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ASSESSMENT OF POST MONSOON WATER QUALITY PARAMETERS FOR IRRIGATION IN UDUPI DISTRICT OF KARNATAKA INDIA

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ABSTRACT

A study conducted during the 2022-23 period aimed to characterize the coastal water bodies of Udupi district for optimal irrigation use. A total of fifty-one representative water samples were randomly collected from various locations across the region between October and November 2022. These samples were sourced from diverse water bodies, including the sea, bore wells, lakes, open wells, rivers, and streams. Each sample was analyzed and categorized into different water quality classes following standard procedures. The geographical coordinates of each sampling site were recorded. The frequency distribution of water samples based on pH_{iw} revealed that the majority (70.59 per cent) fell within the neutral range of 6.5–7.3, followed by 15.69 per cent in the slightly alkaline range of 7.3–7.8. Additionally, 7.84 per cent of the samples were slightly acidic (pH 6.0–6.5), 3.92 per cent were moderately acidic (pH 5.5–6.0), and 1.96 per cent were moderately alkaline (pH 7.8–8.4). This distribution indicates that the majority of water samples were neutral to slightly alkaline, suggesting no significant risk of alkali hazards for irrigation purposes. Regarding electrical conductivity (EC_{iw}), 11.76 per cent of the samples had EC values below 0.25 dS m^{-1}, while 29.42 per cent had EC_{iw} values greater than 2.25 dS m^{-1}. Despite variations in EC_{iw}, all samples maintained mean magnesium to calcium (Mg/Ca) ratio higher than 0.63, and the mean chloride concentration exceeded 4.0 meq L^{-1}. Based on the CSSRI guidelines, the water quality of the samples was classified as follows: 64.71 per cent were rated as good, 13.73 per cent as high SAR saline, 17.65 per cent as saline, and 3.92 per cent as marginally saline.

Key words: CSSRI Karnal, Post-monsoon season, Magnesium to calcium ratio, Water quality classes.

Introduction

The coastal zone is an area where land and sea interact, with both marine and terrestrial environments influencing this region (Rao and Suresh, 2001). India has an extensive coastline stretching 7,516.6 km, with the peninsular region bordered by the Arabian Sea to the west, the Bay of Bengal to the east, and the Indian Ocean to the south. The total coastal area makes up 15.14 per cent of the country's total geographical area. Of India's entire coastline, Karnataka has a 320 km stretch, and its coastal region represents 6.09 per cent of the state's area (Shamsudheen and Dasog, 2005). The challenges of resource evaluation and management in the coastal zone are notably different from those of inland areas. For the systematic development of coastal regions, accurate data on soil and water, concerning their characteristics, potential, and limitations, is crucial.

In coastal regions, groundwater serves as the primary source of freshwater, and its over-exploitation is widespread to meet the growing demands for domestic, agricultural, and industrial purposes (Hamed *et al*., 2018). The excessive extraction of groundwater disrupts the hydrodynamic balance between freshwater and seawater in the aquifer, leading to the upward movement of seawater (Van Camp *et al.*, 2014). This results in a reduction of available fresh groundwater resources in coastal zones (Alfarrah and Walraevens, 2018; Werner *et al.*, 2013). The vertical movement of seawater into the coastal aquifer is controlled by a well-established mathematical equation known as the "Ghyben-Herzberg relationship" (Narayan *et al.*, 2007). This relationship suggests that for every one-meter rise in the water table, the thickness of the seawater layer decreases by 40 meters. A drop in groundwater levels below the mean sea level leads to a reversal of the hydraulic gradient, causing seawater to move inland within the coastal aquifer (Lee and Cheng, 1974; Nair *et al.*, 2013). The inland encroachment of seawater into the aquifer is referred to as seawater intrusion, a primary factor in the degradation of coastal groundwater resources. Seawater intrusion not only disrupts industrial and agricultural development in the region but also negatively impacts the quality of life for local populations (Demirel, 2004).

