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Groundwater quality parameters in Naguleru Sub-Basin of Guntur District, Andhra Pradesh, India

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ABSTRACT

Water has been a precious resource for human life. The extent of utility of water resource for any purpose is dependent on a variety of factors like economic development, standard of living, industrialization and agriculture practices in a particular region. The ground water is a major source of domestic and agricultural activities in the present study area. The study area is classified into two divisions, the northern Command area and the southern Non-command area both lying in the same climatic region. The Command area is occupied by limestones and the Non-command area by hills of Quartzites, Phyllites and Shales. The results revealed that ground waters in the study area are slightly alkaline in nature. In terms of potability, although, concentrations of many parameters are within the limits of dirnking water quality standards (WHO (1993), ISI(1991) the ground water of the area is effected by the excess of salinity content, the excess of which can cause gastrointestinal problems to the local population.

Introduction

Naguleru sub-basin of Krishna river is situated in the Palnad basin, on the western part of the Guntur District of Andhra Pradesh State of India as shown in Figure1. It is located in between the north latitudes of $16^{0}14'29''$ and $16^{0}43'05''$ and the east longitudes of $79^{0}35'24''$ and $79^{0}50'43''$ and it falls in SOI Toposheet Nos.56 P/10, P/11, P/12, P/14 and P/15 on 1:50,000 scale. The areal extent of the study area is 572 sq.km., of which 201.09 sq km area is covered by forests and hills, the study area is covered by the five mandals. There are about 22 revenue villages and 25 hamlet villages in the Naguleru-sub basin.

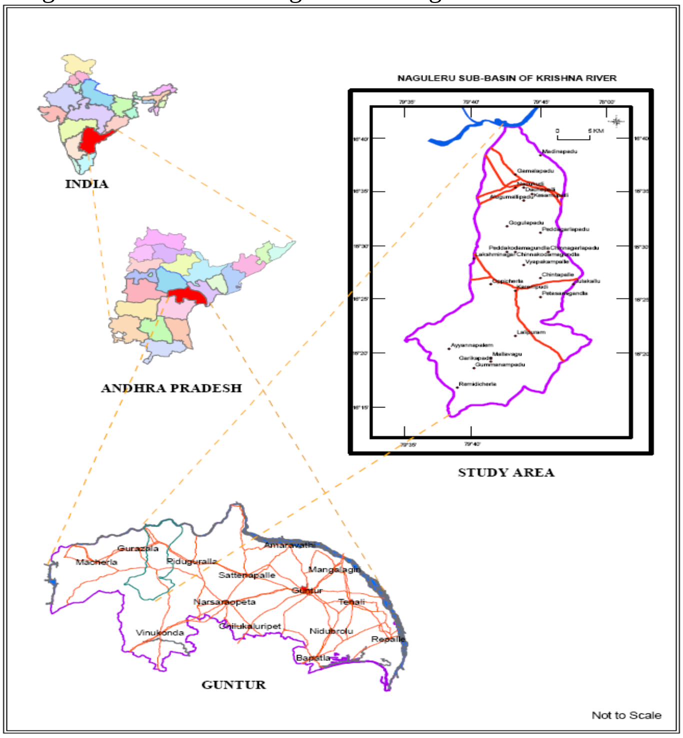

Fig. 1 Location Map of the Study Area

Physiography

Naguleru sub-basin is physiographically divided into two parts, i.e., 1) the non-command area (southern part) and 2) the command area (northern part). Within this sub-basin some isolated hills are observed with steep to medium slopes. On the periphery of Krishna River, steep sided gorges are also observed. Thus the topography is highly undulating having high to moderate slopes in the foothill zones and moderate to gentle slopes in middle zones of the study area. The study area covers 572 sq kms.

Geology:

The study area generally comes under Cuddapah Super Group, particularly Kurnool group. The granite gneisses belonging to Archean age form the basement in the area above which quartzite and limestones were deposited (GWD, Guntur, Government of Andhra Pradesh, 1998). The northern half of the study area mainly consists of Nargi lime stones except at northern part where a patch of Banaganapalli conglomerates and quartzites is vividly observed. They are horizontal at some places and dipping in SE direction with amounts varying from 2^{0}-35^{0}. Higher dips are observed in south of Gogulapadu village (GWD, Guntur, Govt. of A.P., Jan 1999). The southern portion is mostly occupied by Cumbhum shales/phyllites. The other minor formations include Cumbhum dolomite/limestone, Cumbhum quartzites, Koilakuntla limestones, Banaganapalli conglomerate/quartzite. The Koilakuntla limestone triangular in shape is underlined by Cumbhum quartzite as the basement.

