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Pawar KS
Division of Soil Science, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Pune, Maharashtra, India

Pondkule RG
Assistant Professor, Division of Soil Science, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Pune, Maharashtra, India

Gaikwad RD
Assistant Professor, Division of Soil Science, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Pune, Maharashtra, India

Navale PK
Division of Soil Science, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Pune, Maharashtra, India

Shinde PV
Division of Soil Science, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Pune, Maharashtra, India

Corresponding Author:
Pawar KS
Division of Soil Science, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Pune, Maharashtra, India

Assessment of derived irrigation water quality parameters in the Nira command area of Baramati Tehsil

Pawar KS, Pondkule RG, Gaikwad RD, Navale PK and Shinde PV

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Abstract
The quality of irrigation water in the Nira command area of Baramati tehsil, Maharashtra was assessed during April-May 2025 using 105 samples (53 open wells, 52 borewells) from 15 villages. Samples were analyzed for derived parameters including Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Magnesium Adsorption Ratio (MAR), Mg^{2+}:Ca^{2+} ratio, Cl^-:SO_4^{2-} ratio and Total Dissolved Solids (TDS). SAR values ranged from 1.43- 6.43 in open wells and 2.01-6.08 in borewells, indicating low sodium hazard. RSC was below 1.25 meq L^{-1} in all samples, showing safe levels for irrigation. MAR values averaged 49.71% in open wells and 50.63% in borewells, reflecting mostly acceptable magnesium levels. Mg^{2+}:Ca^{2+} and Cl^-:SO_4^{2-} ratios were within safe limits, while TDS ranged from 294-998 mg L^{-1} (open wells) and 358-1683 mg L^{-1} (borewells) suggesting moderate salinity risk particularly in borewells. Overall, irrigation water in the Nira command area is suitable for most crops though borewell water may require careful management to prevent long-term soil degradation.

Keywords: Nira command area, Baramati tehsil, SAR, RSC, MAR, Mg:Ca, TDS

Introduction

Agriculture, a vital sector of the economy, depends largely on the availability and quality of irrigation water. The suitability of water for irrigation is influenced by factors such as dissolved salts-including sodium (Na^+), calcium (Ca^{2+}), magnesium (Mg^{2+}) and bicarbonates (HCO_3^-) which directly affect soil structure, fertility and crop productivity (Ayers & Westcot, 1985; Chhabra, 1996) [1, 4]. Freshwater resources constitute only 2.5% of the total global water, with groundwater serving as a critical source in areas where surface water is limited (Shiklomanov & Rodda, 2003) [13]. In India, one-third of the land falls under arid or semi-arid zones, making groundwater essential for irrigation, especially in regions with irregular rainfall.

The quality of groundwater can deteriorate due to natural geogenic processes or anthropogenic activities such as excessive fertilizer use, industrial discharge and improper waste disposal, leading to soil salinity, alkalinity, or ion imbalances that reduce crop yield and soil productivity (Sharma & Tyagi, 2004) [12]. Parameters such as pH, electrical conductivity (EC), major cations (Ca^{2+}, Mg^{2+}, Na^+, K^+) and anions (HCO_3^-, Cl^-, SO_4^{2-}, NO_3^-) are widely used to assess water quality and determine its suitability for irrigation (Richards, 1954) [9].

In Maharashtra, well irrigation accounts for over 56% of the irrigated area, with Baramati tehsil of Pune district depending significantly on the Nira River and groundwater sources for irrigation of its 104,107 hectares of cultivable land, of which 39.9% is irrigated. The Nira command area, a major sugarcane-producing region faces challenges from spatial and temporal variations in water quality.

The present study, "Assessment of Derived Irrigation Water Quality Parameters in the Nira Command Area of Baramati Tehsil," aims to evaluate groundwater from open wells and borewells, analyze derived parameters such as SAR, RSC, MAR, Mg^{2+}:Ca^{2+}, Cl^-:SO_4^{2-} and TDS and classify the water's suitability for irrigation to support sustainable agricultural practices in the region.

2. Materials and Methods

2.1 Study Area

The study was conducted in the Nira Command Area of Baramati tehsil, Pune district, Maharashtra, lying between 18°00'-18°05' N latitude and 74°00'-74°05' E longitude. The region has a semi-arid climate with hot summers reaching up to 40 °C, mild winters and an average annual rainfall of 550-600 mm, predominantly received during the June-September monsoon period.

The command area consists of alluvial plains with clayey to loamy soils, which support major crops such as sugarcane, wheat, maize and pulses. Continuous use of groundwater for irrigation raises concerns regarding salinity, sodicity and related chemical imbalances, making the assessment of derived irrigation water quality parameters essential for sustainable agriculture.

