International Journal of Research in Agronomy 2024; SP-7(8): 221-226

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
www.agronomyjournals.com
2024; SP-7(8): 221-226
Received: 02-05-2024
Accepted: 05-06-2024

Shridhar
Department of Soil Science, College of Agriculture, KSNUAHS, Shivamogga, Karnataka, India

Ravikumar D
Department of Soil Science, ICAR-KVK, Chitradurga, Babbur Farm, Hiriyur, Karnataka, India

Gurumurthy KT
Department of Soil Science, College of Agriculture, KSNUAHS, Shivamogga, Karnataka, India

Jayaprakash R
Department of Soil Science, AHRS, Sringeri, Karnataka, India

Jadeyegowda M
Department of Agronomy, College of Forestry, Ponnampet, Karnataka, India

Shoba S
Department of Food Process Engineering, DSLD College of Horticultural Engineering and Food Technology, Devihosur, Haveri, Karnataka, India

Corresponding Author:
Shridhar
Department of Soil Science, College of Agriculture, KSNUAHS, Shivamogga, Karnataka, India

Assessment of water quality parameters for irrigation in Udupi district of Karnataka

Shridhar, Ravikumar D, Gurumurthy KT, Jayaprakash R, Jadeyegowda M and Shoba S

DOI: https://doi.org/10.33545/2618060X.2024.v7.i8Sd.1256

Abstract
A study was conducted in 2022-23 to characterize the coastal water bodies of Udupi district for optimal irrigation use. Fifty-one representative water samples were randomly collected from various geographical locations between April and May 2022. These samples, taken from the sea, bore wells, lakes, open wells, rivers, and streams across the study area, were analyzed and categorized into different water quality classes according to standard procedures. Geographical coordinates were recorded at each sampling site. The frequency distribution of water samples based on pH revealed that the highest percentage (52.94%) fell within the pH range of 6.5-7.3 (neutral), followed by 29.41% in the 7.3-7.8 range (slightly alkaline), 1.96% in the 6.0-6.5 range (slightly acidic), 1.96% in the 5.5-6.0 range (moderately acidic), and 13.73% in the 7.8-8.4 range (moderately alkaline). This indicates that the water samples predominantly ranged from neutral to slightly alkaline, suggesting no potential alkali hazard when using this groundwater for irrigation. Regarding electrical conductivity (EC), 7.84% and 31.38% of the samples had EC values of <0.25 dS m-1 and >4 dS m^{-1}, respectively. However, at all levels of EC_{iw}, the mean Mg/Ca ratio was higher than 0.63, and the mean chloride content was higher than 4.0 meq L^{-1} in the study area. According to the CSSRI guidelines, 66.67%, 19.61%, 11.76%, and 3.92% of the samples were classified as having good, high SAR saline, saline, and marginally saline water quality, respectively.

Keywords: Udupi district, coastal water body quality, residual sodium carbonate, sodium adsorption ratio

Introduction
The Coastal zone is an area of interaction between land and sea. Both marine and terrestrial environments influence this zone (Rao and Suresh, 2001) [16]. India has a long coastline of 7,516.6 km. its peninsular region is, bounded by the Arabian Sea on the west, the Bay of Bengal on the east and the Indian Ocean on its south. The total coastal area represents 15.14 percent of the total geographical area of the country. Out of the total coastline of India, 320 km coastline is in Karnataka and its coastal region accounts for 6.09 percent of the area of the state (Shamsudheen and Dasog, 2005) [17]. The problem of resource evaluation and management in the coastal region is strikingly different from those of hinterland. For the planned development of coastal areas reliable information on soil and water with respect to their nature, potential and limitation is very essential.

In coastal areas, groundwater being the primary source of fresh-water is exploited indiscriminately to fulfill the increasing water demands for domestic, agricultural as well as industrial usages (Hamed *et al.*, 2018) [5]. The excessive withdrawal of groundwater disturbs hydrodynamic equilibrium that exists between the freshwater – seawater in the aquifer and causes upward movement of the seawater (Van Camp *et al.*, 2014) [18]. This causes depletion in the available fresh groundwater resources in coastal areas (Alfarrah and Walraevens, 2018; Werner *et al.*, 2013) [1, 20]. The upward or downward movement of seawater into the coastal aquifer is governed by a well-established mathematical relationship known as the “Ghyben-Herzberg relationship” (Narayan *et al.*, 2007) [13]. The relationship indicates that for a one-meter increase in the water table, the thickness of seawater reduces by 40 m. A decline in groundwater level below the mean sea level leads to a reversal of hydraulic gradient and causes inland movement of seawater in the coastal aquifer (Lee and Cheng, 1974; Nair *et al.*, 2013) [9, 12].

