		(μ S/cm)	(mg/L)	Anions (mg/L)							Cations (mg/L)			
KW-1	7.16	1230	787.2	350	1.02	25	9	210	280	298.2	44.85	3.03	80	36.48
KW-2	7.3	1860	1190.4	370	1.05	44	40	90	732	532.5	227.7	35.1	100	31.61
KW-3	7.65	1400	896	240	2.01	22.5	10	120	207.4	1043.3	100.3	2.57	64	19.45
KW-4	7.55	1600	1024	410	2.1	25.5	40	120	536.8	1086.3	273.2	32.29	160	2.43
KW-5	7.18	1280	819.2	540	1.1	24	50	132	280.6	482.8	35.88	4.75	164	31.61
KW-6	7.11	1640	1049.6	480	1.01	25	70	102	646.6	511.2	227.7	36.45	132	36.48
KW-7	7.35	1750	1120	400	3.01	24	20	108	695.4	795.2	161.9	4.17	200	24.32
KW-8	7.35	880	563.2	240	1.05	17	8	72	366	284	41.86	2.45	84	7.29
KW-9	7.08	880	563.2	280	1	20	9	48	488	284	93.84	2.88	108	2.43
KW-10	7.3	780	499.2	300	1	20	20	36	475.8	184.6	40.25	3.51	76	26.75
KW-11	7.15	780	499.2	270	1	20	20	42	500.2	220.1	59.8	3.7	88	12.16
KW-12	7.62	750	480	300	1	15	20	60	439.2	269.8	19.35	7.37	120	2.43
KW-13	7.6	1240	793.6	360	2	24	30	30	817.4	447.3	180.6	3.19	108	21.88
KW-14	7.25	1730	1107.2	400	1.1	24	50	30	780.8	681.6	60.6	146.6	148	7.29
KW-15	7.6	850	544	300	1.02	20	10	54	597.8	149.1	63.48	3.08	72	29.18
KW-16	7.45	600	384	260	1.1	15	20	48	512.4	85.2	46.1	3.66	60	26.75
KW-17	7.2	3080	1971.2	450	1.07	15	52	60	988.2	1036.6	128.3	232.8	120	36.48
KW-18	7.36	1280	819.2	330	1	20	30	84	585.6	923	138	7.41	100	19.45
Average	7.35	1311.67	839.47	348.89	1.31	22.22	28.22	80.33	551.68	517.49	107.98	29.73	110.22	20.80
Min	7.08	600	384	240	1	15	8	30	207.4	85.2	19.35	2.45	60	2.43
Max	7.65	3080	1971.2	540	3.01	44	70	210	988.2	1086.3	273.2	232.8	200	36.48

Table 2. Groundwater samples of the study area exceeding the desirable and permissible limits prescribed by WHO for drinking purposes

Parameters	WHO 1997		No. of samples exceeding desirable limit	No. of samples exceeding permissible limit
	Desirable limit	Permissible limit		
pH	6.5-8.5	9.2	-	-
EC (μ S/cm)	750	1,500	16	6
TDS (mg/L)	500	1,500	16	1
Ca ²⁺ (mg/L)	75	200	15	-
F ⁻ (mg/L)	0.6-0.9	1.5	18	4
Mg ²⁺ (mg/L)	30	150	5	-
SO ₄ ²⁻ (mg/L)	200	600	-	-
NO ₃ ⁻ (mg/L)	-	45	-	4
Cl ⁻ (mg/L)	250	600	14	6
Na ⁺ (mg/L)	50	200	14	3
TH (mg/L)	100	500	18	1

The chloride content varied from 85.2 to 1086.3 mg/L, indicating that in the groundwater of the study area is caused by the influences of irrigation return- flows and chemical fertilizers. The ground truth is that the agricultural activity is intensive and long-term, and no other sources are evident. However, only six groundwater locations (KW-3, KW-4, KW-7, KW-14 KW-17 and KW-18) are exceeding maximum permissible limit of 600 mg/L (Table 2) and Distribution map of chloride is shown in Fig. 1.

