International Journal of Plant & Soil Science

Volume 38, Issue 6, Page 437-445, 2026; Article no.IJPSS.159784
ISSN: 2320-7035

Ground Water Quality Indices and Irrigation Suitability Assessment in Agricultural Regions of Coastal Andhra Pradesh, India

K. Himabindu [a++*] and N. Goutami [b++]

[a] Vignan's Foundation for Science, Technology and Research, Vadlamudi, India.
[b] College of Horticulture, Chinalataripi, Dr. YSRHU, Andhra Pradesh, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2026/v38i66135

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/159784

Original Research Article

Received: 09/04/2026
Published: 13/06/2026

Abstract

Ground Water is the principle source of irrigation in the agricultural regions of coastal Andhra Pradesh, where water quality plays a crucial role in maintaining soil health and sustaining crop productivity. The intent of the present study was to assess and categories the irrigation water quality of Vadlamudi, Vejendla, Guntur, Vijayawada, Tenali and Chirala. Key physicochemical parameters, including pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), and Permeability Index (PI), were measured in Ground Water samples taken from bore wells and tube wells. Standard irrigation water quality rating systems pertaining to salinity and sodicity hazards were used to assess the impact of Ground Water for irrigation. The findings revealed that Ground Water quality in selected agricultural regions of coastal Andhra Pradesh is generally suitable for irrigation, with some outliers in

[++] *Assistant Professor (Soil Science)*
**Corresponding author: E-mail: kh_ahs@vignan.ac.in;*

Cite as: *Himabindu, K., & Goutami, N. (2026). Ground Water Quality Indices and Irrigation Suitability Assessment in Agricultural Regions of Coastal Andhra Pradesh, India. International Journal of Plant & Soil Science, 38(6), 437–445. https://doi.org/10.9734/ijpss/2026/v38i66135*

coastal and intensively cultivated areas. Approximately 62.5% of samples belonged to the C3 salinity class, while sodium hazard was low, with over 90% of samples classified as S1 (low SAR). Most samples (78.1%) were safe based on RSC, and PI results suggested good to moderate soil permeability. The higher EC and TDS values recorded in coastal areas such as Chirala show the influence of seawater intrusion and salt deposition. Although overall groundwater suitability for irrigation remains acceptable, continuous use of saline water may adversely affect soil structure, nutrient availability, and crop productivity. Therefore, regular monitoring of groundwater quality, adoption of efficient irrigation practices, improved drainage management, and cultivation of salt-tolerant crops are essential for sustaining soil health and agricultural productivity in the region.

Keywords: Ground water suitability; EC; SAR; RSC; irrigation water quality; coastal Andhra Pradesh.

1. Introduction

Ground Water is vital for sustaining agricultural output, particularly in areas where reliance on irrigation is growing as a result of erratic rainfall and diminishing surface water supplies (Ayers & Westcot, 1985; Rao *et al*., 2022). Since Ground Water is widely used for crop production in many Andhra Pradesh agricultural districts, evaluating its quality is crucial to protecting soil health and crop yield (CGWB, 2025). Irrigation water's chemical makeup has a direct impact on permeability, soil structure, nutrient availability, and overall agricultural sustainability. over time, excessive salt and sodium buildup in irrigation water may cause soil deterioration, reduced infiltration and lower crop yields (Richards, 1954; Chidambaram *et al*., 2022, Jagadeesh et al., 2024).

The relevance of ground water quality assessment and its appropriateness for irrigation in the agricultural regions of coastal Andhra Pradesh is driven by the increasing demand for efficient and sensible exploitation of existing water resources. With increased pressure on freshwater resources due to agricultural intensification, urbanization, and climate unpredictability, ensuring the quality of irrigation water has become a vital component of sustainable agricultural growth. The evaluation of irrigation water quality through established indices provides valuable information on salinity, sodicity, and alkalinity hazards, enabling the identification of potential risks associated with soil salinization, reduced permeability, and land deterioration (Richards, 1954; Ayers & Westcot, 1985). Such assessments are essential for retaining long-term soil productivity and ensuring sustainable crop production in irrigated agroecosystems.

Variations in Ground Water quality were caused by continuous agricultural intensification, industrial activity, urban growth and the use of improper fertilizers (Ahada and Suthar, 2017; Mukate *et al*., 2020 and Marghade *et al*., 2015). Therefore, to determine the suitability of Ground Water for irrigation, it must be periodically monitored and classified. pH, electrical conductivity, total dissolved solids, sodium adsorption ratio, residual sodium carbonate, and ionic concentration are used in water quality assessments to provide important information about possible impact on soil and crops (Richards, 1954; Dimple *et al*., 2022).