The inland movement of seawater into the coastal aquifer is called seawater intrusion, which has been the major cause of deterioration of the coastal groundwater resources. Seawater intrusion not only affects the industrial and agriculture growth in the area but also hampers the living standards of people (Demirel, 2004) [4].

Knowledge of hydrological processes (change of groundwater level, groundwater quality and tidal level) in coastal aquifers is important because approximately 50 percent of the world's population live in coastal zones, particularly in low-lying deltaic areas within 60 km of the shoreline (Kumar *et. al*., 2013) [8]. Coastal aquifers typically serve as a major source of freshwater, such as drinking or irrigation water (Rahman *et. al*., 2011) [14]. The groundwater level is a key parameter for evaluating spatial and temporal changes in groundwater environments (Iwasaki *et. al*., 2013) [7]. The groundwater level is governed by various factors. Climate change, as reflected in precipitation and evaporation rates, influences the groundwater level fluctuation (Chen *et. al*., 2004) [3].

The water used for irrigation purpose always contains soluble salts irrespective of their source, but the total concentrations and the kind of salt present in any irrigation water are important in deciding whether it will be suitable for irrigation or not. Moreover, the sodium being the most hazardous ion, its proportion to other cations plays very important role. Most of the ground water aquifers situated along the shoreline has been deteriorated by sea water intrusion. In present study an attempt was made to study the spatio-temporal variability of salinity in coastal water bodies of Udupi District, Karnataka.

Materials and Methods

The location of the study area consisting of some part of coastal area of Brahmavara taluk, Udupi district, which consisting an area of 12,594.79 ha which was depicted in Fig. 1, which comes under the coastal zone of Karnataka (Agro-climatic zone No. 10). Udupi district is located between 74^0 45' to 74^0 46' E longitudes and 13^0 24' 45' to 13^0 25' 30'' N latitudes and receives an average rainfall of 4672 mm at mean sea level of 27 meter.

The representative water samples of fifty-one from sea, bore well, lake, open well, river and stream were collected randomly which represents the whole study area and geographical locations were registered at each sampling site (Fig. 2) (Plate. 1). The samples were collected during April-May 2022 in capped high density PVC bottles, fortified with 1mL toluene to arrest any biological activity. The samples were analyzed for salinity/ sodicity parameters viz., pH, electrical conductivity (EC), cationic concentrations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and anionic concentrations (Cl^{-}, SO_4^{2-}, CO_3^{2-} and HCO_3^{-}) as per standard procedures outlined by Richards (1954). Calcium and Mg were estimated by Versenate method while Na and K were analyzed by flame photometry. The anions viz., CO_3^{2-} and HCO_3^{-} were estimated by titration with standard acid. The Cl^{-} and SO_4^{2-} were estimated by titration with silver nitrate and precipitation as barium sulfate. The values obtained were used to compute for sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) as under:

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

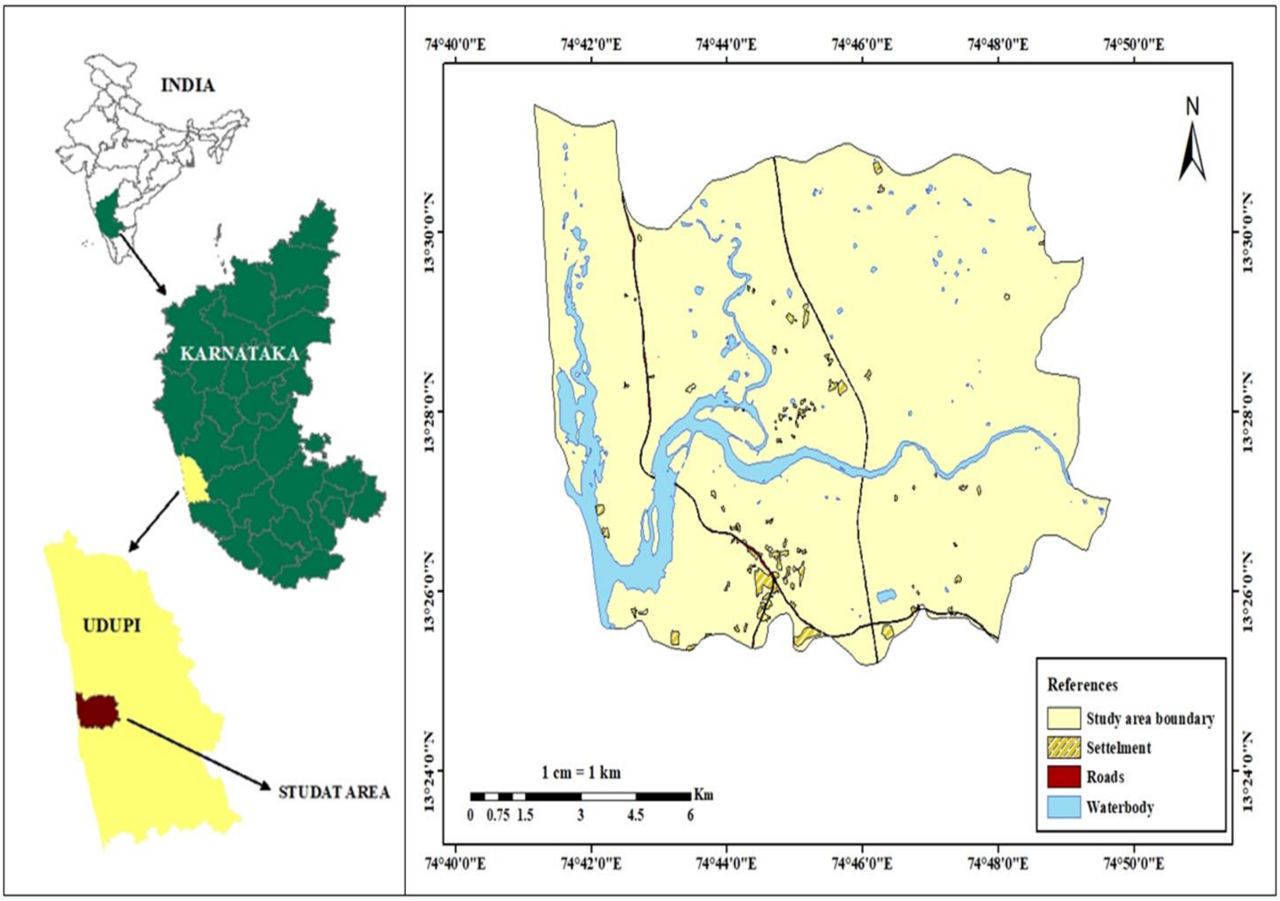

Fig 1: Location map of the study area

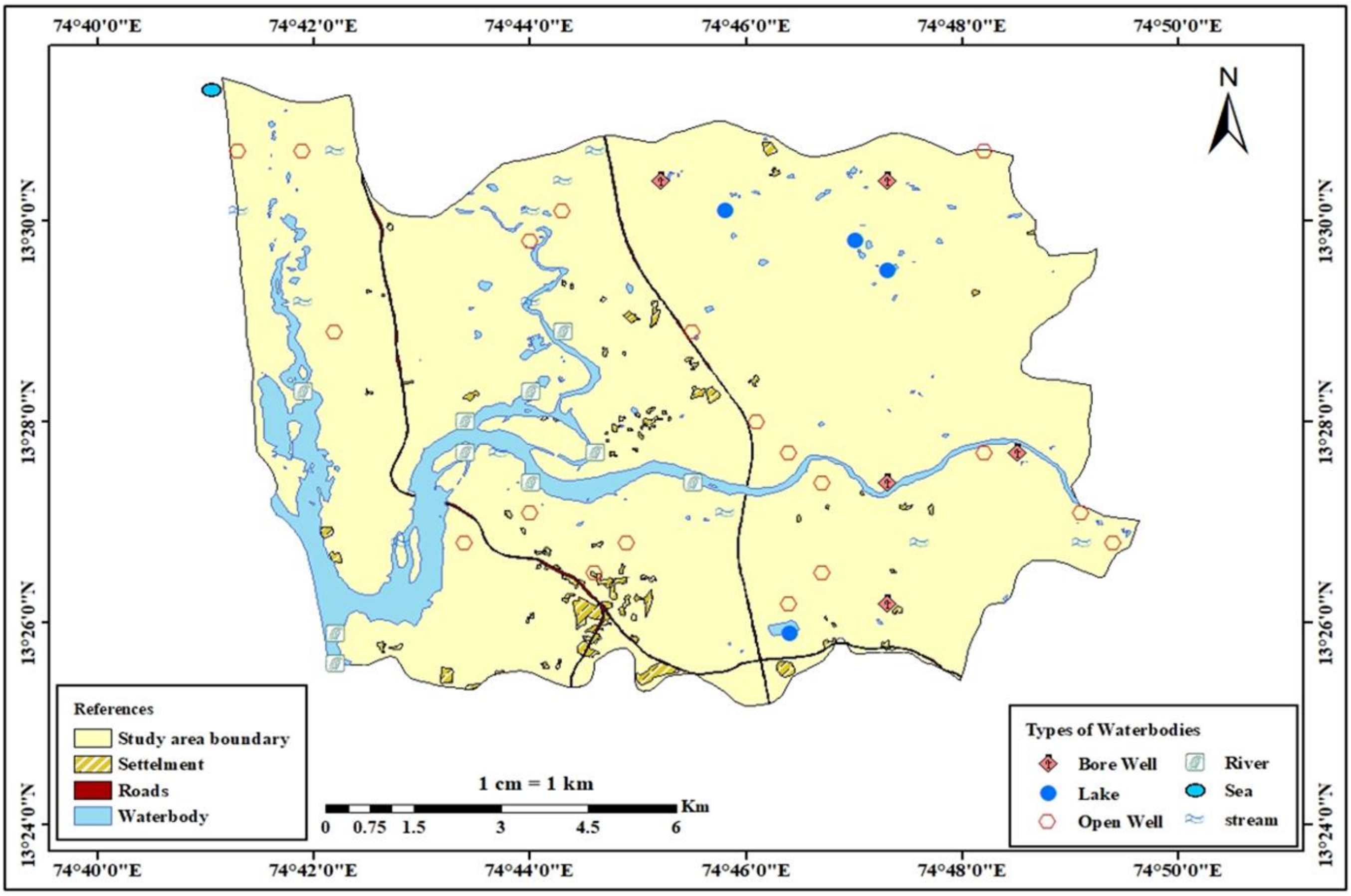

Fig 2: Water sampling points of the study area

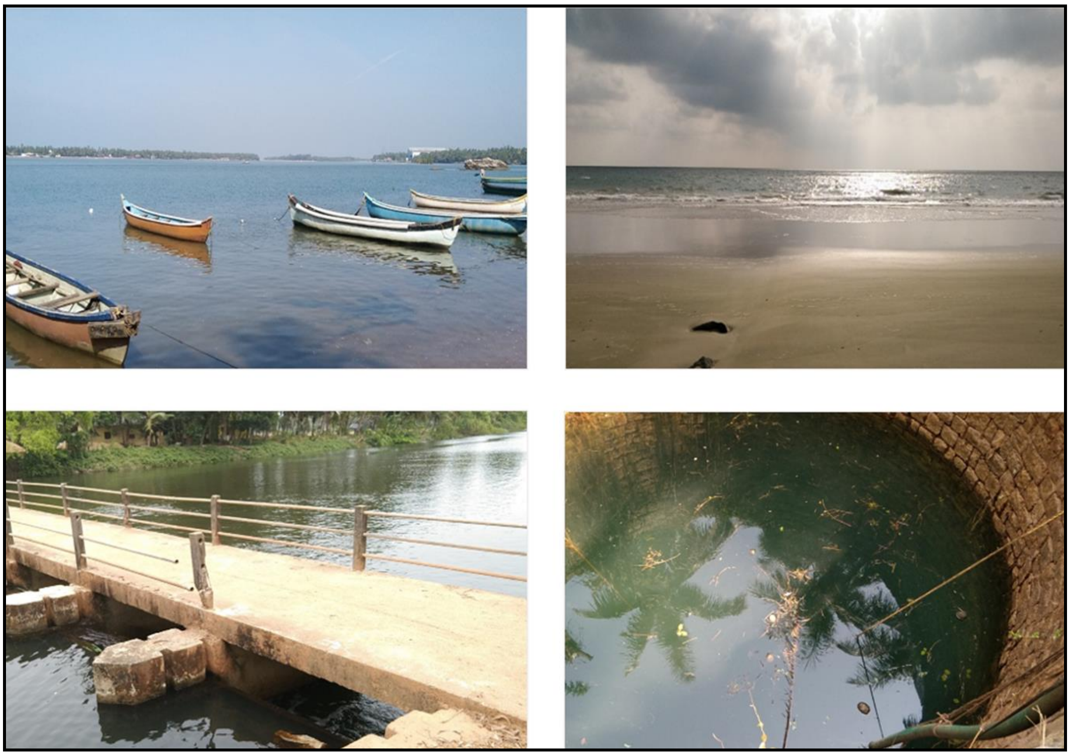

Plate 1: Water sample collection sources in the study area

$$RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+}); \text{ mmol } L^{-1}$$

Considering EC, SAR and RSC, underground water quality for irrigation was categorized based on the criteria as outlined by Minhas *et al*. (1998b) [11] as detailed below.

Overall classification of irrigation water given by Central Soil Salinity Research Institute (CSSRI), Karnal.

Table 1: Overall classification of irrigation water given by Central Soil Salinity Research Institute (CSSRI), Karnal

