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Assessment of Quality of Ground Water in and Around Kurnool, Andhra Pradesh, India.

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ABSTRACT

The Chemical quality of ground water in Kurnool area has been taken up for evaluation of its suitability for drinking, irrigation and industrial purposes. Ground water samples from drinking water sources were collected. The quality analysis has been made through the estimation of Na^+, K^+, Ca^{2+}, Mg^{2+}, CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, TDS, EC, pH and calculations of SAR, RSC PS, PI and SSP. The analytical data show that ground water of the study areas is suitable for general domestic purpose and agricultural purposes. The observations reveal that most of the ground water samples are alkaline in nature and have high hardness.

Keywords: ground water, quality analysis,

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INTRODUCTION

Galloping population, rapid industrial development and excessive and ceaseless use of fertilizers and pesticides in agriculture vitiated the quality of ground water. Hence quality of ground water has become one of the important environmental issues. Ground water is an important source for domestic, agricultural and industrial consumption. Quality of ground water demands as much as its quantity and it is described by its physical, chemical and biological characteristics which are interlinked. Quality of ground water and its suitability for drinking and irrigational purposes is important for its safe and effective use. Several studies were made on the quality of ground water [1-3]. The present study deals with ground water quality of Kurnool of Andhra Pradesh, India with special reference to suitability of ground water for drinking and irrigation purposes. Since the study area is a semi-arid region, ground water is the primary source for drinking water.

Study Area

The Kurnool which is named after its headquarters, lies in the south-west corner of Andhra Pradesh. The study area is drained by Tungabhadra river and industries are present in and around Tungabhadra river. Climatologically, the study area falls under semi-arid region and receives rainfall from south-west monsoon from June to September and north-east monsoon from October – December. The average annual rainfall is 1063 mm, of which monsoon rainfall is 820 mm. The soils of the study area are mostly red loamy type and in small portions with a black cotton soils. The usual crops grown are chillies, groundnut and paddy.

METHODS AND MATERIALS

Forty ground water samples were collected from different sources which are extensively used for drinking and other domestic purposes. The chemical analysis is carried out by using AAS. Major chemical constituents like K^+, Ca^{2+}, Mg^{2+} (Cations); CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-} (Anions); pH and EC were measured. The constituents analysed and parameters computed are Si, Ca, Mg, Na, K, CO_3, HCO_3, SO_4, Cl, TDS, EC, pH, SAR, SSP classification.

RESULTS AND DISCUSSION

The general chemical characteristics of ground water samples are shown in Table 1. The average chemical quality of selected parameters, which contribute to drinking and irrigation quality, is given in Table 2. The water quality of the study area has been evaluated for domestic and irrigational purposes.

Table 1: Statistical Parameters of ground water samples

Sl. No.	Constituents	Units	Min.	Max.	Mean	S.D.	C.V.
1	Silica	mg/l	2.5	50.0	19.19	7.42	38.67
2	Calcium	mg/l	14.0	138.0	40.85	24.10	59.00
3	Magnesium	mg/l	1.0	271.0	36.40	39.10	107.42
4	Sodium	mg/l	14.0	432.0	157.20	91.21	57.39
5	Potassium	mg/l	0.0	372.0	62.48	60.09	96.17
6	Carbonate	mg/l	0.0	134.0	62.65	24.14	38.53
7	Bicarbonate	mg/l	110.0	1020.0	387.60	179.60	46.34
8	Sulphate	mg/l	0.0	110.0	33.67	20.50	60.89
9	Chloride	mg/l	16.0	1016.0	141.80	119.60	84.34
10	Total Dissolved Solids	mg/l	248.0	1841.0	744.10	239.00	32.16
11	Hardness as $CaCO_3$	mg/l	61.0	1360.0	246.09	152.19	61.84
12	Alkalinity as $CaCO_3$	mg/l	92.0	1026.0	406.18	177.19	43.80
13	Non-Carbonate Hardness	mg/l	0.0	1111.0	31.62	113.86	360.09
14	Specific Conductance	μ mhos/cm	421.0	2630.0	1167.00	378.40	32.43
15	PH		7.0	10.8	8.10	0.62	7.38
16	Sodium Adsorption Ratio		0.2	21.9	4.85	3.20	65.98
17	Per cent Sodium		22.3	96.8	62.24	16.12	25.90
18	Potential Salinity		0.7	29.0	4.33	3.39	78.29
19	Residual Sodium Carbonate		0.0	21.2	4.40	3.27	74.32

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Table 2: Sodium Adsorption Ratio Classification

Sl.No.	SAR	Water Category	No. of Samples from the study area
1	< 10	Excellent	36
2	10 – 18	Good	2
3	18 – 26	Fair	1
4	> 26	Poor	1

Suitability of ground water for domestic purposes

The suitability of ground water for domestic purposes has been evaluated on the basis of hardness, total dissolved solids and chloride concentrations. Moreover, Collin's ratio has been computed for the evaluation of ground water for drinking purposes.