2.2 Water Sample Collection

During April-May 2025, a total of 105 irrigation water samples were collected, comprising 53 open well and 52 borewell samples, from 15 villages of the Nira Command Area. Sampling was carried out using a 1 km grid method with the help of GPS. The villages sampled included Songaon, Mekhali, Nirawaghaj, Khandaj, Shiravali, Sangavi, Kambaleshwar, Pandharwadi, Late, Korhale Khurd, Sadobachi Wadi, Hol, Murum, Wanewadi and Nimbut.

At each location, water was allowed to flow for 2-3 minutes prior to collection to remove stagnant water. Clean, pre-washed 1-liter polyethylene bottles were used. Each bottle was rinsed twice with the same water sample to avoid contamination. All samples were properly labeled with sample ID, village, source type (open well or borewell), GPS location and date of collection.

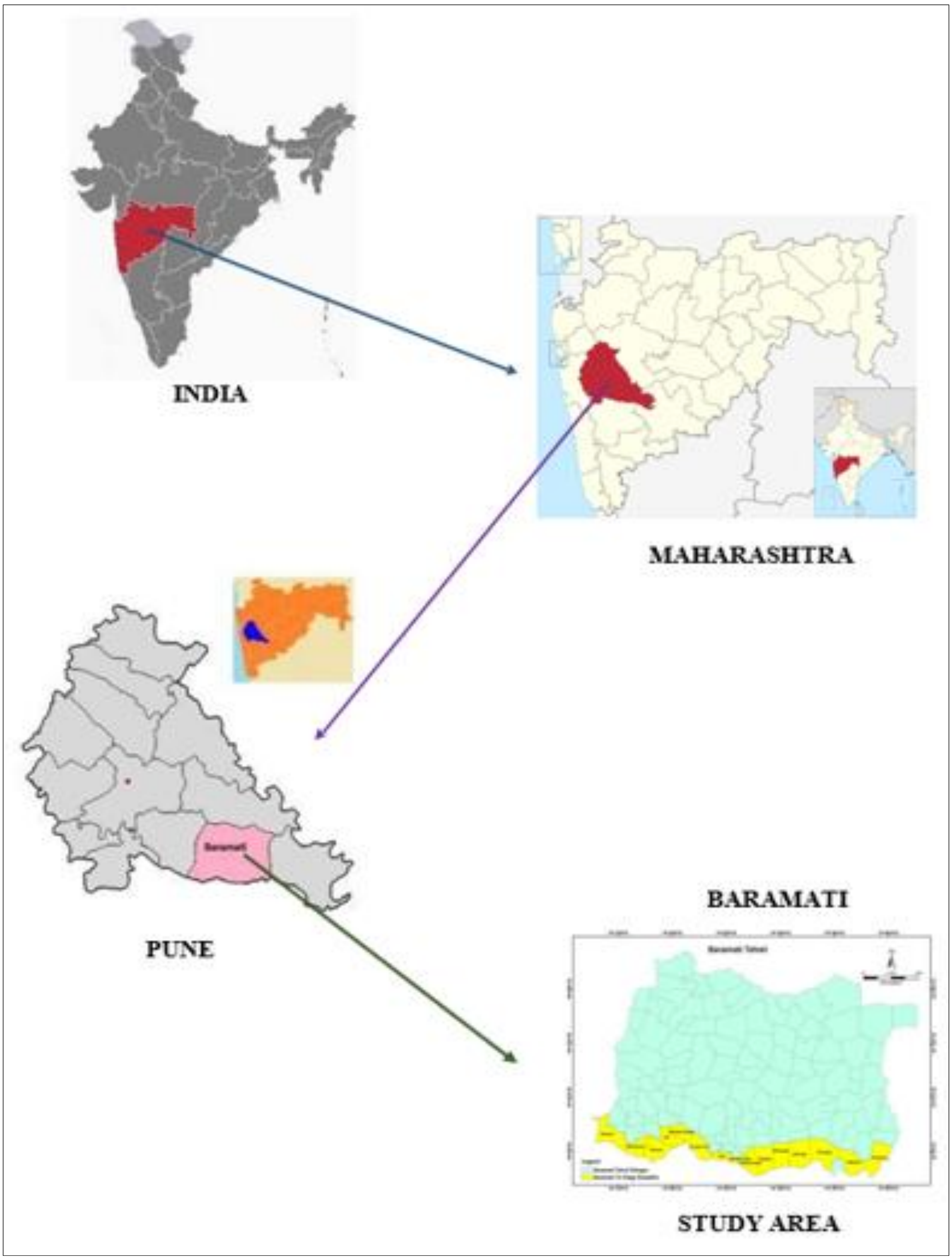
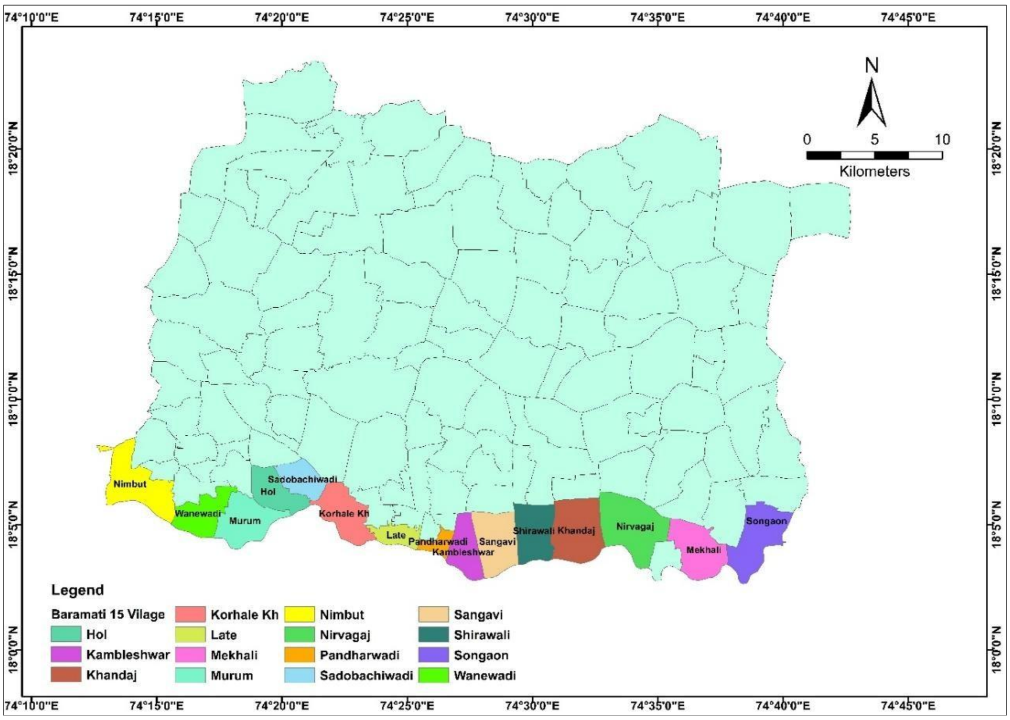