	EC (dS m^{-1})	SAR	RSC (mmol L^{-1})
I. Good water	<2.0	<10.0	<2.50
II. Saline water			
Marginally saline	2- 4	<10.0	<2.50
Saline	>4.0	<10.0	<2.50
High SAR saline	>4.0	>10.0	<2.50
III Alkali water			
a Marginally alkali	<4.0	<10.0	2.50-4.0
b. Alkali	<4.0	<10.0	>4.0
c. Highly alkali	Variable	>10.0	>4.0

Results and Discussion

The frequency distribution of water samples based on pH revealed that the highest percentage (52.94%) fell within the pH range of 6.5-7.3 (neutral), followed by 29.41% in the 7.3-7.8 range (slightly alkaline), 1.96% in the 6.0-6.5 range (slightly acidic), 1.96% in the 5.5-6.0 range (moderately acidic), and 13.73% in the 7.8-8.4 range (moderately alkaline). This indicates that the water samples predominantly ranged from neutral to slightly alkaline, suggesting no potential alkali hazard when using this groundwater for irrigation (Table 1). Regarding electrical conductivity (EC), 31.38%, 29.41%, 29.41%, 7.84% and 1.96% of samples had EC values of >4 dS m^{-1} (Unsuitable), 0.25-0.75 dS m^{-1} (Good), 0.75-2.25 dS m^{-1} (Permissible), <0.25 dS m^{-1} (Excellent) and 2.25-4.0 dS m^{-1}(Doubtful) respectively (Table 2). It is equally or rather more important to look at the ionic composition of water samples so as to provide more detailed information about the EC_{iw}. With respect to the ionic composition, Na^{+} ion was the dominant cation (Table 3) followed by Mg^{2+} and Ca^{2+} in the study area. Ramprakash *et al.* (2013) [15] also reported higher concentration of Na^{+} (ranging from 2.90 to 60.2 me L^{-1}) than other cations in underground waters of Beri block of Jhajjar district in Haryana.