The silica present in the ground water varies between 2.5 mg/l and 50.0 with an average of 19.19 mg/l due to the presence of excessive granites and gneisses. The pH of ground water ranges from 7.0 to 10.8 and the water can be said to be neutral to high alkaline. Hardness is one of the important parameters in the evaluation of quality of water. Hardness in ground water is primarily due to the presence of HCO_3^{-1}, SO_4^{2-}, Cl^- and nitrates of calcium and magnesium. The hardness as $CaCO_3$ of the ground water in the study area ranges from 61 mg/l to 1360 mg/l with an average of 246.09 mg/l. Hardness is believed to have no harmful effects on human beings. Total dissolved solids indicate the general quality of ground water. The TDS values in the study area vary from 248 mg/l to 1841 mg/l. The mean calcium and magnesium concentrations are 40.85 mg/l and 36.40 mg/l respectively and more than 95 % of the samples are within the Indian standards. The high concentration of Ca, Mg and total hardness can cause encrustations in water supply structures and adverse effect on domestic use. However, hardness is temporary in nature and can be removed by boiling.

Chloride is the best indicator of pollution. Chloride concentration varies from 16 mg / l to 1016 mg/l with an average of 141.80 mg/l. Excess chloride concentration in ground water effects potability of water and also causes corrosion of the water supply structure. The sulphate concentration ranges from 0 mg/l to 110 mg/l with an average of 33.67 and is below the desirable limit of the 200 mg/l and hence the water is potable with respect to sulphate concentration.

Suitability of ground water for irrigational purposes

The chemical quality of ground water is an important factor considered in evaluating its suitability for irrigation purposes. Suitability of ground water for irrigation depends upon its mineral constituents. Salts present in the water, besides affecting the growth of plants, directly also affect the soil structure, permeability and aeration, which indirectly affect the plant growth. It is an imperative to have knowledge of ground water quality before utilization and recommending for irrigation. Some of the adopted methods to evaluate ground water suitability for irrigation are Sodium Adsorption Ratio (SAR), and Potential Index (PI) and are presented in the Table 3.

Sodium hazard

Due to the process of base exchange, the sodium present in the soil is replaced by the calcium and reduces the permeability of soil, which has greater effects on the plant growth. Therefore it is very important factor in classifying irrigation water. Sodium content in chemical analysis is reported as per cent sodium, which is defined (Wilcox, 1948) as

$$\text{Percent Sodium} = \frac{Na + K}{Ca + Mg + Na + K} \times 100$$

Sodium Adsorption Ratio (SAR)

Sodium Adsorption Ratio (SAR) refers to the predominance of Na over Ca and Mg ions and is related to the adsorption of Na ions by soil to which water is added. The relative abundance of sodium in exchange reaction with soil is expressed in terms of a ratio known as Sodium Adsorption Ratio (SAR), which is defined as

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$$SAR = Na / \sqrt{Ca + Mg/2}$$

High sodium leads to the development of alkali soil, which has unfavourable structure and restricts aeration. The samples are classified basing on SAR and is shown in the Table 3. The ground water of the study area is excellent for irrigation.

Table 3: Indices water quality parameters

Sampling station	TDS	SP. Con.	SAR	Percent Sodium	PI
1	248	420	1.02	29	55.56
2	737	1196	2.10	45	56.08
3	881	1462	4.03	53	67.29
4	376	610	0.75	39	53.49
5	456	796	0.97	40	49.03
6	1841	2630	1.59	23	23.75
7	843	1221	3.72	52	64.26
8	709	1069	2.80	46	62.88
9	620	951	1.43	54	63.57
10	673	958	0.60	47	41.36
11	578	991	2.44	43	68.11
12	722	1192	3.05	50	61.58
13	697	1259	3.76	55	70.14
14	652	1096	3.07	49	62.22
15	876	1359	3.95	53	64.59
16	705	1265	7.85	79	96.79
17	443	690	2.40	53	70.35
18	626	998	4.53	72	86.48
19	719	1153	3.72	56	66.46
20	828	1354	3.14	51	59.63
21	1199	1811	3.03	44	33.70
22	565	843	9.26	83	106.27
23	603	938	3.07	64	77.92
24	688	1160	3.38	73	84.95
25	325	511	0.62	22	45.38
26	682	1059	5.01	62	75.08
27	869	1500	3.57	54	64.25
28	522	861	6.13	77	98.65
29	623	992	3.81	56	72.89
30	855	1320	2.59	69	82.24
31	857	1311	1.82	64	68.33
32	942	1591	8.25	78	92.95
33	586	961	2.77	53	68.22
34	669	1051	2.26	51	62.02
35	488	798	2.49	55	72.50
36	708	1158	13.55	90	112.80
37	443	672	1.67	54	67.73
38	991	1562	5.73	67	80.99
39	695	1173	1.11	50	54.29
40	678	1088	1.58	31	44.19