Understanding hydrological processes (such as changes in groundwater levels, water quality, and tidal fluctuations) in coastal aquifers is crucial because around 50 per cent of the global population resides in coastal areas, especially in low-lying deltaic regions within 60 km of the coast (Kumar *et al.*, 2013). Coastal aquifers are often a primary source of freshwater, used for purposes like drinking or irrigation (Rahman *et al.*, 2011). The groundwater level is a critical factor for assessing both spatial and temporal variations in groundwater systems (Iwasaki *et al.*, 2013). Various elements influence the groundwater level, with climate change, as evidenced by shifts in precipitation and evaporation rates, playing a significant role in groundwater fluctuations (Chen *et al.*, 2004).

Water used for irrigation always contains dissolved salts, regardless of its origin, but the overall concentration

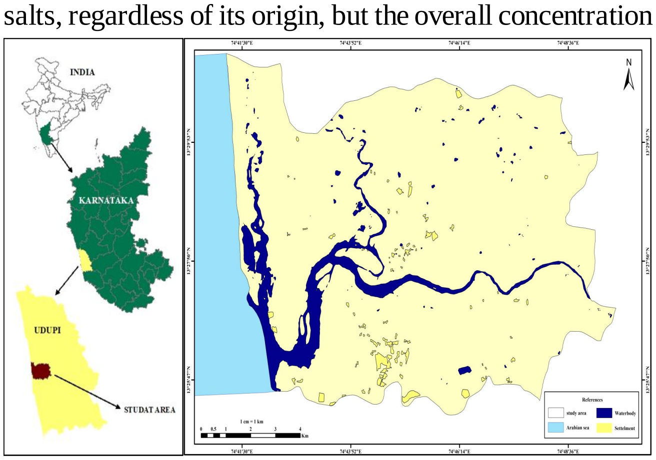

Fig. 1: Location map of the study area.

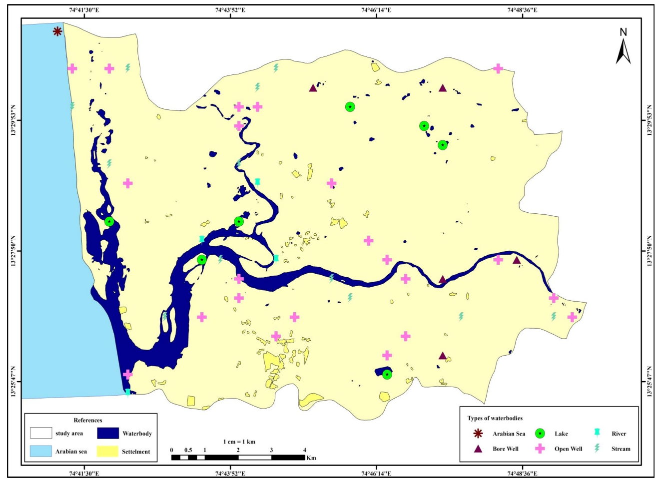

Fig. 2: Water sampling points of the study area.

and type of salts present in the irrigation water are crucial in determining its suitability for agricultural use. Additionally, since sodium is the most harmful ion, its ratio to other cations is a critical factor. Many groundwater aquifers along coastal regions have been degraded due to seawater intrusion. The current study aims to examine the spatial and temporal variation in salinity in the coastal water bodies of Udupi District, Karnataka.

Material and Methods

The study area is located in a part of the coastal region of Brahmavara taluk, Udupi district, covering an area of 11,540.34 ha, as shown in Fig. 1. This area lies within the coastal zone of Karnataka (Agro-climatic zone No. 10). Udupi district is positioned between longitudes 74° 45' E to 74° 46' E and latitudes 13° 24' 45'' N to 13° 25' 30'' N, receiving an average annual rainfall of 4,672 mm at a mean sea level of 27 meters.