The NO₃⁻ has also a non-lithological source [13], reflecting a man-made pollution. The concentration of NO₃⁻ does not exceed 10 mg/L in water under natural conditions [2]. Since the concentration of NO₃⁻ varies from 8 to 70 mg/L (average 28.22 mg/L) in the study area (Table 1), the higher NO₃⁻ than that of 10 mg/L is indicative of anthropogenic contamination. Excessive NO₃⁻ in drinking water can cause a number of disorders including methaemoglobinaemia in infants, gastric cancer, goiter, birth malformations and hypertension [10]. The maximum acceptable limit of NO₃⁻ is 45 mg/L, only four groundwater locations (KW-5, KW-6, KW-14 and KW-17) are exceeding prescribed limit (Table 2) and distribution of nitrate is shown in Fig.2.

[14] reports that the apatite, biotite, clay and chemical fertilizers are responsible for increased F⁻ content in the groundwater of the study area. Similar observations on F⁻ concentration are also reported from different parts of Andhra Pradesh, India [15; 16 and 17]. Fluoride is an essential element for maintaining normal development of teeth and bones. The concentration of F⁻ varies from 1 to 3.01 mg/L (average 1.31mg/L) in the study area (Table 1).

Concentration of fluoride also was found to be only four groundwater locations (KW-3, KW-4 and KW-13) are the above the permissible limits of 1.5 mg/L (Table 2) and distribution of fluoride is shown in Fig.3.

SO₄²⁻ is a naturally occurring ion in almost all kinds of water bodies and plays an important role in total hardness of water. Moreover, its concentration of more than 200 mg/L is not desirable for domestic purposes. At higher concentration, SO₄²⁻ may cause gastro-intestinal irritation particularly when Mg²⁺ and Na⁺ are also present in drinking water resources. It varies from 15 to 44 mg/L and all groundwater samples shows SO₄²⁻ concentration below desirable limit of 200 mg/L (Table 2) and distribution of sulphate is shown in Fig.4. Bicarbonate usually the primary anion in groundwater is derived from the carbon dioxide released by the organic decomposition in the soils, where CO₂ is generated by root respiration and decay of humus that in turn combines with rainwater to form bicarbonates [5 and 18]. The concentration of HCO₃⁻ (207.4 - 988.2 mg/L) was much higher than CO₃²⁻ (30 - 210 mg/L).

