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Assessment of groundwater quality for irrigation purpose in Medak district, Telangana

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Abstract
The present study represents the quality of ground water of Medak district of Telangana state, India during the month of November and December of year 2023. Total 168 ground water samples from bore wells were collected and GPS locations of sampling points were recorded from Medak. The ground water samples were analyzed for quality parameters physico-chemical and chemical properties *viz.*, pH, EC, Na^+ and Ca^{+2}+Mg^{+2}. The Sodium Adsorption Ratio was also calculated for these ground water samples. The results found that all ground water samples from Medak district were neutral to alkaline in reaction and having pH 7.02 during pre-monsoon and 7.48 during post-monsoon season respectively. The pH, EC and SAR in groundwater ranged from 6.76-8.67, 0.23-2.53 (dS m^{-1}), and 0.32-8.93 %, respectively. The concentration of cations *viz.*, Ca^{+2}+Mg^{+2} and Na^+ varied from 0.8-8.6 meq L^{-1}, 0.4-14.4 meq L^{-1} with mean values of 4.5,7.4 me L^{-1}, respectively. The relative abundance of ions for most of the water samples were Ca^{+2}+Mg^{+2} > Na^+ for cations. The study revealed that based on SAR 100% samples were in excellent category for irrigation (<10 SAR).

Keywords: Groundwater quality, electrical conductivity, sodium adsorption ratio, Medak, irrigation suitability.

Introduction
Water is essential for the organic ecosystem of modern society, which also plays an important role in the development of irrigation, industrial and scientific societies (Rao *et al.*, 2022) [1]. Groundwater is the main source of water for drinking and irrigation in India and its overall development is about 63.33% at national level. The stage of ground water development is very high in the northern states of Delhi (119.61%), Haryana (136.91%), Punjab (165.77%) and Rajasthan (139.88%). In case of southern Peninsular India, the groundwater development is 80.94% in Tamil Nadu, 69.87% in Karnataka while 48.77% in Andhra Pradesh and Telangana. It was lower in the southern states as the quantum of groundwater available from aquifers is lesser due to hard rock geology (Kaledhonkar, *et al.*, 2022) [2].
The importance of irrigation has increased in agriculture throughout the world as the irrigated area has increased substantially during the last few decades. Earlier in 1950's net irrigated area was 20.80 million hectares which has increased to three fold and in 2020-21 the area under net irrigation is 68.6 million hectares (Annual report 2020-21, DOAFW). According to Rao *et al.*, 2014 [3] over extraction of ground water brings salts to soil surface where they get precipitated when water evaporates.
Indiscriminate use of poor quality water for irrigating agricultural crops deteriorates the productivity of soils through salinity, sodicity and toxic effects. Salinity and sodicity risk associated with groundwater irrigation jeopardizing crop productivity (Kamra *et al.*, 2002) [4]. India accounts for 2.2% of the global land and 4% of the world water resources and has 16% of the world's population. The excessive use of low-quality groundwater can lead to accumulation of salts in soil. It is estimated that by 2050, 50 per cent of world arable land will be affected by salinity (Bartels and Sunkar, 2005) [5]. The use of ground water of marginal (saline or sodic) and poor (highly sodic or both) quality for irrigation may degrade the soils especially at the tail end of the canal system. This practice may also give rise to some apparent and hidden soil problems directly or indirectly associated with tube well irrigation. In arid areas the accumulation of salts

in the soil is faster under irrigation than non-irrigated conditions. Therefore, by far the largest proportion of saline soils has developed under the influence of irrigation. The effect of ground water on soil salinity is often left out consideration**.**

According to an estimate, 20% of total cultivated and 33% of irrigated agricultural lands worldwide are afflicted by high salinity (Shrivasata and Kumar, 2015) [6]. Around 52 million ha lands are salt-affected in South Asia. Around 85% area worldwide is only slightly to moderately affected by high salt concentrations while the remainder 15% suffers from severe to extreme limitations for crop cultivation (Wicke *et al*., 2011) [7]. In India, the salt-affected soils constitute nearly 5% of the net cultivated area, spreading from Jammu & Kashmir (Ladakh region) in north to Kanyakumari in south, and Andaman & Nicobar Islands in the east to Gujarat in the west.Soil salinization, in addition to reducing net cultivable area, has serious implications for agricultural productivity and quality, the choice of cultivable crops, biodiversity, water quality, supply of water for critical human needs and industry, the longevity of infrastructure and the livelihood security of the people. For all important crops, average yields in salt stressed environments are only a fraction, somewhere between 20 and 50% of record yields (Shrivasata and Kumar, 2015) [6].