A total of fifty-one representative water samples were randomly collected from various sources, including the sea, bore wells, lakes, open wells, rivers, and streams, which represent the entire study area. Geographical coordinates were recorded at each sampling location (Fig. 2) (Plate 1). The samples were gathered during October-

Plate 1: Water sample collection sources in the study area

Table 1: Per cent distribution of pH_{iw} content in the water samples.

S. No	pH_{iw} Classes	Range	Per cent of samples
1	Moderately acid	5.5-6.0	3.92 (2, 5.47)
2	Slightly acid	6.0-6.5	7.84 (4, 6.25)
3	Neutral	6.5-7.3	70.59 (36, 6.92)
4	Slightly alkaline	7.3-7.8	15.69 (8, 7.48)
5	Moderately alkaline	7.8-8.4	1.96 (1, 7.97)
Note: Values in parentheses indicate number of samples and mean values of respective classes, respectively. (Richards, 1954)			

November 2022 in sealed high-density PVC bottles, each containing 1 mL of toluene to prevent any biological activity. These samples were analyzed for salinity/sodicity parameters, including pH, electrical conductivity (EC), cation concentrations (Ca^{2+} , Mg^{2+} , Na^{+} , and K^{+}), and anion concentrations (Cl^{-} , SO_4^{2-} , CO_3^{2-} , and HCO_3^{-}), following the standard methods outlined by Richards (1954). Calcium and magnesium were measured using the Versenate method, while sodium and potassium were analyzed *via* flame photometry. The anions, CO_3^{2-} and HCO_3^{-} , were quantified through titration with a standard acid, while chloride and sulfate were determined by titration with silver nitrate and precipitation as barium sulfate. The resulting values were then used to calculate the sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) using the following formulas:

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

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

Based on the criteria established by Minhas *et al.* (1998b), the groundwater quality for irrigation was classified considering EC, SAR, and RSC, as explained below.

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	<2.5
II. Saline water			
a. Marginally saline	2.0-4.0	≤10	<2.5
b. Saline	>4.0	≤10.	<2.5
c. High SAR saline	>4.0	>10	<2.5
III Alkali water			
a Marginally alkali	<4.0	<10	2.5-4.0
b. Alkali	<4.0	<10	>4.0
c. Highly alkali	<4.0	>10	>4.0

Results and Discussion

The distribution of water samples based on pH_{iw} showed that the largest proportion (70.59 per cent) fell within the pH range of 6.5-7.3 (neutral), followed by 15.69 per cent in the 7.3-7.8 range (slightly alkaline), 7.84 per cent in the 6.0-6.5 range (slightly acidic), 3.92 per cent in the 5.5-6.0 range (moderately acidic), and 1.96 per cent in the 7.8-8.4 range (moderately alkaline). This suggests that most of the water samples were neutral to slightly alkaline, indicating no significant risk of alkalinity when using this groundwater for irrigation (Table 1). In terms of electrical conductivity (EC_{iw}), 29.42, 35.29, 23.53 and 11.76 per cent of the samples had EC_{iw} values of >2.25 dS m^{-1} (very high soluble salts), 0.75-2.25 dS m^{-1} (high soluble salts), 00.25-0.75 dS m^{-1} (medium soluble salts) and <0.25 dS m^{-1} (low soluble salts), respectively (Table 2). It is equally, if not more, crucial to examine the ionic composition of the water samples to gain a deeper understanding of the EC_{iw}. Regarding ionic composition, Na^{+} was the predominant cation (Table 3), followed by Mg^{2+} and Ca^{2+} in the study area. Similar findings were reported by Ramprakash *et al.*, (2013), who observed higher concentrations of Na^{+} (ranging from 2.90 to 60.2 me L^{-1}) compared to other cations in the underground waters of Beri block in Jhajjar district, Haryana.

