E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(8): 532-536
Received: 14-06-2024
Accepted: 21-07-2024

Srividya N
Master Student,
Department of Soil Science and Agricultural Chemistry,
College of Agriculture, PJTSAU,
Rajendranagar, Hyderabad,
Telangana, India

T Anjaiah
Programme Co-Ordinator, KVK,
Rudrur, Telangana, India

Shankaraiah M
Principal Scientist,
Department of Soil Science,
AICRP on Micronutrients,
Agricultural Research Institute,
Rajendranagar, Hyderabad,
Telangana, India

Siva Lakshmi Y
Principal Scientist,
Department of Agronomy, Maize Research Centre, Agriculture Research Institute, Rajendranagar,
PJTSAU, Hyderabad, Telangana,
India

Corresponding Author:
Srividya N
Master Student,
Department of Soil Science and Agricultural Chemistry,
College of Agriculture, PJTSAU,
Rajendranagar, Hyderabad,
Telangana, India

Assessment of groundwater quality for irrigation purpose in Yadadri Bhuvanagiri district, Telangana

Srividya N, T Anjaiah, Shankaraiah M and Siva Lakshmi Y

DOI: https://doi.org/10.33545/2618060X.2024.v7.i8Sg.1327

Abstract
Groundwater is the most important natural resource in arid and semiarid areas. Due to human and industrial activities the quality of ground water is deteriorating often may not suitable for drinking and crop production as well. Thus the quality assessment is essential to maintain the soil and crop productivity at higher levels. The assessment of ground water quality was carried out in Yadadri Bhuvanagiri district. A total of 215 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 CO_3^{-2}, HCO_3^-. The pH, EC, SAR and RSC in groundwater ranged from 1.73-8.84,0.02-4.12 (dS m^{-1}), 0.3-14.29 (mmol L^{-1}), and -47.2-38.6 (meq L^{-1}), respectively. The concentration of cations *viz*., Ca^{+2}+Mg^{+2} and Na^+ varied from 2.2-50.8 meq L^{-1}, 0.8-22 meq L^{-1} with mean values of 12.79,6.17 me L^{-1}, respectively. Concentration of anions *viz*., CO_3^{-2}, HCO_3^-, Cl^- and SO_4^{-2} varied from 0-2.4,0.2-14.6,0.8-31.2 and 0.02-1.82 meq L^{-1} with average values of 0.15, 8.88, 7.35 and 0.29 me L^{-1}, respectively. The relative abundance of ions for most of the water samples were Ca^{+2}+Mg^{+2} > Na^+ for cations and HCO_3^- > Cl^- > SO_4^{-2} > CO_3^{-2} for anions. The study revealed that 97.7% samples were in excellent category for irrigation (<10 SAR) and 2.33% (10-18 SAR) samples are good for irrigation. Based on the RSC, about 6.51% of water samples were in safe category while 20.5% samples are not suitable for irrigation.

Keywords: Groundwater quality, electrical conductivity, residual sodium carbonate, sodium adsorption ratio, Yadadri Bhuvanagiri, irrigation suitability

Introduction
Groundwater is the major source of water for domestic, agricultural and industrial purposes in many countries. The salinity and sodicity risk associated with Groundwater irrigation jeopardizing crop productivity (Kamra *et al*., 2002) [1]. 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 percent of world arable land will be affected by salinity (Bartels and Sunkar, 2005) [2]. 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 percent of water resources, good quality water availability for agriculture will reduce because of increased demand by industries, energy sector and municipalities by 2025 (Minhas and Tyagi, 1998) [3]. Therefore, water quality assessment and its management options need to be given greater attention in developing countries. The chemical characteristics of groundwater play 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 *et al*., 2019) [4]. Indiscriminate use of poor-quality water for irrigating agricultural crops deteriorates the productivity of soils through salinity, sodicity and toxic effects. However, concerted efforts at different research centers situated in different agro climatic zones of the country have yielded important concepts and feasible technologies for the sustainable irrigation groundwater quality for irrigation with poor-quality water (Minhas and Tyagi, 1998) [3]. The over-exploitation of ground water has immensely affected its quality and quantity. In several parts of the world, lots of studies have been already carried out to assess the ground water quality (Belkhiri and Mouni, 2012) [5]. Sarath Prasanth *et al.* (2012) [6] evaluated the groundwater quality and its suitability for

