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Assessing Groundwater Quality and its Suitability for Irrigation purpose in Kothur area, Mahabubnagar District, Telangana State, India

KEYWORDS: Groundwater Quality, Irrigation, Water type, Kothur, Mahabubnagar.

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ABSTRACT *In order to assess the groundwater suitability for drinking and irrigation purposes in parts of Kothur area, Mahabubnagar district, Andhra Pradesh. 50 groundwater samples were collected and analyzed for various parameters. The various parameters were evaluated such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Na+, K+, Ca2+, Mg2+, Cl-, HCO3-, CO3-, SO4-, NO3- and Chemical index like Sodium Adsorption Ratio (SAR), Sodium Percentage (% Na) Residual Sodium Carbonate (RSC), Magnesium Hazard (MH) and Kelly Ratio (KI) were calculated based on the analytical results. Based on US salinity diagram, 80% of the groundwater samples fall in the C2-S1 water class, indicating medium salinity and low sodium waters. The abundance of the major ions is as follows: CO3 > NO3 > Cl and K > Mg > Ca. These parameters were compared with standard limits and were found to be in limits and suitable for irrigation purpose.*

INTRODUCTION:

Water resource has played a critical and vital role throughout the history in the growth and development of human civilization. In modern times, water resources have critical importance in the economic growth of all contemporary societies. Therefore, water resource assessment and sustainability consideration are of utmost importance, especially, in the developing countries like India where water is commonly of economical and social significance. Access to safe drinking water remains an urgent necessity, as 30% of urban and 90% of rural Indian population still depend completely on untreated surface or groundwater resources (Kumar et al. 2005). Water quality plays an important role in promoting agricultural production and standard of human health. While access to drinking water in India has increased over the past decades but the tremendous adverse impact of unsafe water on health continues. Scarcity of clean and potable drinking water has emerged in recent years as one of the most serious developmental issues in many parts of West Bengal Jharkhand, Orissa, Western Uttar Pradesh, Andhra Pradesh, Rajasthan and Punjab. Public ignorance to environmental considerations, indiscriminate disposal of anthropogenic, agricultural and mining wastes, unplanned application of agrochemicals and fertilizers and overexploitation of groundwater resources caused excess accumulation of pollutants on the land and contamination of available surface and groundwater resources (Subramanian 2000; Singh 2000; CPCB 2008). The overdependence on groundwater has led to 66 million people in 22 states at risk due to excessive fluoride and around 10 million at risk due to arsenic in six states (Ghosh 2007).

Materials and Methods

In order to assess the groundwater quality, 50 groundwater samples have been collected. The water samples collected in the field were analyzed for electrical conductivity (EC), pH, total dissolved solids (TDS), Total Hardness (TH), major cations like calcium, magnesium, sodium, potassium and anions like bicarbonate, carbonate, chloride, nitrate and sulphate, trace element like fluoride in the laboratory using the standard methods given by the American Public Health Association (APPHA, 1995). Sampling was carried out using pre-cleaned polyethylene containers. The results were evaluated in accordance with the drinking water quality standards given by the World Health Organization (WHO, 2004) and Bureau of Indian Standard (BIS, 2009)

The pH was measured with Digital pH Meter (Model 802 Systronics) and Ec was measured with Conductivity Meter (Model 304 Systronics), Sodium and Potassium was measured with Flame photometer (Model Systronics 130). Sulphates and Nitrates were measured with Spectronics 21 (Model BAUSCH & LOMB), Carbonate, Bicarbonate, Calcium, Magnesium, Total Dissolved Solids, Total Hardness, and Chloride by titrimetric methods, Fluoride concentration was measured with Orion ion analyzer with fluoride ion selective electrode. Nitrate was determined by spectrophotometer. The concentration of EC is expressed in microsiemens/cm at 25°C and TDS, TH, Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, $C1^{-}$, SO_4^{-}, NO_3^{-}, CO_3^{-}, HCO_3^{-} and F^{-} are expressed in mg /l. Location map of the water sample is shown in the (Fig. 1).

RESULTS AND DISCUSSION

Understanding the groundwater quality is important as it is the main factor determining its suitability for drinking, domestic, agricultural and industrial purposes**.** The chemical composition of groundwater results from the geochemical processes occurring as water reacts with the geologic materials which it flows (Appelo, Postma, 1996)**.** Physical and chemical parameters including statistical measures such as minimum, maximum, mean, Median, Std.Dev are summarized in Table 1. Classification of groundwater on the basis of SAR, (% Na), PI and KI is shown in Table 2.