Groundwater always contains little amount of soluble salts. The kind and quality of these salts depend upon the sources for recharge of the groundwater and the strata through which it flows. Agriculture sector used 89 per cent of water resources, good quality water availability for agriculture will reduce because of increased demand by industries, energy sector and municipalities by 2025. The chemical parameters of groundwater play a significant role in classifying and assessing water quality. Considering the individual and paired ionic concentration, certain indices are proposed to find out the alkali hazards. Residual sodium carbonate (RSC) can be used as a criterion for finding the suitability of irrigation waters. It was observed that the criteria used in the classification of waters for a particular purpose considering the individual concentration may not find its suitability for other purposes and better results can be obtained only by considering the combined chemistry of all the ions rather than individual or paired ionic characters (Sadashivaiah *et al.,* 2008) [8].

Therefore, water quality assessment and it's management options need to be given greater attention in developing countries. The quality of groundwater plays an important role in classifying and assessing water quality. Quality of irrigation water is an important consideration in irrigated areas and it depends on primarily on the salt concentration and magnitude of sodium to other cations (Singh, A., 2019) [9].

In Telangana, there was 51 per cent increase in the gross sown area from 131 lakh acres (2014) to 198 lakh acres (2021-22) with 117 per cent rise in irrigated area after bifurcation. In Medak district there are about 65492 tube wells. Saline sodic soils area in Medak district is 34341 ha which comprises of 12.42 per cent of total area of Medak district. The groundwater quality was drastically deteriorated by many factors such as: anthropogenic, agricultural pesticides, water rock interaction, industrial waste, municipal waste, leakage of septic tanks, animal and human waste. Therefore, the present study was initiated to estimate the ground water quality and extent of saline area in Medak district of Telangana state (Telangana State Statistical Abstract, 2021).

Materials and Methods

The study area was Medak district, one of the Western districts of Telangana lies approximately between 17°27' to 18°19' North Latitudes and 77°28' to 79°10' East Longitudes. The district shares boundaries with Sangareddy, Kamareddy, Siddipet and Medchal districts and bounded on the North by Nizambad and Karimnagar, East by Warangal and Nalgonda, South by Rangareddy district and West by Karnataka State. The total area of the district is 2,765 Sq. Km and ranks 16th position contributing about 3.53 % area of the State. The shape of the district is rectangular from West to East.

Medak district is situated at a considerable distance from the sea-coast, the climate is tropical and is characterized by hot summer and dry except during the South-west monsoon season. As per the climate conditions of the district, the year may be divided into four seasons. The hot (summer) season is from March to May. From March onwards the temperature continues to rise and May is generally the hottest month in the year. The period from June to September constitutes the South-west monsoon (SW rainy) season and October to December is North-East monsoon (NE rainy) season. The cold (winter) season is from January to February. With the advance of South-west monsoon by about the middle of June there is an appreciable drop in temperature. By October the day temperature begins to increase slightly, but the night temperature steadily decreases. After November, both day and night temperature decreases rapidly.

The average rainfall in the district is 713 mm per annum. The average number of rainy days in the district was 37. The maximum temperature in the district averaged is 38.7 °C. The minimum temperature averaged is 11.8 °C.

A total of 168 samples were collected and GPS locations of sampling points were recorded. The water samples were analyzed for various physico-chemical and chemical properties *viz*., pH, EC, Na^+ and Ca^{+2}+Mg^{+2}.

Table 1: Methods used for estimation of different hydro-chemical parameters of groundwater

S. No.	Parameter	Method	Reference
1.	pH	Digital pH meter	Richards (1973)
2.	EC (dS m^{-1})	Conductivity meter	Richards (1973)
3.	Ca^{+2}+Mg^{+2} (meq L^{-1})	Versenate titration method	Richards (1973)
4.	Na^+ (meq L^{-1})	Flame photometry method	Richards (1973)
5.	Sodium Adsorption Ratio (SAR)	$SAR=[Na^+]/\sqrt{([Ca^{2+}]+[Mg^{2+}])/2}$	Richards (1973)