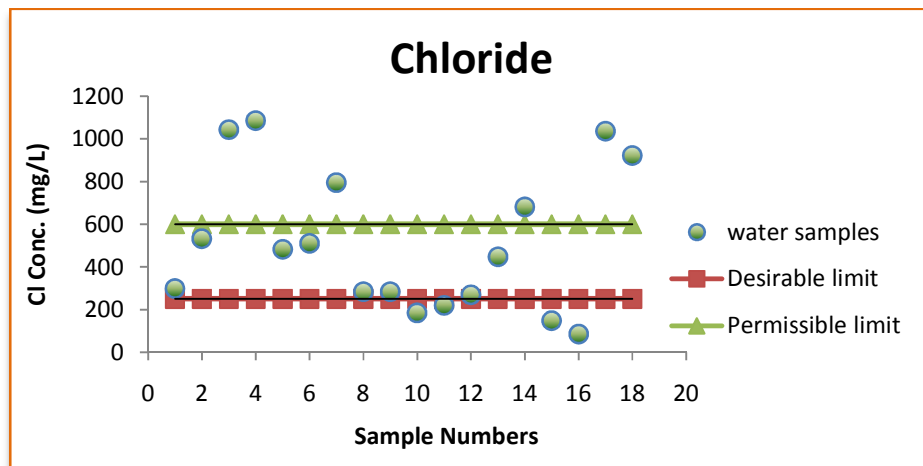


Fig.1 Distribution of Chloride

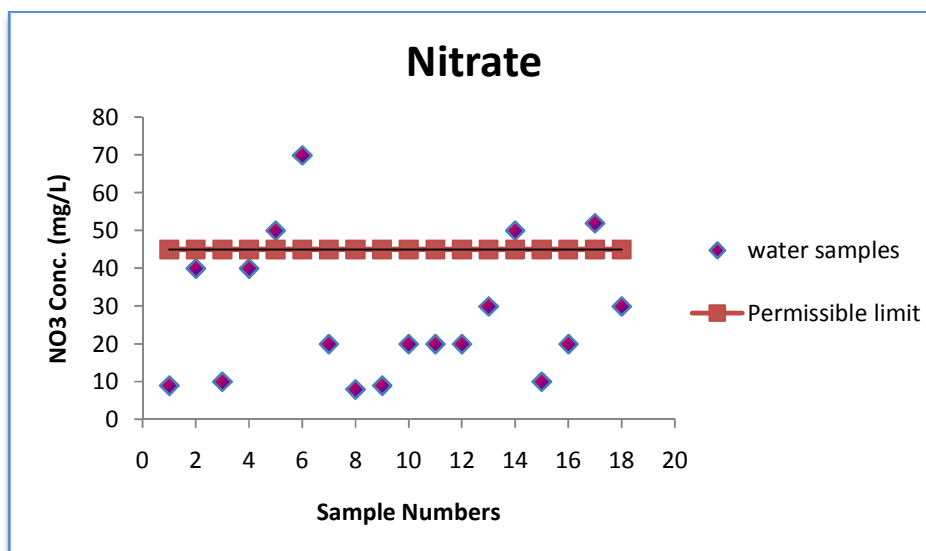


Fig.2 Distribution of Nitrate

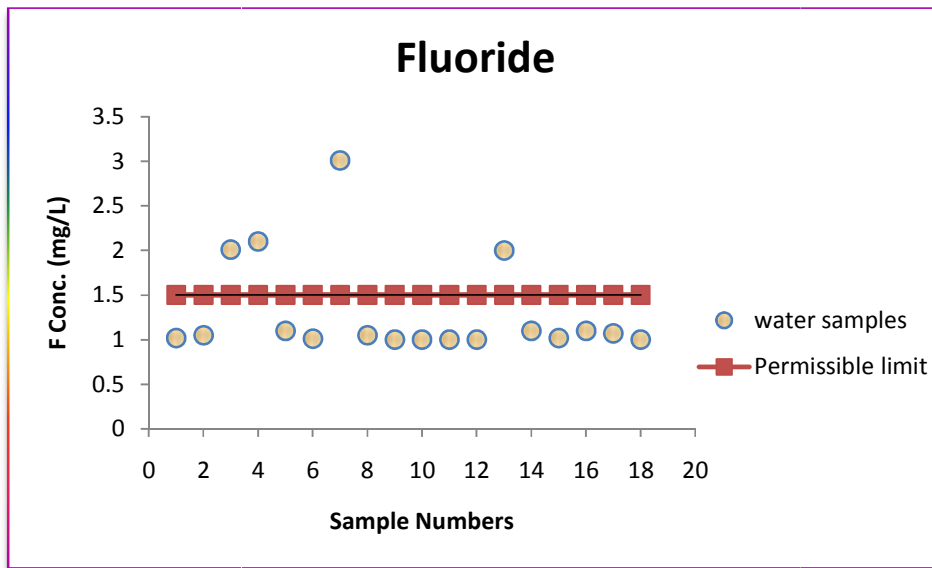


Fig.3 Distribution of Fluoride

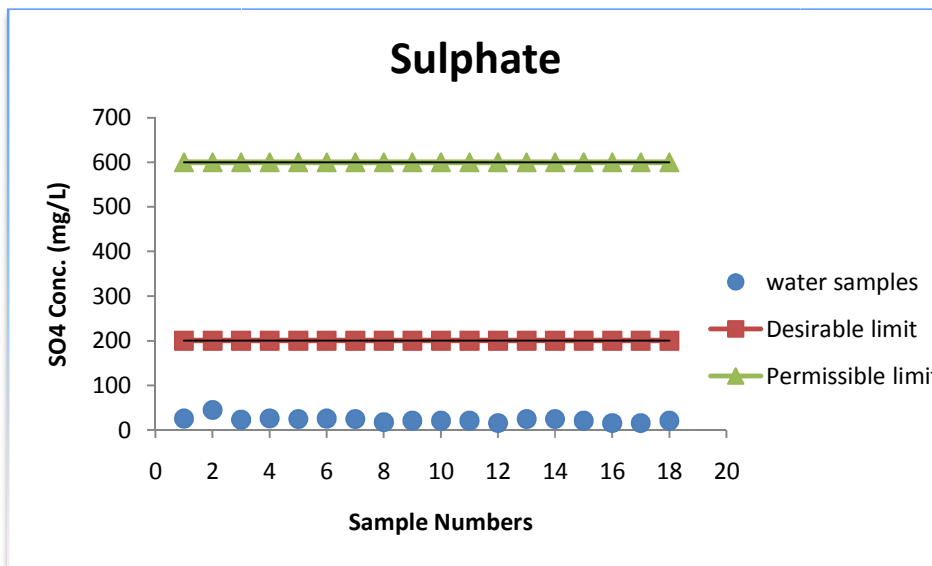


Fig.4 Distribution of Sulphate

Cation chemistry:

In the study area, the Na⁺ concentration ranges from 19.35 to 273.2 mg/L (Table 1). The factors, which are responsible for high concentrate ion of Na⁺ are weathering of rock forming minerals like sodium plagioclase, halite and anthropogenic sources like domestic and animal waste. The high concentration of Na⁺ may pose a risk to the persons suffering from cardiac, renal and circulatory changes [4]. However, three groundwater samples (KW-2, KW-4 and KW-6) exceed WHO [19] standard and are not fit for drinking (Table 2) and distribution map of sodium is shown in Fig.5.

Calcium and magnesium are essential nutrients for plants and animals, as also essential for bone, nervous system and cell development. Ca and Mg are the main contributors towards hardness. In general, the presence of Ca²⁺ and Mg²⁺ in water are beneficial and no limits on Ca²⁺ and Mg²⁺ have been prescribed for protection of human and aquatic health. Ca²⁺ and Mg²⁺ in drinking water may provide nutritional benefits for the people. One possible adverse effect from ingesting high concentration of Ca²⁺ for long periods of time may be an increased risk of kidney

stones. Concentration of calcium ranges from 60 to 200 mg/L, while that of the concentration of Mg^{2+} is varied from 2.43 to 36.48 mg/L (Table 1). Concentrations of Ca^{2+} and Mg^{2+} are within the WHO prescribed limits of 200 and 150 mg/L respectively. The concentration of potassium varies from 2.45 to 232.83 mg/L with significant fluctuation. K^+ is an essential nutrient but if ingested in excess may behave as a laxative. Only five groundwater locations (KW-2, KW-4, KW-6, KW-14 and KW-17) have K^+ concentration above the recommended value of 12 mg/L according to WHO [21].

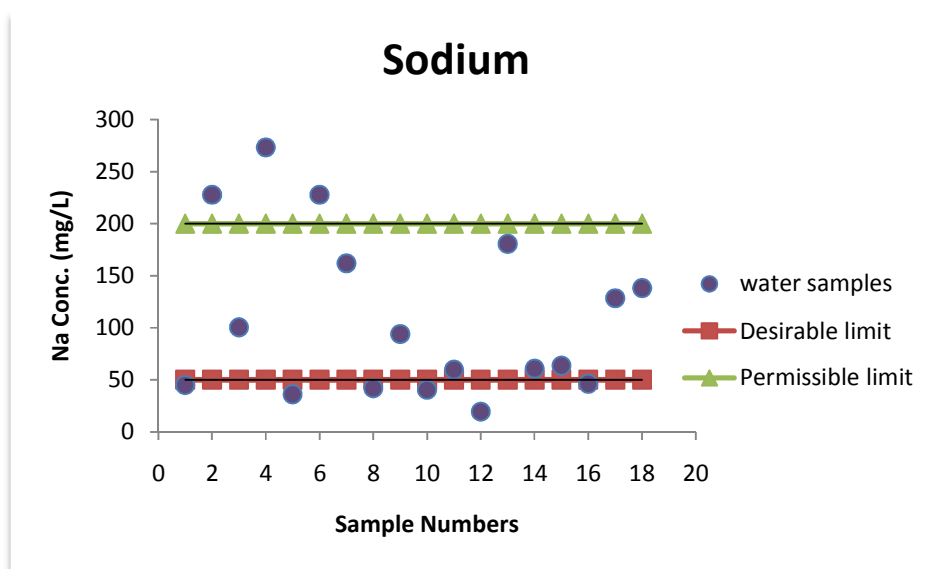


Fig.5 Distribution map of Sodium

CONCLUSION

The results of major ion chemistry reveal the all groundwater locations from study area are found to be very hard type. According to Davis and De Wiest classification, 4 are desirable for drinking, 8 are permissible for drinking and six are useful for agricultural purposes. Only four Groundwater locations have nitrate concentration above the tolerance limit of 45 mg/L and not suitable for drinking. Elevated fluoride concentrations, four groundwater locations much greater than the prescribed limit of 1.5 mg/L, which is not suitable for drinking.

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