At all levels of EC_{iw}, although no clear pattern was observed, the average Mg/Ca ratio in the study area (Table 4) exceeded 0.63, which is considered the threshold for

Table 2: Per cent distribution of EC_{iw} content in the water samples

S. No	EC_{iw} Classes	Range (dS m^{-1})	Post-monsoon
1	Low	<0.25	11.76 (6, 0.16 dS m^{-1})
2	Medium	0.25 to 0.75	23.53 (12, 0.53 dS m^{-1})
3	High	0.75 to 2.25	35.29 (18, 1.07 dS m^{-1})
4	Very high	>2.25	29.42 (15, 16.14 dS m^{-1})
Note: Values in parentheses indicate number of samples and mean values of respective classes, respectively. (Richards, 1954)			

Table 3: Ionic composition of water samples for post-monsoon season.

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

Table 4: Per cent distribution of water samples for the relationship between Mg/Ca and Cl/SO_4 ratio with the salinity for post-monsoon season.

EC_{iw} (dS m^{-1}) range	Mg/Ca ratio	Cl/SO_4 ratio
<2.0	56.86 (29, 1.02)	1.96 (1, 1.97)
2.0-4.0	33.33 (17, 3.05)	3.92 (2, 3.44)
>4.0	9.80 (5, 5.87)	94.12 (48, 39.23)
Note: Values in parentheses indicate number of samples and mean values of respective classes, respectively.		

Table 5: Mean chemical composition of water samples for post-monsoon season.

Range/ Mean	pH_{iw}	EC_{iw} (dS m^{-1})	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-} (me L^{-1})	SO_4^{2-}	HCO_3^{-}	CO_3^{2-}	SAR	RSC (me L^{-1})
Min.	5.60	0.11	0.50	0.20	0.07	0.01	0.70	0.07	0.1	0.10	0.06	-85.6
Max.	7.97	32.90	18.90	72.60	70.14	12.63	69.14	3.76	0.5	0.50	25.22	-0.40
Mean.	6.93	5.26	3.75	9.86	10.75	2.05	13.28	0.70	0.25	0.23	3.36	-13.80

potential Mg^{2+} hazard, as Mg^{2+} begins to behave similarly to Na^{+}. Typically, the Mg/Ca ratio of waters in equilibrium with calcite and dolomite is expected to be 0.63 (Minhas *et al.*, 1998a). The per cent distribution of relationship between Mg/Ca ratio with the salinity indicated that 56.86, 33.33 and 9.80 per cent of samples comes under the category of Mg/Ca ratio with the salinity <2.0, 2.0-4.0 and >4.0 dS m^{-1} respectively, which indicated that higher per cent of samples had no Mg hazard in relation to salinity. Similar to the Mg/Ca ratio, the mean value of the Cl/SO_4 ratio at all levels of EC_{iw} exceeded 2.0 (Table 4), which is considered the threshold for potential Cl^{-} hazard. This ratio is reported to be harmful if used for sprinkler irrigation on certain sensitive horticultural crops (Vishwanath *et al.*, 2016).

Among anions, generally Cl^{-} ion was dominant (Table 3) followed by SO_4^{2-}, HCO_3^{-} and CO_3^{2-}. Ramprakash *et al.*, (2013) 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). 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). 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 per cent distribution of water samples concerning relationship between $Cl:SO_4$ ratio with the salinity of water samples revealed that, 94.12, 3.92 and 1.96 per cent of water samples were in the category of >4.0 dS m^{-1}, 2.0-4.0 dS m^{-1} and <2.0 dS m^{-1} respectively, which indicated that higher per cent of samples had Cl^{-} hazard in relation to salinity.

Computation of SAR value provides a useful index of the sodium hazard when applied to soils as well as crops (Ramprakash *et al.*, 2013). 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, levels above which are considered harmful in terms of alkalinity/sodicity effects. When examining pH, EC_{iw}, SAR and RSC values individually, it appears that the underground water quality in these taluks was generally not problematic. However, when samples were grouped based on salinity and alkalinity hazards, considering EC_{iw}, SAR, and RSC values together as outlined by Minhas *et al.*, (1998b), it became clear that there were instances of poor-quality water for irrigation within the study area (Table 6).