Fig 2.1: Location map of Nira command area of Baramati tehsil



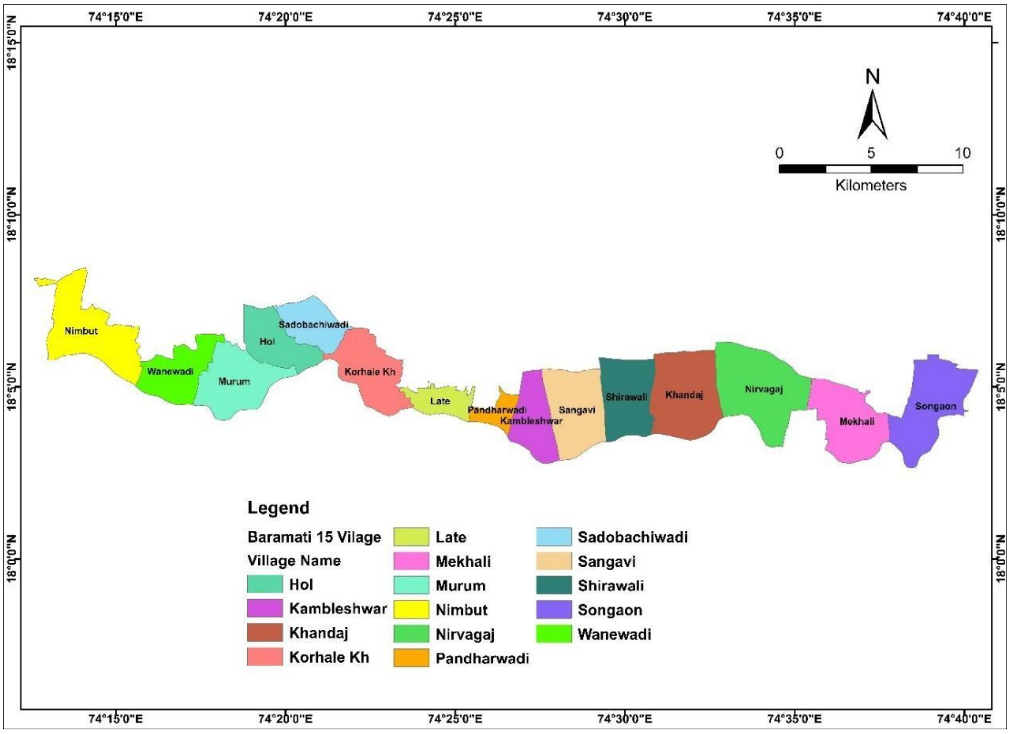


Fig 2.2: Location map of sampling sites in Nira command area of Baramati tehsil

2.3 Laboratory Analysis for Derived Parameters

The collected water samples were analyzed in the Soil and Water Testing Laboratory using standard methods (APHA, 2017). After determining major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}), anions (CO_3^{2-}, HCO_3^{-}, Cl^{-}, SO_4^{2-}) and EC/TDS, the following derived parameters were computed:

2.3.1 Sodium Adsorption Ratio (SAR)

SAR was calculated using:

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

Values were used to assess the sodicity hazard of irrigation water.

2.3.2 Residual Sodium Carbonate (RSC)

RSC was interpreted to evaluate carbonate and bicarbonate hazards.

$$RSC = [HCO_3^{-} + CO_3^{2-}] - [Ca^{2+} + Mg^{2+}]$$

2.3.3 Magnesium to Calcium Ratio (Mg^{2+}: Ca^{2+})

This ratio was used to determine magnesium dominance and its ton soil structure.

$$Mg:Ca = Ca^{2+}/ Mg^{2+}$$

2.3.4 Chloride to Sulphate Ratio ($Cl^{-}:SO_4^{2-}$)
The ratio was used to differentiate salinity origin and to assess ion balance.

$Cl:SO4 = Cl^{-} / SO_4^{2-}$

2.3.5 Magnesium Adsorption Ratio (MAR)

$$MAR = \frac{Mg2+}{Ca^{2+} + Mg^{2+}} \times 100$$

MAR helps to understand magnesium hazard and its effect on permeability.

2.3.6 Total Dissolved Solids (TDS)
TDS was calculated from EC using:

$$TDS\ (mgL^{-1}) = EC\ (dSm^{-1}) \times 640$$

TDS was used to classify the overall salinity of irrigation water.

3. Results
3.1 Sodium Adsorption Ratio (SAR)
SAR is an important indicator of sodicity hazard in irrigation water. In the Nira Command Area, SAR values in open well water ranged from 1.43 to 6.43 with a mean of 3.49, SD 1.06 and CV 30.44%, indicating moderate variability. All 53 samples were below SAR < 10, classifying them under low sodium hazard.

In borewell water, SAR ranged from 2.01 to 6.08 with a mean of 3.74, SD 1.04 and CV 27.66%. All 52 borewell samples also fell within the low SAR category (<10).

Overall, all 105 water samples (open wells and borewells) from all 15 villages were classified as safe for irrigation, with no samples falling in the moderate, high, or very high SAR categories. This indicates no sodicity risk in the study area and the water is suitable even for salt-sensitive crops.

These results agree with Khapra and Singh (2024) [14] evaluated SAR levels in freshwater and greywater and reported that higher SAR values reduce soil permeability and negatively affect crop growth. Their findings support the present study, where SAR remained within safe limits for most samples, indicating minimal sodium hazard.

Table 3.1: Concentration of SAR and RSC in open well and bore well of Nira command area of Baramati tehsil

	SAR		RSC	
	Open well	**Borewell**	**Open well**	**Borewell**
MIN	1.43	2.01	-2.30	-8.60
MAX	6.43	6.08	1.20	-0.45
MEAN	3.49	3.74	0.54	-3.24
SD	1.06	1.04	0.66	1.84
CV	30.44	27.66	94.44	-56.59