Table 2: Ground water quality parameters of Medak district

S. No.	Mandal	No. of samples	pH		EC (dS m -1)		SAR	
			Range	Mean	Range	Mean	Range	Mean
1.	Alladurg	8	7.16-8.26	7.71	0.36-2.15	1.26	0.32-4.25	2.28
2.	Chegunta	8	7.62-8.19	7.91	0.38-0.81	0.60	0.70-3.80	2.25
3.	Chilpiched	8	7.93-8.48	8.21	0.39-1.15	0.77	1.61-4.74	3.18
4.	Haveli Ghanpur	8	6.94-8.67	7.81	0.43-2.53	1.48	0.51-8.93	4.72
5.	Kowdipally	8	7.92-8.42	8.17	0.29-1.10	0.70	0.60-1.94	1.27
6.	Kulcharam	8	7.00-8.52	7.76	0.36-0.83	0.60	1.00-4.73	2.87
7.	Manoharabad	8	6.83-7.48	7.16	0.24-0.92	0.58	0.54-4.34	2.44
8.	Masaipet	8	6.76-8.25	7.51	0.26-2.29	1.28	1.03-3.47	2.25
9.	Medak	8	7.35-8.29	7.82	0.37-1.81	1.09	0.59-3.73	2.16
10.	Narsapur	8	7.81-8.33	8.07	0.29-0.90	0.60	0.58-4.06	2.32
11.	Narsingi	8	7.49-8.27	7.88	0.63-1.04	0.84	0.58-5.38	2.98
12.	Nizampet	8	7.59-8.23	7.91	0.64-2.21	1.43	1.05-4.49	2.77
13.	Papanapet	8	7.94-8.46	8.20	0.51-1.29	0.90	0.51-7.80	4.15
14.	Ramayampet	8	7.45-8.32	7.89	0.49-0.87	0.68	1.64-3.91	2.78
15.	Regode	8	6.95-8.10	7.53	0.31-0.66	0.49	0.56-3.01	1.79
16.	Shankarampet A	8	6.94-8.22	7.58	0.38-0.66	0.52	0.37-2.83	1.60
17.	Shankarampet R	8	6.86-7.38	7.12	0.23-0.67	0.45	0.67-2.54	1.60
18.	Shivampet	8	6.96-8.32	7.64	0.54-2.26	1.40	0.75-5.55	3.15
19.	Tekmal	8	7.49-8.46	7.98	0.58-1.45	1.02	0.53-4.26	1.85
20.	Toopran	8	7.50-8.10	7.80	0.58-1.93	1.26	1.44-4.88	3.16
21.	Yeldurthy	8	7.19-8.13	7.66	0.44-0.88	0.66	0.76-3.58	2.17
Average			6.76-8.67	7.71	0.23-2.53	1.38	0.32-8.93	4.62

Results and Discussion

pH of water samples

The pH values of water samples ranged from 6.76 to 8.67 with mean value of 7.71. The highest mean pH value was found in paddy grown area in Haveli Ghanpur (8.67) *mandal* and the lowest was found in paddy grown area in Masaipet (6.76) *mandal*. The pH value of most of the samples was below 8.0. The high pH of water might be due to anthropogenic activities such as fertilizer use in the study area.

Electrical Conductivity (dS m^{-1})

The electrical conductivity of water samples ranged from 0.23 to 2.53 dS m^{-1} with mean value of 1.38 dS m^{-1}. The highest mean EC value was found in paddy grown area in Haveli Ghanpur (2.53) *mandal* and the lowest was found in paddy grown area in Shankarampet R (0.23) *mandal*. The large variation in EC is mainly attributed to geochemical process like ion exchange, reverse exchange, evaporation, silicate weathering, rock water interaction, sulphate reduction and oxidation processes and anthropogenic activities like application of agrochemicals (Ramesh and Elango, 2012) [10].

Sodium Adsorption Ratio (SAR)

SAR identifies category of irrigation water. If it is less than 10, it is best for irrigation purpose. SAR values of water samples ranged from 0.32-8.93 with mean of 4.62. The highest mean SAR value was found in paddy grown area of Haveli Ghanpur *mandal* (8.93) and the lowest value was in paddy grown area in Alladurg *mandal* (0.32). Proper soil management practices have to be adopted while irrigating to fine textured soils. Chemical amendments like gypsum have to be applied to soils while irrigating with S3 (1826) class water. The high SAR waters can lead to increase in detrimental levels of sodium in soils (Bhat *et al.*, 2018) [11]. The SAR values of irrigation water affect the extent to which sodium is adsorbed by the soil (Sundha *et al.*, 2020) [12].