Permeability Index

Doreen (1964) classified irrigation waters [4] based on the Permeability Index (PI), where

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$$PI = \frac{Na + \sqrt{HCO_3}}{Ca + Mg + Na} \times 100$$

Waters can be classified as Class I, Class II and Class III orders. Accordingly, Class I and Class II waters can be categorized as good for irrigation with 75 per cent or more causing maximum permeability. Class III waters are unsuitable with 25 per cent of maximum permeability. About 65 per cent of waters belong to Class I and 35 per cent to Class II waters and 25 per cent to Class III, which belong to unsuitable category.

Factor Analysis

Factor analysis is a technique of quantitative multivariate analysis with the goal of representing the interrelationships among a set of variables or objects. Factor analysis gives a simple interpretation of a given body of data and affords fundamental description of a particular set of variables related. The first factor explains 26.8 per cent variance (Table 4). It is strongly loaded positively with EC, SO_4, HCO_3 and Cl (Table 5). Second factor explains 20.1 per cent of the total variance and is strongly loaded with Na, HCO_3, Ca, Mg and Cl. Third factor explains 14.7 per cent of variance to the total variance and strongly loaded with CO_3, pH and Ca. Fourth factor explains 10.1 per cent of the total variance and strongly loaded on Potassium only and the fifth factor explains 9.3 per cent of the total variance and strongly loaded with Mg and Ca.

Table 4: Eigen Values

Sl. No.	Eigen Value	Per cent of Variance	Cumulative Per cent of Variance
1	2.682	26.8	26.8
2	2.009	20.1	46.9
3	1.467	14.7	61.6
4	1.010	10.1	71.7
5	0.928	9.3	81.0
6	0.737	7.4	88.4
7	0.615	6.1	94.5
8	0.346	3.5	98.0
9	0.131	1.3	99.3
10	0.075	0.7	100.0

Table 5: Factor Loadings

Sl. No.	Factor Constituent	Factor Loadings									
		1	2	3	4	5	6	7	8	9	10
1	Ca	0.093	-0.377	-0.417	-0.073	-0.386	0.169	0.063	0.484	-0.232	-0.078
2	Mg	0.276	-0.380	0.243	0.239	0.412	-0.425	-0.023	0.329	-0.391	-0.204
3	Na	0.307	0.433	-0.237	0.349	-0.134	0.033	0.074	-0.362	-0.368	-0.178
4	K	0.236	-0.138	0.336	-0.740	-0.148	-0.066	0.190	-0.321	0.309	-0.069
5	CO_3	0.194	0.230	0.439	0.102	-0.304	-0.236	-0.590	0.132	0.033	-0.172
6	HCO_3	0.334	0.432	-0.179	-0.201	0.106	-0.313	0.374	0.390	0.083	0.471
7	SO_4	0.371	0.081	0.087	-0.143	0.337	0.720	-0.321	0.236	-0.103	0.110
8	Cl	0.339	-0.481	-0.020	0.301	-0.076	0.066	0.098	-0.300	0.104	0.604
9	pH	-0.092	0.096	0.393	0.308	-0.208	0.327	0.386	0.197	-0.013	-0.028
10	EC	0.384	-0.007	-0.042	0.041	-0.076	-0.017	0.103	-0.053	0.388	-0.339

CONCLUSIONS

Ground water quality of the study area has been assessed basing on the chemical data. Most of the chemical constituents are within the permissible limits prescribed by WHO for both drinking and irrigation purposes. Above all ground water is having high hardness, alkalinity and low salinity. Collin's ratio indicated that ground water is safe for drinking but a few samples are slightly contaminated. According to SAR, all ground water samples are suitable for irrigation. Factor analysis indicates 5 factors, which are responsible for variation in the quality of ground water, such as conductivity factor, sodium factor, carbonate factor,

potassium factor and magnesium factor. More or less ground water in the study area is suitable for all the purposes except at few places where ground water is unsuitable for irrigation. The results of the study provide information needed for ground water quality management in the study area.

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