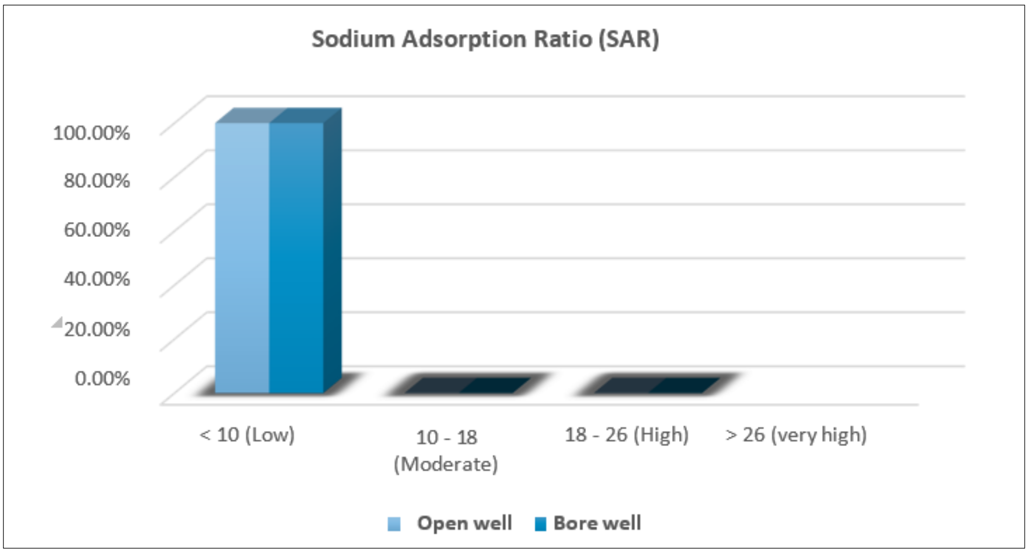


Fig 3.1: Sodium Adsorption Ratio (SAR) in Nira command area of Baramati tehsil

3.2 Residual Sodium Carbonate (RSC)
RSC indicates the balance between carbonates/bicarbonates and calcium/magnesium in irrigation water. In the Nira Command Area, open well RSC values ranged from -2.30 to 1.20 meq L^{-1}, with a mean of 0.54, SD 0.66 and a high CV of 94.44%, reflecting large variability among samples. A few samples from Khandaj, Shirawali and Hol showed higher RSC values (up to 1.20), but all remained within the safe (<1.25 meq L^{-1}) category.

Borewell water showed entirely negative RSC values, ranging from -8.60 to -0.45, with a mean of -3.24, SD 1.84 and CV -56.59%, indicating no risk of carbonate hazard. The most negative RSC values occurred in Sangavi and Kambaleshwar, while the least negative was recorded at Hol.

Overall, all 105 samples (53 open wells and 52 borewells) fell under the safe category (RSC < 1.25 meq L^{-1}) and no sample fell into moderate or unsafe classes. All 15 villages showed 100% safe water for RSC, confirming the absence of carbonate-related sodicity risk in the region.

The findings agree with earlier reports by Hiranmai and Neeraj (2024) [7] assessed salt-affected soils in the Indo-Gangetic Plains and highlighted that elevated RSC leads to soil alkalinity problems and reduced infiltration. This aligns with the current study, where RSC values were generally low, indicating safe conditions for irrigation. Choudhary *et al*. (2020) [5], who also observed predominantly negative to low-positive RSC values, indicating safe irrigation water in similar groundwater environments.

3.3 Magnesium to Calcium Ratio (Mg^{2+}: Ca^{2+})

The Mg^{2+}: Ca^{2+} ratio helps assess the potential for soil dispersion under irrigation. In open well water, the ratio ranged from 0.60 to 1.73, with a mean of 1.03, SD 0.29 and CV 28.01%, indicating moderate variability. Higher ratios (up to 1.73 in Wanewadi) indicate magnesium dominance, which may reduce soil permeability with long-term use.

Borewell water showed Mg^{2+}: Ca^{2+} values between 0.67 and 1.33, with a mean of 0.99, SD 0.18 and CV 17.80%, reflecting low variability. Most samples showed nearly balanced Ca-Mg concentrations, suggesting minimal risk to soil structure.

Previous research by Bhindhu P *et al.* (2021) [2] and Sarkar B *et al.* (2021) [11] reported that Mg^{2+}: Ca^{2+} > 2.0 can cause severe soil degradation and the present study shows ratios well below this threshold, indicating safe conditions.