Table 3: Ionic composition of irrigation water (Soluble cations expressed in meq L^{-1})

S. No.	Mandal	Na^+		$Ca^{+2}+Mg^{+2}$	
		Range	Mean	Range	Mean
1.	Alladurg	0.4-8	4.2	2.7-7.1	4.9
2.	Chegunta	0.8-3.4	2.1	1.4-3	2.2
3.	Chilpiched	1.5-5.3	3.4	1.3-4.1	2.7
4.	Haveli Ghanpur	0.7-14.4	7.5	2-5.2	3.6
5.	Kowdipally	0.7-3.3	2.0	2.1-5.8	3.9
6.	Kulcharam	1.1-4.1	2.6	1.5-5.3	3.4
7.	Manoharabad	0.5-3.5	2.0	1.3-2.3	1.8
8.	Masaipet	0.8-3.8	2.3	1.2-3	2.1
9.	Medak	0.7-5.9	3.3	1.9-5.0	3.4
10.	Narsapur	0.5-4.3	2.4	0.7-3.1	1.9
11.	Narsingi	0.7-5.1	2.9	1.7-3.8	2.7
12.	Nizampet	1.1-5.5	3.3	1.9-3.9	2.9
13.	Papanapet	0.8-7.6	4.2	1.8-4.9	3.3
14.	Ramayampet	1.8-4.4	3.1	1.6-3.8	2.7
15.	Regode	0.7-3.5	2.1	1.3-3.1	2.2
16.	Shankarampet A	0.4-2.9	1.6	0.4-2.9	2.8
17.	Shankarampet R	0.6-2.1	1.3	0.6-2.1	1.8
18.	Shivampet	0.9-8.6	4.7	0.9-8.6	3.0
19.	Tekmal	0.7-7.0	2.4	0.7-7.0	3.7
20.	Toopran	1.7-8.1	4.9	1.7-8.1	3.9
21.	Yeldurthy	0.8-3.5	2.1	0.8-3.5	3.3
Average		0.4-14.4	7.4	0.4-8.6	4.5

Cationic Composition

Sodium was dominant among the cations (mean 7.4 meq L^{-1}). The order of cations in Medak district was $Na^+ > Ca^{+2}+Mg^{+2}$. The cationic concentration followed the order sodium, calcium, and magnesium. The presence of sodium in groundwater primarily results from the chemical decomposition of feldspars (Kumar *et al.*, 2009) [13] and the presence also predicts the sodicity danger of the water (Singh *et al.*, 2018) [14].

Table 5: Classification of ground water samples based on SAR (Richards, 1954)

Class	Value	No. of samples	Percent of samples
Safe	<10	168	100
Moderately safe	10-18	0	0
Moderately unsafe	18-26	0	0
Unsafe	>26	0	0

Classification of Ground Waters

The sodium adsorption ratio (SAR) is an irrigation water quality parameter used in the management of sodium-affected soils. It is an indicator of the suitability of water for use in agricultural irrigation, as determined from the concentrations of the main alkaline and earth alkaline cations present in the water. It is also a standard diagnostic parameter for the sodicity hazard of a soil, as determined from analysis of pore water extracted from the soil (Reeve *et al.*,1954) [15]. Irrigation water having SAR value between 0-10, i.e., low sodium water poses almost no risk of exchangeable sodium, medium sodium water having SAR 10-18 can show considerable hazard, while on the contrary, high and very-high sodium water with SAR 18-26 and greater than 26, respectively, are regarded as unfavourable as they can lead to detrimental levels of exchangeable sodium in soils (Ayers and Westcot, 1976) [16]. According to this classification 100 per cent samples belonged to safe category.

Conclusion

In the present study, the water samples were found to be generally safe with respect to pH, sodium content, and SAR. The concentrations of cations were in the following order: $Na^{+}>Ca^{+2}+Mg^{+2}$. When considering EC 29.16% of the samples were deemed unsuitable for irrigation, specifically in the Papanapet and *Tekmal mandals*. Samples from these mandals were classified as unsuitable for irrigation due to high salt content. Assessing the quality of irrigated groundwater can assist farmers in selecting appropriate crops and implementing agronomic practices to achieve profitable yields while maintaining soil health.

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