Methodology:

A total of 50 water samples were collected in the study area in a grid pattern of 2x2 km in polythene bottles(2 litres) from bore wells and hand pumps that were extensively used for domestic and irrigation purpose. The techniques and methods that followed for collection, preservation, analysis and interpretation of water samples are as given by Thatcher (1960), Brown et al. (1970), Hem (1970) and APHA (1992). The pH and EC were measured with portable ion meters. TDS and

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Calcium were estimated by EDTA titrimetric method, and magnesium estimated by the difference of the hardness and calcium. Total alkalinity, carbonate and bicarbonate, chloride were estimated by titrimetric method. Sodium and potassium were estimated by flame photometer. The sulphate estimation were done by the gravimetric method. The silica is analysed by the UV-spectrophotometer. Total dissolved solids were estimated using calculation method. SAR, RSC were computed from milli-equavalent values of calcium, magnesium, sodium, potassium , carbonate, bicarbonate, sulphate and chloride.

Results and Discussions

The constituents analyzed and the parameters computed include silica, calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulphate, chloride, fluoride, total dissolved solids, hardness as $CaCO_3$ alkalinity as $CaCO_3$, non-carbonate hardness, specific conductance, hydrogen-ion concentration (P^H), sodium adsorption ratio (SAR), per cent sodium, potential salinity (PS) and residual sodium carbonate (RSC). From the Table No.3 it is clear that the majority of the chemical constituents are within the limits of WHO and ISI standards.

The source of silica is mostly from quartzites, while other rocks also contribute by their constituent minerals (feldspars and ferromagnesian minerals). Silica concentration in the quality of water ranges between 4 mg/l and 26 mg/l with an average of 13.3 mg/l. Calcium is an important cation and is abundant in ground water being derived from limestone, dolomite and gypsum and also derived from cation exchange process (Garrels 1976) . Weathering of metamorphic rocks also releases Ca^{+2} from minerals such as feldspars, amphiboles and pyroxenes. The mean Ca value of the study area is 51 mg/l and is within the normal range as the desirable limit of calcium for drinking water is 75 mg/l (ISI, 1983). Magnesium and calcium are the two elements mainly responsible for hardness of water. Limestone and dolomite are the major magnesium-bearing minerals. The presence of carbon dioxide influences the solubility of magnesium. The desirable limit of magnesium in natural water is 30 mg/l (ISI, 1983). The concentrations in majority of the samples fall within the desirable limit. The concentration of Mg varies between 4.8 mg/l and the 96 mg/l and the average is 43.68mg/l. Sodium is released into ground water due to weathering of plagioclase feldspars, clay minerals and amphiboles. The Na concentration ranges between 47 mg/l and 410 mg/l with an average of 176.76mg/l. Potassium in many respects is similar to sodium. In ground water, potassium is released due to weathering of metamorphic rocks rich in orthoclase, microcline and muscovite etc. It is less abundant than sodium. The highest value is recorded in sample no.3 which is due to gneissic rock. Potassium is very minute in the waters in general and it varies between 2 mg/l and 90 mg/l. and a mean of 9.28 mg/l.

The carbonate is very essential anion in the quality of water. It ranges from 20 mg/l and 120 mg/l with an average of 52.13 mg/l. The desirable limit of these two in the drinking water is 400mg/l of carbonates and 100mg/l of bicarbonates. The bicarbonate of water quality varies between 70 mg/l and 400 mg/l with mean of 209.60. Sulphate is found in smaller concentrations in most of the natural waters. Pyrite crystals are the main source of sulphate concentration in ground water, the other mineral being gypsum (Elango et al. 2003 ; Jeevanandam et al. 2006). Sulphate ions are readily soluble in water and removed by barium (Ba) and strontium (Sr). The sulphate concentration is high and ranges between 11.3 mg/l and 433.2 mg/l. with the mean of 106.73 mg/l. In all the natural waters chloride is present and the desirable range is 250 mg/l. The various minerals such as apatite, mica and hornblende are the sources of chloride concentration in ground water. Chloride in water is a stronger oxidizing agent than oxygen. Chloride present in water is harmful for bacteria and it improves the quality of water. Chloride is an important anion and indicates hardness of water. The chloride ranges from 11 mg/l and 586 mg/l with the mean value of 221.11.

Total Dissolved Soilds (TDS)

The total dissolved solids are important in judging the quality of water as these indicate hardness of water. The TDS ranges between 321 mg/l and 1776 mg/l. with the mean of 780.43 mg/l .