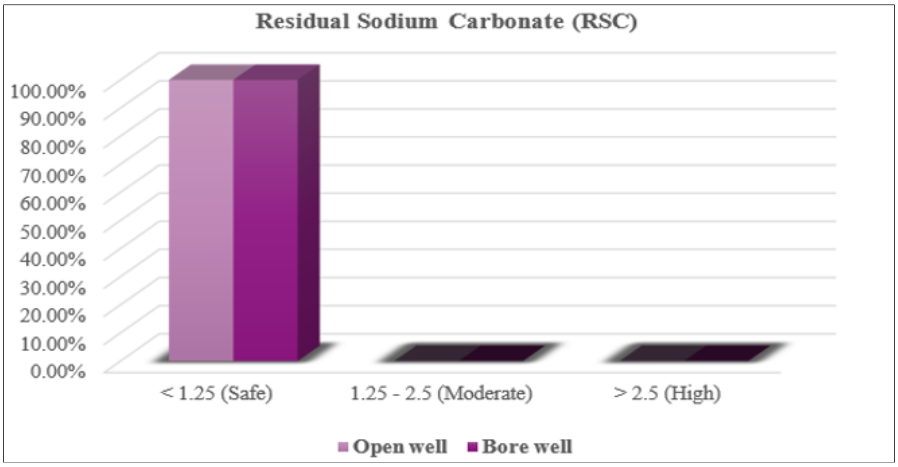


Fig. 3.2: Residual Sodium Carbonate (RSC) in Nira command area of Baramati tehsil

Table 3.2: Concentration of Mg^{2+}: Ca^{2+} and Cl^-: $SO_4 2^-$ in open well and bore well of Nira command area of Baramati tehsil

	Mg^{2+}: Ca^{2+}		Cl^-: $SO_4 2^-$	
	Open well	Borewell	Open well	Borewell
MIN	0.60	0.67	0.32	0.31
MAX	1.73	1.33	2.78	2.84
MEAN	1.03	0.99	0.97	1.27
SD	0.29	0.18	0.49	0.50
CV	28.01	17.80	50.30	39.05

3.4 Chloride to Sulphate Ratio (Cl^-:SO_4^{2-})

The Cl^-:SO_4^{2-} ratio differentiates chloride-dominant from sulphate-dominant water. In open wells, the ratio varied from 0.32 to 2.78, with a mean of 0.97, SD 0.49 and CV 50.30%, indicating high variability. Most samples showed balanced ion concentrations, though a few chloride-dominant samples (e.g., Kambaleshwar) may pose risks for chloride-sensitive crops.

Borewell samples showed ratios ranging from 0.31 to 2.84, with a mean of 1.27, SD 0.50 and CV 39.05%. The higher values reflect chloride dominance in some locations, which may contribute to potential salinity stress if used continuously.

These findings align with Rathod *et al.* (2021) [10], who also reported spatial variation in Cl^-:SO_4^{2-} ratios in command area waters influenced by geology and agricultural practices.

3.5 Magnesium Adsorption Ratio (MAR)

MAR is used to assess the dominance of magnesium in irrigation water, as higher values can negatively affect soil structure. In open well samples, MAR ranged from 23.67 to 62.50 with a mean of 49.71, SD 7.75 and CV 15.59%, indicating moderate variability. Nearly half of the samples had MAR <50 (Excellent), while the remaining fell in the 50-70 (Good) category. A few locations such as Mekhali, Korhale Kh., Murum, Late and Wanewadi showed higher MAR values, suggesting the need for periodic monitoring.

In borewell water, MAR values varied from 42.86 to 60.00, with a mean of 50.63, SD 4.46 and CV 8.80%, reflecting low variability. Most samples clustered near the critical limit of 50, indicating slightly elevated magnesium levels. No samples exceeded the “Poor” category (>70) and 40% were “Excellent” while 60% were “Good.”

Previous research by Gugulothu S *et al.* (2022) [6] reported that MAR values above 50 increase the risk of soil permeability reduction and structural degradation. In the present study, most MAR values were below or close to this threshold, indicating generally safe conditions for irrigation.

Table 3.3: Concentration of MAR and TDS in open well and bore well of Nira command area of Baramati tehsil

	MAR		TDS (mgL-1)	
	Open well	Borewell	Open well	Borewell
MIN	23.67	42.86	294.40	358.40
MAX	62.50	60.00	998.40	1683.20
MEAN	49.71	50.63	631.18	891.08
SD	7.75	4.46	179.43	336.41
CV	15.59	8.80	28.43	37.75

Table 3.4: Categorization of water sample from Nira command area of Baramati tehsil according to MAR classification

MAR Range	Number of Samples (OW)	Percentage of Samples (OW)	Number of Samples (BW)	Percentage of Samples (BW)	Suitability for irrigation
< 50 (Excellent)	26	49.06%	21	40.38%	Ideal for all crops
50-70 (Good)	27	50.94%	31	59.62%	Moderate permeability; suitable for tolerant crops
> 70 (Poor)	0	0.00%	0	0.00%	High magnesium hazard; restricts root growth