IRRIGATION WATER QUALITY

Sodium Adsorption Ratio (SAR)

Sodium adsorption ratio (SAR) is an important parameter for determining the suitability of groundwater for irrigation because it is a measure of alkali/sodium hazard to crops, SAR is defined by Karanth (Karanth, 1987) as Equation (1)

$$SAR = \frac{Na}{\sqrt{(Ca+Mg)/2}} \text{ -------- } (1)$$

Where all ionic concentrations are expressed in meq/l. The

SAR values range from 0.63 to 3.6 and according to the Richards (Richards, 1954) classification based on SAR values (Table 2), all of samples are belong to the excellent category. The analytical data plotted on the US salinity diagram (Figure 1) (USDA, 1954) illustrates that 80% of the groundwater samples fall in the field of C2-S1, indicating medium salinity and low sodium water, which can be used for irrigation on all types of soil without danger of exchangeable sodium.

Percentage of Sodium (% Na)

Irrigation water containing large amounts of sodium is of special concern due to sodium's effects on soil and poses a sodium hazards. Excess sodium in water produces the undesirable effects of changing soil properties and reducing soil permeability (Subba Rao, 2006). Hence, the assessment of sodium percentage is necessary while considering the suitability for irrigation, which is computed by Eq. 1.

$$\%N = \frac{(Na+K)}{Ca+Mg+Na+K} x100 \text{-------------------- (1).}$$

Where all the ion concentrations are expressed in meq/L. The %Na values varied from 17.64 to 57.8 meq/L (Table 2). The Wilcox (1955) diagram (Figure 2) relating sodium percentage and total concentration shows that % 07 of the groundwater samples fall in the field of good to permissible for irrigation purposes and 93% of the groundwater samples fall in the field of excellent to good for irrigation.

Permeability Index (PI)

The Permeability Index (PI) values also depicts suitability of groundwater for irrigation purposes, since long-term use of irrigation water can affect the soil permeability, influenced by the Na^+, Ca^{2+}, Mg^{2+} and HCO_3^- contents of the soil. The PI can be expressed as

$$PI = \frac{(Na+K)+\sqrt{HCO_3}}{Ca+Mg+Na+K} x100 \text{----- (4)}$$

The concentrations are reported in meq/l. (Doneen, 1964) developed a criterion for assessing the suitability of water for irrigation based on PI, where waters can be classified as classes I, II, and III. The PI of the area varied from 28.01 to 86.81 and the average value is 60.22. According to PI values, 7% groundwater samples had fallen in class I, 82% in class II and 11% in class III of the Doneen's chart [35] which is shown in (Figure 3).

Kelley's Ratio

Sodium measured against Ca^{2+} and Mg^{2+} is used to calculated by (Eq.) Kelley's [21].

$$KR = \frac{Na}{Ca+Mg} \text{...................... (4)}$$

Where all the ion concentrations are expressed in meq/L. A Kelley's index (KI) of more than one indicates an excess level of sodium in waters. Therefore, water with a KI (<1) is suitable for irrigation, while those with a KI (>1) unsuitable (Kelley, 1940). In the present study area KI values varied from 0.17 to 1.24 (Table 2). According to Kelley's index 89% groundwater locations are suitable for irrigation and11% groundwater locations are unsuitable for irrigation.

Conclusions

The dominant hydrochemical facieses of groundwater is Ca-Na-Mg-HCO_3-Cl. The concentrations of major ions in groundwater are within the permissible limits for drinking except in some places. The suitability of water for irrigation was assessed on the basis of SAR and shows that all of the groundwater in Kothur area is classified as excellent for irrigation. The analytical data plotted on the US salinity diagram illustrates that 80% of the groundwater samples fall in the field of C2-S1, indicating medium salinity and low sodium water. Based on Wilcox classification ninety three percent of the waters belong to excellent to good which is indicate that groundwater suitable for irrigation, According to PI values the groundwater in study area is suitable for irrigation purposes. Kelley's index and magnesium hazard suggest that the groundwater is not safe in 61%, 11% and 48% of groundwater respectively. Assessment of water samples from various methods indicated that groundwater in study area is chemically suitable agricultural uses.

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Table 1. Statistical Summary of the Chemical Composition of Groundwater

Parameter	Minimum	Maximum	Mean	Median	Std.Dev	Acceptable Limit(WHO,2004) (BIS, 2009)	% of samples exceeding the limit
pH	7.42	8.8	8.04	8.1	0.29	6.5-8.5	5
EC	78.44	1569	387.88	314	272.86	1500	4
TDS	50.2	1004.03	248.2	201	174.57	500	5
CO_3^-	0	15	7.411	6	3.46	10	89
HCO_3^-	48.8	219.6	122.35	122	38.81	500	Nil
Cl^-	21.3	678.05	123.75	56.85	135.62	250	7
TH	75	560	206	172	104.28	200	39
Ca^{++}	16.03	154.03	41.232	32.000	26.535	75	5
Mg^{++}	2.91	83.83	26.326	23.000	17.107	30	29
Na^+	17	182	55.589	44.500	35.608	250	Nil
K^+	10	47	15.161	14.000	6.771	10	89
SO_4^-	4	180	29.705	20.000	33.83	200	Nil

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Table 2. Classification of Groundwater Irrigation Suitability and % of Samples Falling In Various Categories.