Table 1: Frequency distribution of water samples with respect to pH of Study area

Particulars			
Sl. No	**pH_{iw} Classes**	**Range**	**Percent of samples**
1	Moderately acid	5.5-6.0	1.96 (1, 5.75)
2	Slightly acid	6.0-6.5	1.96 (1, 6.40)
3	Neutral	6.5-7.3	52.94 (27, 6.98)
4	Slightly alkaline	7.3-7.8	29.41 (15, 7.6)
5	Moderately alkaline	7.8-8.4	13.73 (7, 8.13)

Note: Values in parenthesis indicates number of samples and mean values of respective classes respectively. (Richards, 1954)

Table 2: Frequency distribution of water samples with respect to EC_{iw} of Study area

Particulars			
Sl. No	**EC_{iw} Classes**	**EC_{iw} range (dS m^{-1})**	**Percent of samples**
1	Excellent	<0.25	7.84 (4, 0.19 dS m^{-1})
2	Good	0.25 to 0.75	29.41 (15, 0.51 dS m^{-1})
3	Permissible	0.75 to 2.25	29.41 (15, 1.11 dS m^{-1})
4	Doubtful	2.25 to 4.00	1.96 (1, 3.21 dS m^{-1})
5	Unsuitable	>4.00	31.38 (16, 26.29 dS m^{-1})

Note: Values in parenthesis indicates number of samples and mean values of respective classes respectively. (Richards, 1954)

Table 3: Ionic composition of water samples of study area

	Ionic dominance
Cations	$Na^{+} > Mg^{2+} > Ca^{2+} > K^{+}$
Anions	$Cl^{-} > SO_4^{2-} > HCO_3^{-} > CO_3^{2-}$

At all the levels of ECiw, though there was no specific trend, the mean Mg/Ca ratio in the study area (Table 4) was higher than 0.63 which was reported to be critical for causing Mg^{2+} hazard as the Mg^{2+} starts behaving more like Na^{+}. Generally, Mg:Ca ratio of waters in equilibrium with calcite and dolomite should be 0.63 (Minhas *et al*., 1998a) [10]. It varied from 1.12, 2.94 and 4.92 at EC_{iw} <2.0, 2.0-4.0 and >4.0 dSm^{-1}, respectively.

Among anions, generally Cl^{-} ion was dominant (Table 3) followed by SO_4^{2-}/ HCO_3^{-} and CO_3^{2-}. Ramprakash *et al.* (2013) [15] also reported the dominance of Cl^{-} ion (1.70-76.30 meq L^{-1}) in the groundwater of Beri block of Jhajjar district in Haryana. Similar results were also reported by Chauhan *et al.* (2010) [2]. The mean chloride contents (Table 5) were higher than 3.0 meq L^{-1} in the study area. Waters with predominance of Cl^{-} ions have been shown to be more toxic as compared to SO_4^{2-} ion because of reduced osmotic effects of SO_4^{2-} ions as of ion pair formations and lesser solubility of SO_4^{2-} salts (Minhas *et al*., 1998a) [10]. Because of dominance of Cl^{-}, the Cl/SO_4 ratio was also >2.0 (Table 4) in majority of samples irrespective of EC which is reported to be harmful if used for sprinkler irrigation in some of the sensitive horticultural crops. The Cl/SO_4 ratio varied from 1.161, 3.81 and 24.29 at EC_{iw} <2.0, 2.0-4.0 and >4.0 dSm^{-1}, respectively indicating the potential chloride injury of these waters in sensitive crops.

Computation of SAR value provides a useful index of the sodium hazard when applied to soils as well as crops (Ramprakash *et al*., 2013) [15]. Though there were variations in SAR and RSC values within a study area (Table 5), however the mean SAR and RSC values in the study area were less than 10 and 2.5 meq L^{-1}, respectively above which were considered to be harmful as far as alkalinity/ sodicity effect is considered. Looking at pH, EC_{iw}, SAR and RSC values individually, it appears that as such underground water quality in these taluks was not problematic. However, when attempt was made to group samples as per salinity and alkalinity hazards envisaged on their use for irrigation (Minhas *et al*., 1998b) [11] considering EC_{iw}, SAR and RSC values together as discussed earlier, there exist poor quality water samples for irrigation in the study area (Table 6).