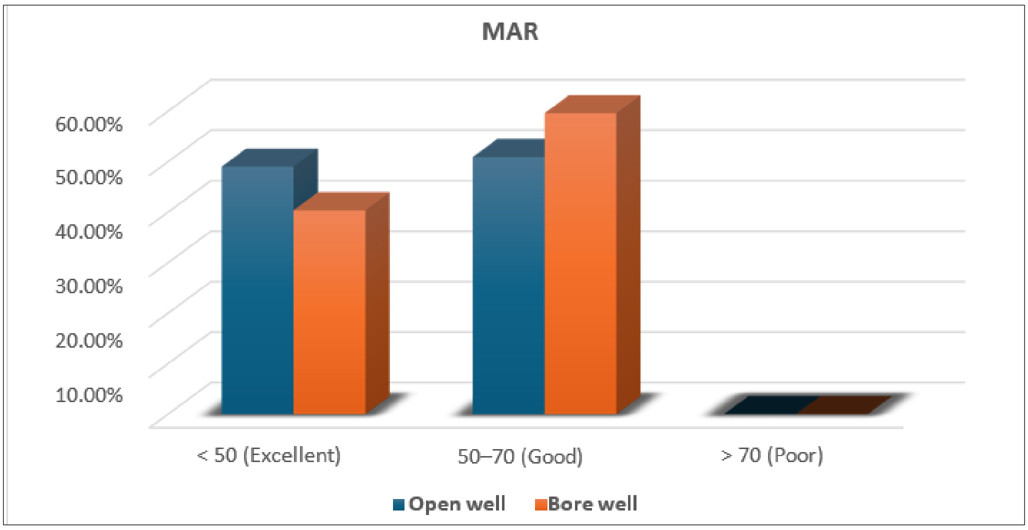


Fig. 3.3: Magnesium Adsorption Ratio (MAR) in Nira command area of Baramati tehsil

3.6 Total Dissolved Solids (TDS)

TDS in open well water of the Nira command area ranged from 294.40 to 998.40 mg L^{-1}, with a mean of 631.18 mg L^{-1}, indicating mostly moderate salinity. Lower values at Kambaleshwar suggest good-quality water, while higher TDS at Songaon may pose salinity risks in the long term. Borewell TDS varied more widely (358.40 to 1683.20 mg L^{-1}, mean 891.08 mg L^{-1}), indicating deeper groundwater is comparatively more saline. Based on classification, 18.87% of open wells and 9.62% of borewells fell in the "good" category (<450 mg L^{-1}), while the remaining samples were moderately saline, with none exceeding 2000 mg L^{-1}. Thus, all water samples are suitable for irrigation, but borewells require more careful management for salt-sensitive crops. Similar TDS ranges were reported by Charan G *et al*. (2023) [3] and Singh R *et al*. (2024) [14], supporting the observed variability.

Table 3.5: Categorization of water sample from Nira command area of Baramati tehsil according to TDS classification

TDS Range (mgL-1)	Number of Samples (OW)	Percentage of Samples (OW)	Number of Samples (BW)	Percentage of Samples (BW)	Suitability for irrigation
< 450 (Good)	10	18.87%	5	9.62%	Suitable for all irrigation purposes
450-2000 (Moderate)	43	81.13%	47	90.38%	Moderately suitable for irrigation
> 2000 (Unsuitable)	0	0.00%	0	0.00%	Unsuitable due to high salinity risk