agricultural use in the coastal stretch of Alappuzha district in Kerala. In Tamil Nadu, several researchers (Srinivasamoorthy *et al.*, 2011; Sajil Kumar and James, 2013; Krishna Kumar *et al.*, 2012) [7, 8, 9] carried some research work in the groundwater quality studies. Excessive irrigation activities also resulted in groundwater pollution in India (Pawar and Shaikh, 1995; Sujatha and Reddy, 2003) [10, 11]. The over exploitation of groundwater in the coastal zones has detrimentally affected its quality and quantity and may result in negative water balance, triggering seawater intrusion. Therefore, an evaluation of quality of the groundwater is an important task to be done in a scientific way. A better understanding of the chemistry of groundwater is very essential to properly evaluate the risk of development of secondary salinization or alkalization. Hence, the study was carried out to assess the groundwater quality for irrigation in Yadadri Bhuvanagiri.

Materials and Methods

The Yadadri Bhuvanagiri district lies in between 17.6294^0 N and 78.0917^0 E. Bhuvanagiri has a total geographical area of 3,091 km^2. In Bhuvanagiri, the wet season is overcast, the dry season is windy and mostly cloudy, and it is hot and oppressive year round. Over the course of the year, the temperature typically varies from 73°F to 98°F and is rarely below 71°F or above 101°F. The hot season in Bhuvanagiri lasts for 3.3 months, from April 20 to July 30, with an average daily high temperature exceeding 95°F. May is the hottest month, with an average high of 97°F and a low of 83°F. The cool season also lasts 3.3 months, from November 6 to February 16, with an average daily high temperature below 86°F. January is the coldest month, with an average low of 73°F and a high of 83°F.The area within 2 miles of Bhuvanagiri is covered by cropland (94%) within 10 miles by cropland (87%), and within 50 miles by cropland (53%) and water (40%).

A total of 215 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 CO_3^{-2}, HCO_3^-.

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

S. No.	Parameter	Method	Reference
1.	pH	Digital pH meter	Richards (1954)
2.	EC (dS m^{-1})	Conductivity meter	Richards (1954)
3.	Ca^{+2}+Mg^{+2} (meq L^{-1})	Versenate titration method	Richards (1954)
4.	Na^+ (meq L^{-1})	Flame photometry method	Richards (1954)
5.	CO_3^- & HCO_3^- (meq L^{-1})	Titration with standard H_2SO_4	Richards (1954)
6.	Cl^- (meq L^{-1})	Titration with standard $AgNO_3$	Richards (1954)
7.	Residual sodium carbonate (RSC) (meq L^{-1})	RSC = (CO_3^{-2}+ HCO_3^-) - Ca^{+2} + Mg^{+2}	Richards (1954)
8.	Sodium Adsorption Ratio (SAR)	SAR= $[Na^+]/\sqrt{([Ca^{2+}] + [Mg^{2+}])/2}$	Richards (1954)

Results and Discussion

Table 2: Ground water quality parameters of Yadadri Bhuvanagiri district

S. No.	Mandal	No. of samples	pH		EC (dS m^{-1})		SAR		RSC (meq L^{-1})	
			Range	Mean	Range	Mean	Range	Mean	Range	Mean
1.	Bibinagar	20	7.64-8.38	7.99	0.41-1.68	1.05	0.71-11.44	3.31	-47.2-1.2	-10.2
2.	Aleru	16	7.26-8.63	7.90	0.41-2.31	1.08	0.41-10.68	3.67	-6.6-3	-2.41
3.	Bommalaramaram	30	7.6-8.52	8.08	1.59-0.24	0.75	0.43-8.91	2.13	-23-13	-3.46
4.	Bhongir	28	7.45-8.84	8.10	0.58-3.91	1.41	0.9-14.29	3.93	-35.4-27.6	0.58
5.	Mothkur	7	7.11-9.4	7.57	0.63-1.63	0.96	0.55-3.20	1.47	-13.4-3.6	-4.66
6.	Atmakur	8	7.81-8.39	8.04	0.8-1.75	1.09	0.9-5.64	2.41	-34.8-0.4	-12.4
7.	Turkapally	13	7.2-8.12	7.71	0.31-2.08	1.05	0.3-7.85	2.24	-25.4-12.8	-4.49
8.	Rajapeta	8	7.51-8.19	7.91	0.64-1.73	1.12	1.14-3.88	2.15	-28.2-0.8	-7.7
9.	Yadagirigutta	5	7.76-8.54	8.07	0.65-1.7	1.19	1.2-3.73	2.24	-7.6--2.00	-5.14
10.	Ramannapet	18	7.67-8.44	8.18	0.68-4.12	1.85	1.79-6.07	3.93	-12.8-0.6	-5.71
11.	Addagudur	4	7.44-8.19	8.06	0.00-1.64	0.85	1.58-3.59	2.73	-35.8-1.2	-17
12.	Gundala	4	7.82-8.19	8.03	0.77-0.90	0.84	0.46-1.79	1.09	-35.4--9.4	-21.3
13.	Motakondur	8	7.63-8.5	8.03	0.78-2.12	1.23	0.53-5	2.19	-38.4-22	-3.46
14.	Valigonda	19	7.69-8.37	8.01	0.91-3.01	1.79	0.61-9.21	3.52	-34.4-35	-1.30
15.	Choutuppal	12	7.43-8.46	7.82	0.74-3.83	2.03	0.55-5.8	2.87	-20-38.6	1.20
16.	Narayanpur	5	7.71-8.14	7.90	0.92-2.45	1.69	1.47-6.36	3.56	-19.6-23.2	0.97
17.	Pochampally	10	7.32-8.33	7.70	0.95-2.12	1.69	1.35-4.65	2.77	-22.8-16.2	1.55
Average			7.11-8.84	7.95	0.00-4.12	1.27	0.3-11.44	2.71	-47.2-38.6	-5.58