Table. No.1 Classification of Waters basing on TDS

TDS Range (in mg/l)	Class	No. of samples from the study area
Up to 500	Desirable for drinking	14
500 to 1,000	Permissible for drinking	24
1000 to 3,000	Useful for agricultural Purposes (slightly saline)	12
3000 to 10,000	Moderately saline	--
10,000 to 35,000	Very saline	--
Above 35,000	Brine	--

Hardness, the most important property of water, is mainly due to the presence of carbonate, calcium and magnesium. It is expressed as an equivalent amount of $CaCO_3$. The hardness value is generally termed as hardness as $CaCO_3$ or total hardness. Carbonate hardness includes only that portion of the hardness equal to the HCO_3 + CO_3. If the hardness exceeds alkalinity, the excess is termed as non-carbonate hardness. The hardness of the water samples ranges from 110Mg/l to 620 Mg/l with an average of 355 mg/l.

Sodium Adsorption Ratio (SAR)

The U.S. Salinity Laboratory (1954) proposed the use of sodium adsorption ratio (SAR) for adjudging the quality of water for the use of agricultural purposes. This method utilizes SAR and electrical conductivity as a basis for rating irrigation waters. Kelly (1951) pointed out the importance of sodium concentration in assessing the suitability of ground water for irrigation. Excess sodium in irrigation water reacts with soil and results in clogging of particles and reduction of permeability.

In irrigation water, the values of SAR are used as basis for predicting the alkali or sodium hazard that may result from the use of water. High SAR value may cause damage to soil. SAR refers to the predominance of the Na over Ca and Mg ions and is related to the adsorption of Na ions by soil to which water is added.

Table No.2. Classification of Irrigation water on the basis of SAR

SAR	Water Class	No. of samples from the Study area	Percent
$<$ 10	Excellent	46	98
10 - 18	Good	04	02
18 - 26	Fair	--	
$>$ 26	Poor	--	

As per the above classification 98 per cent of waters in the study area are excellent and 2 per cent are good.

Table. No.3. Standards for quality of drinking water

Chemical Constituents	W.H.O. Standards 1993		Indian Standards 1991		Study area
	Highest Desirable	Maximum permissible	Highest Desirable	Maximum permissible	Mean Values
	(Values are in mg/l)				
Calcium	75	200	75	200	51
Magnesium	30	150	30	150	43.68
Sodium	-	200	-	-	176.5
TDS	500	1500	500	1500	780
Total Hardness	100	500	300	600	355
$CaCO_3$	75	200	75	200	103
Chloride	200	600	250	1000	221
Sulphate	200	400	150	400	128
pH	7.0 – 8.5	6.5 – 9.2	6.5 – 8.5	8.5 – 9.2	7.3

Table.No.4 Analysis of Ground water samples

S.No	Constituents	Command Area	Non-Command Area
1	SiO2 (mg/l)	4 - 22	5 - 26
2	Ca^{2+} (mg/l)	36 - 84	20 - 64
3	Mg^{2+} (mg/l)	4.8 - 96	12 - 91.2
4	Na^{+} (mg/l)	59 - 400	47 - 266
5	K^{+} (mg/l)	2 - 14	3 - 20
6	$CO3^{-}$ (mg/l)	40 - 120	40 - 100
7	$HCO3^{-}$ (mg/l)	80 - 290	220 - 400
8	$SO4^{-}$ (mg/l)	22.07- 33.2	43 - 120
9	Cl^{-} (mg/l)	50 - 586	11 - 365
10	TDS mg/l)	342- 1776	468 - 933
11	Hardness as CaCO3 (mg/l)	140 - 600	330 - 460
12	Alkalinity as CaCO3 (mg/l)	110 - 470	250 - 490
13	NCH (mg/l)	10 - 380	10 - 200
14	EC (m.mhos/Cm)	560 - 2900	785-1560
15	pH	6.5 - 8.1	7.4 - 7.9
16	SAR (meq/l)	2.5 - 10.70	1.0 - 9.48
17	% Na (meq/l)	42.4 - 77.6	23.4 - 100
18	PS (meq/l)	1.6 - 21.1	2.6 - 11.0
19	RSC (meq/l)	0.02 - 2.69	0.3 - 6.7

Conclusions

The results revealed that ground waters in the study area are slightly alkaline in nature. In terms of potability, although, concentrations of many parameters are within the limits of dirnking water quality standards (WHO (1993), ISI(1991) the ground water of the area is effected by the excess of salinity content, the excess of which can cause gastrointestinal problems to the local population. Excess salinity effects the potability of groundwater. The hard ness of water is based on TDS. Of all the samples 14 samples fall within the limits of desirable for drinking purpose and 24 samples fall within limits of permissible for drinking and the remaining 12 samples fall within the limits of useful for agriculture utility (slightly saline).

The sodium and alkali hazard is expressed in terms of SAR. Based on SAR the maximum number of samples(46) fall in excellent class (i.e.,SAR <10) and four samples in good class (i.e.,SAR 10-18). Bicarbonate dominance can be attributed to dissolution and leaching of calcareous aquifer rocks.

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