According to the CSSRI guidelines, 64.71, 13.73, 17.65 and 3.92 per cent of the samples were categorized as having good, high SAR saline, saline, and marginally saline water quality, respectively (Table 6). In line with the same CSSRI, Karnal classification, Ramprakash *et al.*, (2013) also found that 32 per cent of water samples were of good quality, 56.0 per cent were saline and 12.0 per cent were alkali in nature in Beri block, Jhajjar district, Haryana. Similarly, Hebsur *et al.*, (2012) evaluated groundwater quality in the Malaprabha and Ghataprabha command areas in Karnataka and reported that 22.2 and 31.8 per cent of the groundwater samples had various salinity issues in these regions, respectively. In the neighbouring Gadag district, Vishwanath *et al.*, (2015) assessed groundwater quality and found that less than 50 per cent of the 527 underground irrigation water samples were of good quality, followed by 15.95 per cent marginally saline. Additionally, 40.3 per cent of the water samples were considered problematic, exhibiting different issues such as salinity, high SAR saline, marginal alkali I and II and alkali characteristics.

Table 6: Overall water quality classification of water samples as per the guidelines of CSSRI, Karnal for post-monsoon season.

S.	Water quality classes	Water quality parameters			Total no. of samples (51)
		EC_{iw} (dS m^{-1})	SAR	RSC (meq L^{-1})	
1	Good	<2.0	$\leq$ 10	<2.5	33 (64.71%)
2	Marginally saline	2.0-4.0	$\leq$ 10	<2.5	2 (3.92%)
3	Saline	>4.0	$\leq$ 10.	<2.5	9 (17.65%)
4	High SAR saline	>4.0	>10	<2.5	7 (13.73%)
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 findings of the current study, it can be concluded that approximately 29.42 per cent of the water samples in the study area had EC_{iw} >2.25 dS m^{-1}, indicating that these samples contained a high concentration of dissolved salts and were unsuitable for irrigation at the time of sampling. The reduction in EC_{iw} of irrigation water during the post-monsoon season can be attributed to the dilution effect. According to the CSSRI, Karnal guidelines, 17.65 and 13.73 per cent of the water samples in the study area fall under the saline and high SAR saline water quality categories, respectively. Therefore, to use this water efficiently, continuous monitoring and consideration of factors such as rainfall patterns, soil type, crop selection, water management practices, and nutrient management are essential. This strategy is vital for ensuring sustainable agricultural practices in the future.

References

Alfarrah, N. and Walraevens K. (2018). Groundwater overexploitation and seawater intrusion in coastal areas of arid and semi-arid regions. *Water*, **10(2)**, 138- 143.

Chauhan, C.P.S., Chauhan R.S. and Shishodia P.K. (2010). Survey and characterization of ground water quality of district Bharatpur. *Proc. National Seminar on Soil Salinity and Water Quality*. 19-21, CSSRI, Karnal, **10**.

Chen, Z., Grasby S.E. and Osadetz K.G. (2004). Relation between climate variability and groundwater levels in the upper carbonate aquifer, southern Manitoba, Canada. *J. Hydrol*., **290(1-2)**, 43-62.

Demirel, Z. (2004). The history and evaluation of saltwater intrusion into a coastal aquifer in Mersin. Turkey. *J. Environ. Manage*., **70(4)**, 275-282.

Hamed, Y., Hadji R., Redhaounia B., Zighmi K., Baali F. and El Gayar A. (2018). Climate impact on surface and groundwater in North Africa: a global synthesis of findings and recommendations. *Euro-Mediterr. J. Environ. Integr*., **3**, 20-25.