pH of water samples: The pH values of water samples ranged from 7.11 to 8.84 with mean value of 7.95. The highest mean pH value was found in paddy grown area in Ramannapet (8.18) *mandal* and the lowest was found in paddy grown area in Pochampally (7.7) *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 followed by intrusion of brackish water.

Electrical Conductivity (dS m^{-1}): The electrical conductivity of water samples ranged from 0.002 to 4.12 dS m^{-1} with mean value of 1.27 dS m^{-1}. The highest mean EC value was found in paddy grown area in Choutuppal (2.03) *mandal* and the lowest was found in paddy grown area in Bommalaramaram (0.75) *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) [12].

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

S. No.	Mandal	HCO_3^-		CO_3^{2-}		Cl^-		SO_4^{-2}	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
1.	Bibinagar	1.2-5.20	2.85	0.00-2.00	0.18	0.8-10.8	5.98	0.07-1.06	0.31
2.	Aleru	2.00-9.00	4.02	0.00-1.6	0.31	1.6-10.8	5.36	0.02-0.28	0.12
3.	Bommalaramaram	2.6-16.8	7.62	0.00-0.00	0.00	2.4-9.2	5.12	0.03-1.63	0.35
4.	Bhongir	2.2-33.6	11.33	0.00-1.6	0.13	3.2-31.2	8.55	0.03-0.89	0.40
5.	Mothkur	2.2-15.2	8.18	0.00-0.00	0.00	3.2-7.6	4.98	0.04-0.33	0.18
6.	Atmakur	3.2-12.8	8.04	0.00-1.2	0.24	3.6-9.6	6.08	0.06-0.47	0.23
7.	Turkapally	3.4-16.8	7.45	0.00-0.00	0.00	2.4-8.4	4.59	0.03-1.82	0.34
8.	Rajapeta	3.00-8.80	6.08	0.00-2.4	0.60	3.6-7.2	5.2	0.04-0.62	0.21
9.	Yadagirigutta	1.4-12.0	5.23	0.00-1.6	0.46	4.4-12	7.37	0.11-0.30	0.20
10.	Ramannapet	2.2-5.80	3.53	0.00-1.6	0.58	3.6-24.4	10.66	0.04-0.58	0.26
11.	Addagudur	2.4-5.00	3.73	0.00-1.2	0.67	2.4-20	9.73	0.03-0.22	0.12
12.	Gundala	2.4-5.00	3.17	0.00-0.8	0.47	2.00-6.4	4	0.04-0.37	0.21
13.	Motakondur	1.6-32.0	12.18	0.00-0.00	0.00	0.8-16.0	6.92	0.06-0.47	0.25
14.	Valigonda	3.8-43.2	13.94	0.00-0.00	0.00	3.6-21.6	9.96	0.10-0.79	0.32
15.	Choutuppal	2.00-56.00	18.67	0.00-0.8	0.17	3.2-28	12	0.13-1.07	0.49
16.	Narayanpur	7.2-27.2	16.57	0.00-0.00	0.00	3.6-13.6	8.16	0.13-0.68	0.39
17	Pochampally	13.6-28.0	22.13	0.00-0.00	0.00	6.8-14.0	11.07	0.06-0.27	0.15
Average		1.2-28.0	9.10	0.00-2.40	0.22	17.	7.40	0.02-1.82	0.27