As per the CSSRI guidelines, 66.67%, 19.61%, 11.76%, and 3.92% of the samples were classified as having good, high SAR saline, saline, and marginally saline water quality, respectively (Table 6). Based on the same CSSRI, Karnal classification, Ramprakash *et al*., (2013) [15] also reported that 32.0% of water samples were of good quality and 56.0% saline and 12.0% alkali in nature in Beri block of Jhajjar district in Haryana. Similarly, Hebsur *et al*., (2012) [6] assessed groundwater quality in Malaprabha and Ghataprabha command area in Karnataka and reported 22.2 and 31.8% of groundwater with different kinds of salinity problems in these commands, respectively. In the adjoining district Gadag, Vishwanath *et al*. (2015) [19] assessed ground water quality and reported that out of 527 underground irrigation waters, less than 50% of samples were of good quality followed by marginally saline (15.95%). And 40.3% of water samples were found to be problematic of different nature (*i.e.*, Saline, High SAR saline, M. Alkali I & II and Alkali).

Table 4: Percent distribution of water samples for the relationship between Mg/Ca and Cl/SO_4 ratio with the salinity of study area

EC_{iw} (dS m^{-1}) range	Mg/Ca ratio	Cl/SO_4 ratio
<2.0	58.82 (30, 1.12)	1.96 (1, 1.61)
2.0-4.0	35.29 (18, 2.94)	7.84 (4, 3.81)
>4.0	5.88 (3, 4.92)	90.20 (46, 24.29)

Table 5: Mean chemical composition of water samples of study area

Range/Mean	pH	EC (dS m^{-1})	Ca^{2+}	Mg^{2+}	Na^{+}	Cl^{-}	SO_4^{2-}	HCO_3^{-}	CO_3^{2-}	SAR	RSC (me L^{-1})
			(me L^{-1})								
Min.	5.75	0.13	0.70	0.60	0.13	1.10	0.18	0.20	0.10	0.07	-96.80
Max.	8.44	58.90	21.90	79.80	87.56	216.10	4.94	0.90	0.70	18.93	-0.70
Mean.	7.29	8.80	5.24	12.51	14.85	24.73	1.47	0.40	0.32	3.54	-18.41

Table 6: Overall water quality classification of water samples as per the guidelines of CSSRI, Karnal

Sl. No	Water quality classes	Water quality parameters			
		EC_{iw} (dSm^{-1})	SAR	RSC (meq L^{-1})	Total number of samples (51)
1	Good	<2.0	<10	<2.5	34 (66.67%)
2	Marginally saline	2.0-4.0	<10	<2.5	2 (3.92%)
3	Saline	>4.0	<10.	<2.5	6 (11.76%)
4	High SAR saline	>4.0	>10	<2.5	10 (19.61%)
5	Marginally alkali	<4.0	<10	2.5-4.0	-
6	Alkali	<4.0	<10	>4.0	-
7	Highly alkali	<4.0	>10	>4.0	-

Conclusion
Based on the results of present investigation it could be concluded that study area has about 31.38 percent of water samples had EC_{iw} >4.0 dS m^{-1} reflecting that the water samples were unsuitable for irrigation at the time of sampling. The decrease in EC_{iw} of irrigation water is because of dilution effect. As per the guidelines of CSSRI, Karnal 11.76 and 19.61 percent of water samples of study area comes under the saline and higher SAR saline water quality classes. Hence, their efficient utilization necessitates regular monitoring and understanding of factors such as rainfall patterns, soil type, crop selection, water management practices, and nutrient management. This approach is crucial for ensuring sustainable agriculture in the future.