Hebsur, N.S., Selvaraj S. and Channal H.T. (2012). Assessment of the groundwater quality for domestic and agricultural purposes of Malaprabha and Ghataprabha command areas in Northern Karnataka. *J. soil salin. water qual*., **4(1)**, 6-10.

Iwasaki, Y., Ozaki M., Nakamura K., Horino H. and Kawashima S. (2013). Relationship between increment of groundwater level at the beginning of irrigation period and paddy filed area in the Tedori River Alluvial Fan Area, Japan. *Paddy Water Environ*., **11(1-4)**, 551-558.

Kumar, M.V., Lakshmi G.V. and Madhuvani P. (2013). Appraisal of soil fertility status in salt-affected soils of Ongole division, Prakasam district, Andhra Pradesh. *J. Indian Soc. Soil Sci*., **61(4)**, 333-340.

Lee, C.H. and Cheng R.T.S. (1974). On seawater encroachment in coastal aquifers. *Water Resour. Res*., **10(1)**, 1039-1043.

Minhas, P.S., Singh R.B., Hebbara M., Verma B.L. and Subbaiah G.V. (1998a). Effect of poor-quality water on soil and crop. In: Minhas, P.S., Sharma O.P. and Patil S.G (eds) *25years of Research on Management of Salt-affected Soils and Use of Saline Water in Agriculture*. Yugantar Prikashan Pvt. Ltd., New Delhi, 109-149.

Minhas, P.S., Subbaiah G.V., Chauhan C.P.S., Patil S.G., Verma and Dubey S.K. (1998b). Survey for ground water quality. In: Minhas, P.S., Sharma O.P. and Patil S.G., (eds) *25 years of Research on Management of Salt-affected Soils and Use of Saline Water in Agriculture*. Yugantar Prikashan Pvt. Ltd., New Delhi, 85-108.

Nair, I.S., Renganayaki S.P. and Elango L. (2013). Identification of seawater intrusion by Cl/Br ratio and mitigation through managed aquifer recharge in aquifers North of Chennai. India. *J. Groundw. Res*., **2(2)**, 155-162.

Narayan, K.A., Schleeberger C. and Bristow K.L. (2007). Modeling seawater intrusion in the Burdekin delta irrigation area, north Queensland, Australia. *Agric. Water Manag*., **89(1)**, 217-228.

Rahman, M.A., Majumder R.K., Rahman S.H. and Halim M.A. (2011). Sources of deep groundwater salinity in the southwestern zone of Bangladesh. *Environ. Earth Sci*., **63(2)**, 363-373.

Ramprakash, Sanjay Kumar, Rajpal S.K., and Sharma Satyavan (2013). Mapping of groundwater quality of Beri block of Jhajjar district in Haryana. *J. soil salin. water qual*., **5(1)**, 27-33.

Rao, A.T. and Suresh P.V. (2001). *Coastal ecosystems of the Karnataka state, India I mangroves*, Karnataka Association for the Advancement of Science, Bangalore.

Shamsudheen, M. and Dasog G.S. (2005). Characteristics and classification of coastal soils of North Karnataka. *J. Indian Soc. Coastal agric. Res*., **23(1)**, 61-64.

Van Camp, M., Mtoni Y., Mjemah I.C., Bakundukize C. and Walraevens K. (2014). Investigating seawater intrusion due to groundwater pumping with schematic model simulations: the example of the Dar es Salaam coastal aquifer in Tanzania. *J. African Earth Sci*., **96**, 71-78.

Vishwanath, J., Ravikumar D., Karegoudar A.V., Anand S.R. and rajkumar R.H. (2016). Characterization of groundwater for irrigation in Dharwad district of Karnataka. *J. soil salin. water qual*., **8(2)**, 202-206.

Werner, A.D., Bakker M., Post V.E., Vandenbohede A., Lu C., Ataieashtiani B., Simmons C.T. and Barry D. (2013). Seawater intrusion processes investigation and management: recent advances and future challenges. *Adv. Water Resour*., **51(2)**, 3-26.