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 0.3 to 11.44 with mean of 2.71. The highest mean SAR value was found in paddy grown area of Ramannap*et mandal* (mean 3.93) and the lowest value was in paddy grown area in Gundala *mandal* (mean 1.09). 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) [13]. The SAR values of irrigation water affect the extent to which sodium is adsorbed by the soil (Sundha *et al.*, 2020) [14]. The sodicity hazard of associated with such waters are deteriorated soil structure (Singh *et al.*, 2018 [15a]; Todd, 1980 [16]) resulting in the formation of crusts, waterlogging, reduced soil aeration and reduced infiltration rate (Vasanthavigar *et al.*, 2012) [17].

Residual Sodium Carbonate (RSC)

The RSC values of water samples ranged from -47.2 to 38.6 meq L^{-1} with mean value of -5.88. The Highest mean RSC value was found in paddy grown area of Pochampally *mandal* (1.55 meq L^{-1}) and lowest was found in Gundala *mandal* (-21.3 meq L^{-1}). Negative RSC indicates that Na+ buildup is unlikely since Ca^{2+} and Mg^{2+} are in excess of what can be precipitated as CO_3^{2-}. Continuous usage of this water may result in adverse effect on crop and affects yield because of soil sodification.

Table 4: 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.	Bibinagar	1.30-12.0	5.77	2.2-48.4	13.1
2.	Aleru	0.8-19.4	6.53	2.8-10	6.96
3.	Bommalaramaram	1.30-22.0	4.76	3.2-29.6	11.20
4.	Bhongir	1.40-21.2	7.13	3.00-39.2	10.78
5.	Mothkur	1.50-7.70	3.56	5.00-22.2	12.84
6.	Atmakur	2.80-9.10	5.78	5.20-39.2	19.96
7.	Turkapally	1.00-7.50	3.32	4.00-28.8	11.95
8.	Rajapeta	2.50-11.1	6.51	6.80-32.0	14.1
9.	Yadagirigutta	2.80-10.8	5.50	6.60-16.1	10.66
10.	Ramannapet	3.40-17.7	8.97	4.00-17	9.78
11.	Addagudur	3.90-8.60	6.33	4.20-38.2	21.27
12.	Gundala	3.40-11.3	7.62	13.8-37.8	24.93
13.	Motakondur	1.30-11.5	5.03	6.20-40.0	15.26
14.	Valigonda	2.10-20.6	7.50	4.00-39.6	15.11
15.	Choutuppal	1.60-16.7	7.66	7.40-28.6	17.34
16.	Narayanpur	4.30-11.6	7.44	4.00-40.4	17.54
17.	Pochampally	5.10-11.1	7.80	11.00-50.8	21.72
Average		0.80-20.6	6.31	2.20-50.8	14.97

Kiran *et al.* [18]

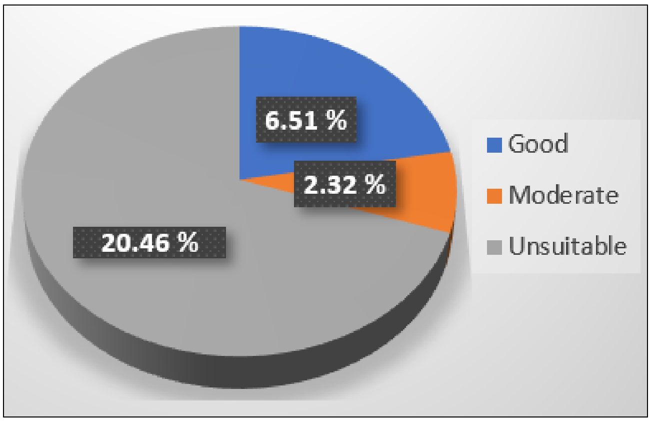

Fig 1: Quality ratings of ground water (% samples) of Yadadri Bhuvanagiri district

Cationic Composition

Calcium and magnesium was dominant among the cations (mean 14.97 meq L^{-1}). The order of cations in Yadadri Bhuvanagiri district was Ca^{+2}+Mg^{2} >Na^{+}. The cationic concentration followed the order sodium, calcium, magnesium and potassium. The presence of sodium in groundwater primarily results from the chemical decomposition of feldspars (Kumar *et al.*, 2009) [19a] and the presence also predicts the sodicity danger of the water (Singh *et al.*, 2018) [15b]. The presence of calcium in groundwater might be attributed to calcium rich minerals such as amphiboles, pyroxenes and feldspars (Jalali, 2010) [20] and the Mg^{+2} in groundwater might be due to olivine minerals in the surrounding rocks and soils.