Category	Ranges	Percent of the samples
Based on Alkalinity Hazard(SAR) (Richards 1954)		
Excellent	<10	100
Good	10-18	00
Doubtful	18-26	00
Unsuitable	>26	00
Residual Sodium Carbonates (Richards 1954)		
Safe for irrigation	<1.25	100
Moderate for irrigation	1.25-2.5	00
Unsuitable for irrigation	>2.5	00
Based on Soluble Sodium Percentage after Wilcox(1955)		
Good to permissible	<20	07
Excellent to good	20–40	93
Doubtful to unsuitable	40–60	00
Unsuitable	60–80	00
Permissible to doubtful	>80	00
Kelley's Ratio(Kelley1951)		
Good	≤1	89
Not good	>1	11

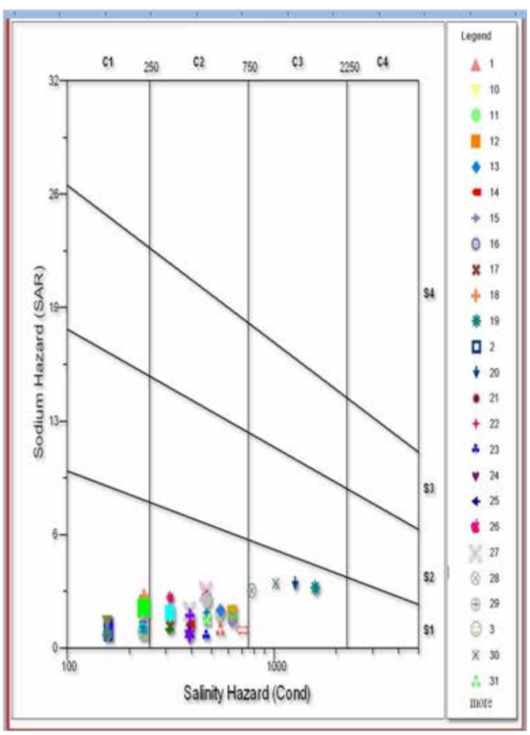

Fig. 1. Rating of Groundwater Samples in Relation To Salinity and Sodium Hazard

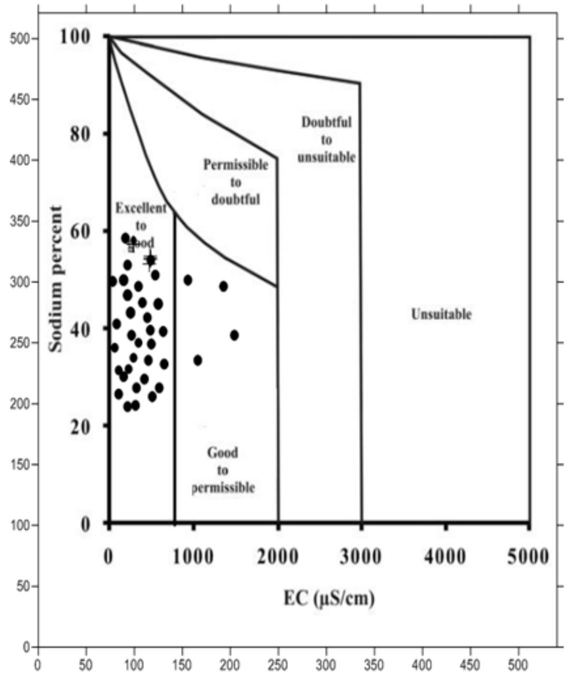

Fig. 2. Rating of Groundwater Samples On The Basis Of Electrical Conductivity and

Percent Sodium (After Wilcox, 1955)

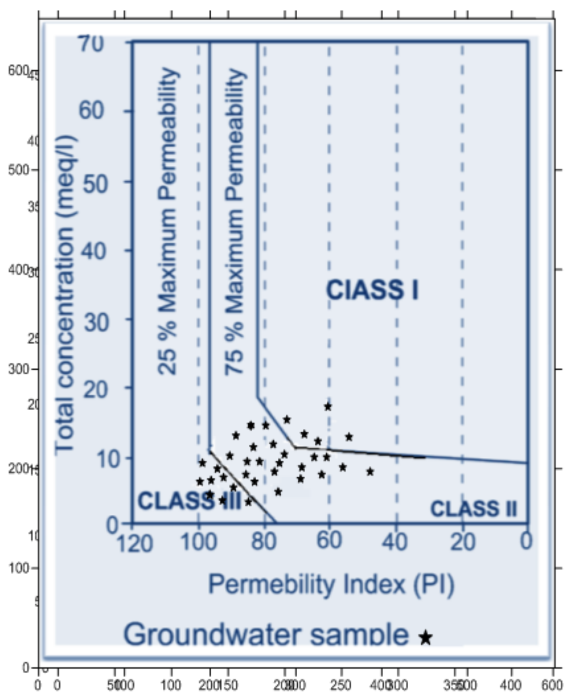

Fig. 3. Doneen Classification (1964) of Irrigation Water Based on The Permeability Index of Study Area.

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