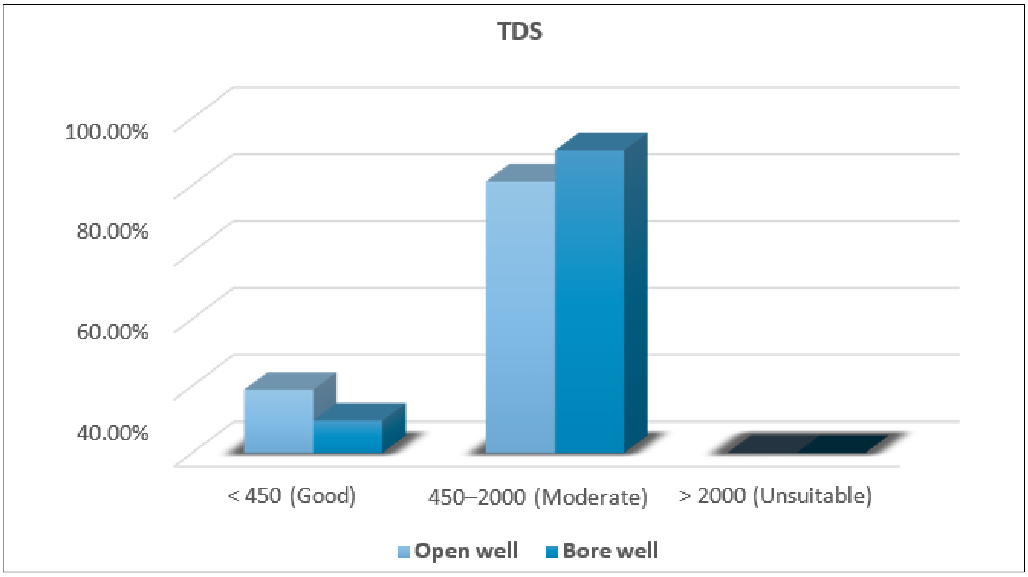


Fig 3.4: Total Dissolved Solids (TDS) in Nira command area of Baramati tehsil

Conclusion

The irrigation water quality assessment of 105 samples (53 open wells and 52 borewells) from the Nira command area of Baramati tehsil revealed that most parameters were within the acceptable limits for agricultural use. pH and EC values indicated generally normal to medium salinity water. Major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and anions (HCO_3^{-}, Cl^{-}, SO_4^{2-}) showed moderate variation between sources, with borewells typically exhibiting higher mineralization. Derived parameters such as SAR, RSC, MAR, TDS and Mg:Ca ratio were mostly within safe limits, though some borewell samples showed elevated values, suggesting a need for cautious use in sensitive soils and crops. MAR and SAR indicated low to moderate sodicity and magnesium hazard, while RSC values confirmed that most waters were suitable without major alkalinity issues. TDS classification showed all samples were below 2000 mg L^{-1}, though borewells had comparatively higher salinity. Overall, both open well and borewell water are fit for irrigation, but borewell water requires better management (leaching, gypsum, crop selection) to prevent long-term soil degradation.

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Conflict of Interest
The authors confirm that there are no competing interests associated with the publication of this research work.

References
1. Ayers RS, Westcot DW. Water quality for agriculture. FAO Irrigation and Drainage Paper No. 29. Rome: Food and Agriculture Organization of the United Nations; 1985. 174 p.
2. Bhindhu PS, Sureshkumar P. Availability indices of calcium and magnesium in soils of Kerala. J Trop Agric. 2021;59(1).
3. Charan G, Bharti VK, Giri A, Kumar P. Evaluation of physico-chemical and heavy metals status in irrigation, stagnant and Indus River water at the trans-Himalayan region. Discov Water. 2023;3(1):3.
4. Chhabra R. Soil salinity and water quality. Rotterdam: A.A. Balkema/CRC Press; 1996.
5. Choudhary BC, Pandey A, Verma AK, Singh A. Groundwater development and management strategies in arid and semi-arid regions of India. J Soil Water Conserv. 2020;19(2):110-118.
6. Gugulothu S, Subbarao N, Das R, Dhakate R. Geochemical evaluation of groundwater and suitability of groundwater quality for irrigation purpose in an agricultural region of South India. Appl Water Sci. 2022;12(6):142.
7. Hiranmai RY, Neeraj A. Assessment of salt-affected soil in Indo-Gangetic Plain of Uttar Pradesh and prediction using regression model. Land Degrad Dev. 2024;35(3):1087-1097.
8. Khapra R, Singh N. Evaluation of residual sodium carbonate (RSC) and sodium adsorption ratio (SAR) in fresh water and laundry grey water for irrigation usage. Environ Qual Manag. 2024;34(1):e22248.
9. Richards LA. Diagnosis and improvement of saline and alkali soils. USDA Handbook No. 60. Washington (DC): U.S. Salinity Laboratory; 1954.
10. Rathod H, Vishwanath J, Rudramurthy HV, Veeresh H, Ananda N. Assessment of spatial and temporal changes in salinity and alkalinity of natural streams/nala water in Sindhanur taluk of Tungabhadra command area in Karnataka. J Farm Sci. 2021;34(3):269-277.
11. Sarkar B, Islam A. Assessing the suitability of groundwater for irrigation in the light of natural forcing and anthropogenic influx: a study in the Gangetic West Bengal, India. Environ Earth Sci. 2021;80(24):807.
12. Sharma SK, Tyagi NK. Management of salt-affected soils and water for sustainable agriculture. Bulletin No. 2/2004. Karnal: Central Soil Salinity Research Institute (CSSRI); 2004.
13. Shiklomanov IA, Rodda J. World water resources at the beginning of the twenty-first century. Cambridge: Cambridge University Press; 2003.
14. Singh R, Singh A, Majumder CB, Vidyarthi AK. Impact of pH, TDS, chloride and nitrate on the groundwater quality using entropy-weighted water quality index and statistical analysis: a case study in the districts of North India. Water Conserv Sci Eng. 2024;9(2):86.