Anionic Composition

The dominant anion was bicarbonate with mean value of 9.10 meq L^{-1}. The higher mean bicarbonate value was found in pochampally *mandal* (22.13 me L^{-1}) and the lowest was found in Bibinagar *mandal* (2.85 meq L^{-1}) (Table.3). The order of dominance of anions in the ground waters of Yadadri Bhuvanagiri district was HCO_3^- > Cl^- > SO_4^{-2} > CO_3^{-2}. Verma *et al.* (2005) [21] observed similar results in case of ground waters of Nagaur district of Rajasthan. The bicarbonate and chloride ions are dominant among all the anions then followed by sulphates and carbonates. The higher concentration of bicarbonate ions in groundwater can be ascribed to carbonate weathering as well as from the dissolution of carbonic acid in the aquifers from the possible mechanisms (Houatmia *et al.*, 2016) [22]. The chloride content in the groundwater may be due to natural process like weathering, dissolution of salt deposits and irrigation drainage return flow (Kumar *et al.*, 2009) [19b]. Loizidou and Kapetanios (1993) [23] proposed that the excess of chloride in the groundwater is by and large taken as an index of groundwater contamination. The sulphate ions in groundwater might be due to the presence of sulphide –bearing minerals and gypsum in aquifer materials, application of sulphate rich fertilizers and industrial wastes (Sridharan and Nathan, 2017) [24]. Moreover, application of soil amendments like gypsum is expected to be responsible for higher SO_4^{-2} content in the groundwater (Pal *et al.*, 2018) [25].

Table 5: Classification of ground water samples based on RSC (meq L^{-1})

Class	Value	No. of samples	Percent of samples
Good	<1.25	14	6.51
Moderate	1.25-2.5	5	2.32
Unsuitable	>2.5	44	20.46

Table 6: Classification of groundwater based on SAR

Class	Value	No. of samples	Percent of samples
Excellent	<10	210	97.67
Good	10-18	5	2.32
Doubtful	18-26	Nil	Nil
Unsuitable	>26	Nil	Nil

Classification of Ground Waters

Residual sodium carbonate is an important parameter that has extraordinary influence on the suitability of irrigation water (Pal *et al.*, 2018) [25b]. RSC water can be categorized into three categories such as safe (4 meq L-1). In the present study, it was found that 14 samples were of safe category, 5 samples were moderately suitable and 44 samples were unsuitable for irrigation purposes.

Ayers and Westcot (1976) [26] reported that 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. According to this classification 97.67 and 2.32 cent samples belonged to excellent, good respectively.

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 and anions were in the following order: $Ca^{2+} + Mg^{2+} > Na^{+}$ and $HCO_3^{-} > Cl^{-} > SO_4^{2-} > CO_3^{2-}$. When considering EC and RSC, 8.37% and 20.46% of the samples were deemed unsuitable for irrigation, specifically in the Ramannapet and Pochampally *mandals*. Samples from these mandals were classified as unsuitable for irrigation due to high salt content and significant alkalinity hazards. 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.

Acknowledgements

I would like to thank the Head, Department of soil science and agricultural chemistry, College of agriculture, PJTSAU for providing for necessary laboratory facilities, other authors who were the encouragement for publishing this paper.

References

1. Kamra SK, Khajanchi L, Singh OP, Boonstra J. Effect of pumping on temporal changes in groundwater quality. Agric Water Manag. 2002;56:169-178.
2. Bartels D, Sunkar R. Drought and salt tolerance in plants. Crit Rev Plant Sci. 2005;24:23-58.
3. Minhas PS, Tyagi NK. Guidelines for irrigation with saline and alkaline waters. Tech Bull no. 1/98, CSSRI, Karnal; c1998.
4. Singh R, Singh AK, Yadav SR, Singh SP, Godara AS, Kaledhonkar MJ, *et al.* Effect of saline water and fertility levels on pearl millet-psyllium crop sequence under drip irrigation in arid region of Rajasthan. J Soil Salinity Water Qual. 2019;11(1):56-62.
5. Belkhiri L, Mouni L. Hydrochemical analysis and evaluation of groundwater quality in El Eulma area, Algeria. Appl Water Sci. 2012;2:127-133.
6. Sarath Prasanth SV, Magesh NS, Jitheshlal KV, Chandrasekar N, Gangadhar K, *et al.* Evaluation of