References

1. Alfarrah N, Walraevens K. Groundwater Overexploitation and Seawater Intrusion in Coastal Areas of Arid and Semi-Arid Regions. Water. 2018;10(2):138-143.
2. Chauhan CPS, Chauhan RS, Shishodia PK. Survey and Characterization of Ground Water Quality of District Bharatpur. In: Proceedings of the National Seminar on Soil Salinity and Water Quality. 2010;19-21: CSSRI, Karnal, pp. 10.
3. Chen Z, Grasby SE, Osadetz KG. Relation Between Climate Variability and Groundwater Levels in the Upper Carbonate Aquifer, Southern Manitoba, Canada. Journal of Hydrology. 2004;290(1-2):43-62.
4. Demirel Z. The History and Evaluation of Saltwater Intrusion into a Coastal Aquifer in Mersin, Turkey. Journal of Environmental Management. 2004;70(4):275-282.
5. Hamed Y, Hadji R, Redhaounia B, Zighmi K, Baali F, El Gayar A. Climate Impact on Surface and Groundwater in North Africa: A Global Synthesis of Findings and Recommendations. Euro-Mediterranean Journal of Environmental Integration. 2018;3:20-25.
6. Hebsur NS, Selvaraj S, Channal HT. Assessment of the Groundwater Quality for Domestic and Agricultural Purposes of Malaprabha and Ghataprabha Command Areas in Northern Karnataka. Journal of Soil Salinity and Water Quality. 2012;4(1):6-10.
7. Iwasaki Y, Ozaki M, Nakamura K, Horino H, Kawashima S. Relationship Between Increment of Groundwater Level at the Beginning of Irrigation Period and Paddy Field Area in the Tedori River Alluvial Fan Area, Japan. Paddy and Water Environment. 2013;11(1-4):551-558.
8. Kumar MV, Lakshmi GV, Madhuvani P. Appraisal of Soil Fertility Status in Salt-Affected Soils of Ongole Division, Prakasam District, Andhra Pradesh. Journal of the Indian Society of Soil Science. 2013;61(4):333-340.
9. Lee CH, Cheng RTS. On Seawater Encroachment in Coastal Aquifers. Water Resources Research. 1974;10(1):1039-1043.
10. Minhas PS, Singh RB, Hebbara M, Verma BL, Subbaiah GV. Effect of Poor-Quality Water on Soil and Crop. In: Minhas PS, Sharma OP, Patil SG, editors. 25 Years of Research on Management of Salt-Affected Soils and Use of Saline Water in Agriculture. Yugantar Prikashan Pvt. Ltd.; New Delhi: c1998a. p. 109-149.
11. Minhas PS, Subbaiah GV, Chauhan CPS, Patil SG, Verma, Dubey SK. Survey for Ground Water Quality. In: Minhas PS, Sharma OP, Patil SG, editors. 25 Years of Research on Management of Salt-Affected Soils and Use of Saline Water in Agriculture. Yugantar Prikashan Pvt. Ltd.; New Delhi; c1998b. p. 85-108.
12. Nair IS, Renganayaki SP, Elango L. Identification of Seawater Intrusion by Cl/Br Ratio and Mitigation Through Managed Aquifer Recharge in Aquifers North of Chennai, India. Journal of Groundwater Research. 2013;2(2):155-62.
13. Narayan KA, Schleeberger C, Bristow KL. Modeling Seawater Intrusion in the Burdekin Delta Irrigation Area, North Queensland, Australia. Agricultural Water Management. 2007;89(1):217-228.
14. Rahman MA, Majumder RK, Rahman SH, Halim MA. Sources of Deep Groundwater Salinity in the Southwestern Zone of Bangladesh. Environmental Earth Sciences. 2011;63(2):363-373.
15. Ramprakash SK, Rajpal SK, Sharma, Satyavan. Mapping of Groundwater Quality of Beri Block of Jhajjar District in Haryana. Journal of Soil Salinity and Water Quality. 2013;5(1):27-33.
16. Rao AT, Suresh PV. Coastal Ecosystems of the Karnataka State, India I Mangroves. Karnataka Association for the Advancement of Science; Bangalore; c2001.
17. Shamsudheen M, Dasog GS. Characteristics and Classification of Coastal Soils of North Karnataka. Journal of the Indian Society of Coastal Agricultural Research. 2005;23(1):61-64.
18. Van Camp M, Mtoni Y, Mjemah IC, Bakundukize C, Walraevens K. Investigating Seawater Intrusion Due to

Groundwater Pumping with Schematic Model Simulations: The Example of the Dar es Salaam Coastal Aquifer in Tanzania. Journal of African Earth Sciences. 2014;96:71-78.
19. Vishwanath J, Ravikumar D, Karegoudar AV, Anand SR, Rajkumar RH. Characterization of Groundwater for Irrigation in Dharwad District of Karnataka. Journal of Soil Salinity and Water Quality. 2015;8(2):202-206.
20. Werner AD, Bakker M, Post VE, Vandenbohede A, Lu C, Ataie-Ashtiani B, *et al*. Seawater Intrusion Processes Investigation and Management: Recent Advances and Future Challenges. Advances in Water Resources. 2013;51(2):3-26.