groundwater quality and its suitability for drinking and agricultural use in the coastal stretch of Alappuzha District, Kerala, India. Appl Water Sci. 2012;2:165-175.
7. Srinivasamoorthy K, Nandha Kumar C, Vijayaraghavan K, Vasanthavigar M, Rajiv Gandhi R, Chidambaram S, *et al*. Groundwater quality assessment from a hard rock terrain, Salem district of Tamil Nadu, India. Arab J Geosci. 2011;4:91-102.
8. Sajil Kumar PJ, James EJ. Physicochemical parameters and their sources in groundwater in the Thirupathur region, Tamil Nadu, South India. Appl Water Sci. 2013;3:219-228.
9. Krishna Kumar S, Chandrasekar N, Seralathan P, Godson PS, Magesh NS. Hydrogeochemical study of shallow carbonate aquifers, Rameswaram Island, India. Environ Monit Assess. 2012;184:4127-4139.
10. Pawar NJ, Shaikh IJ. Nitrate pollution of ground waters from shallow basaltic aquifers, Deccan trap hydrologic province, India. Environ Geol. 1995;25:197-204.
11. Sujatha D, Reddy RB. Quality characterization of groundwater in the south eastern parts of the Ranga Reddy district, Andhra Pradesh, India. Environ Geol. 2003;44(5):570-576.
12. Ramesh K, Elango L. Groundwater quality and its suitability for domestic and agricultural use in Tondiar river basin, Tamil Nadu, India. Environ Monit Assess. 2012;184:3887-3899.
13. Bhat MA, Grewal MS, Ramprakash, Rajpaul, Wani SA, Dar EA, *et al*. Assessment of groundwater quality for irrigation purposes using chemical indices. Indian J Ecol. 2018;43(2):574-579.
14. Sundha P, Basak N, Rai AK, Yadav RK, Sharma PC, Sharma DK, *et al*. Can conjunctive use of gypsum, city waste composts and marginal quality water rehabilitate saline-sodic soils? Soil Tillage Res. 2020;200:104608.
15. Singh RB, Kaledhonkar MJ, Chodhary SK, Shisodia PK, Meena BL. Effect of saline and alkaline water on mustard yield under sprinkler irrigation. J Soil Salinity Water Qual. 2018;10(2):246-253.
16. Todd D. Groundwater Hydrology, 2nd edn. Wiley, New York; c1980. p. 535.
17. Vasanthavigar M, Srinivasamoorthy K, Ganthi RR, Vijayaraghavan K, Sarma VS. Characterization and quality assessment of groundwater with a special emphasis on irrigation utility: Thirumanimuttar sub-basin, Tamil Nadu, India. Arab J Geosci. 2012;5:245-258.
18. Kirankumar C, Lakshmi GV. Assessment of groundwater quality in paddy-sugarcane areas of West Godavari District, Andhra Pradesh; c2014.
19. Kumar SK, Rammohan V, Sahayam JD, Jeevanandam. Assessment of groundwater quality and hydrogeochemistry of Manimukhta river basin. Environ Monit Assess. 2009;159:341-351.
20. Jalali M. Groundwater geochemistry in the Alisadr, Hamadan, Western Iran. Environ Monit Assess. 2010;166:359-369.
21. Verma BL, Sharma Y, Singhania RA. Characterization of underground irrigation waters in Nagaur district of Rajasthan. ISSS, ICSWEQ Voluntary Papers; c2005.
22. Houatmia F, Azouzi R, Charef A, Bedir M. Assessment of groundwater quality for irrigation and drinking purposes and identification of hydro geochemical mechanisms evolution in Northeastern, Tunisia. Environ Earth Sci. 2016;75:746.
23. Loizidou M, Kapetanios EG. Effect of leachate from landfills on underground quality. Sci Total Environ. 1993;128:69-81.
24. Sridharan M, Nathan DS. Groundwater quality assessment for domestic and agriculture purposes in Puducherry region. Appl Water Sci. 2017;7:4037-4053.
25. Pal SK, Rajpaul, Ramprakash, Bhat MA, Yadav SS. Assessment of groundwater quality for irrigation use in Firozpur-Jhirka Block in Mewat district of Haryana, North India. J Soil Salinity Water Qual. 2018;10(2):157-162.
26. Ayers RS, Westcot DW. Water quality for irrigation. Irrigation drainage paper 29. Rome: FAO, United Nations; c1976.