Groundwater quality assessment fosters scientific understanding of the relationships among water quality, soil health, and agricultural sustainability (Marghade *et al.*, 2021; Subba Rao, 2018 and Subba Rao *et al*., 2021)**.** The generated information aids researchers, policymakers, and land managers in creating effective ground water management and soil conservation methods. Such assessments are particularly essential in coastal agricultural regions where groundwater is responsive to salinity intrusion and anthropogenic contamination (Rao *et al*., 2022). Therefore, regular monitoring of groundwater quality is vital for enhancing water-use efficiency, maintaining ecological stability, and promoting sustainable agricultural production (Adimalla & Qian, 2023).

The present study evaluates the quality of irrigation water in some of the agricultural areas in Andhra Pradesh, including Vadlamudi, Vejendla, Guntur, Vijayawada, Chirala, and Tenali. The study intends to produce scientific data that can promote effective water management and sustainable agricultural practices in the study area, as well as to categories Ground Water suitability for irrigation using conventional water quality indices.

2. Materials and Methods

The study was conducted in Six significant agricultural areas of coastal Andhra Pradesh namely Vadlamudi, Vejendla, Guntur, Vijayawada, Tenali, and Chirala were included in Tropical climates, intense agricultural practices and a significant reliance on Ground Water supplies define these regions.

Standard Ground Water quality evaluation techniques were followed in the collection of Ground Water samples from bore wells and tube wells. Clean one-litre plastic bottles were used to randomly gather representative samples. Wells were pumped for 5-10 minutes to collect fresh aquifer water prior to sampling. To avoid contamination and chemical change, the samples were appropriately marked, transported to the laboratory and stored under appropriate conditions before chemical analysis.

The following parameters were determined:

1. **pH:** pH in the water sample was measured potentiometrically using pH meter (Jackson, 1973)
2. **Electrical conductivity (EC):** Conductivity bridge was used to determine the electrical conductivity of the water sample (Willard *et al*., 1974)
3. **Sodium adsorption ratio (SAR):** SAR was computed to indicate the sodicity hazard of irrigation waters by using the following formula (Richards, 1954)

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

4. **Residual sodium carbonate (RSC):** The residual sodium carbonate (RSC) is used to evaluate the quality of irrigation water and is expressed in meL^{-1}(Karanth, 1987)

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

5. **Permeability Index (PI):** Permeability Index was calculated to assess the suitability of irrigation water with respect to its effect on soil permeability. PI was computed using the following formula proposed by Doneen (1964):

   $$PI\ (\%) = [(Na^{+} + \sqrt{HCO_3^{-}}) / (Ca^{2+} + Mg^{2+} + Na^{+})] \times 100$$

6. **Total dissolved solids (TDS):** Total dissolved solids (TDS) represent the total concentration of dissolved inorganic salts and small amounts of organic matter present in water. TDS was estimated from the electrical conductivity (EC) values of water samples using the following formula (Hem, 1985):

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

Chart 1. Salinity hazard (Willard *et al*., 1974)

Class	EC (mSm^{-1})	Salt concentration (g^{-1})	Remarks
C_1-Low salinity	0-25	<0.16	Can be used safely
C_2-Medium salinity	25-75	0.16-0.50	Can be used with moderate leaching
C_3-High salinity	75-225	0.50-1.50	Unsafe for irrigation
C_4-Very high salinity	>225	1.50-3.0	Unsafe for irrigation

Chart 2. Sodium hazard (Richards, 1954)

Class	SAR Value	Remarks
S_1-Low sodium hazard	0-10	Water can be used safely
S_2-Medium sodium hazard	10-18	Appreciable hazard but can be used with appropriate management
S_3-High sodium hazard	18-26	Unsafe for most of the crops
S_4-Very high sodium hazard	>26	Unsafe for most of the crops

Chart 3. Alkalinity hazard (Karanth, 1987)

Class	RSC Value (meL^{-1})	Remarks
A_1- Low alkalinity hazard	<1.25	Little or no hazard
A_2- Medium alkalinity hazard	1.25-2.5	Water can be used with certain management
A_3- High alkalinity hazard	>2.5	Unsuitable for irrigation purpose

3. Results and Discussion

3.1 pH

The pH of Ground Water samples collected from Vadlamudi, Vejendla, Guntur, Vijayawada, Chirala and the Tenali regions were neutral to slightly alkaline in nature, demonstrating the usefulness of Ground Water for irrigation purposes. Based on pH classification, the bulk of Ground Water samples were placed into the neutral category (pH 6.5–7.5), whereas just a few samples belonged to the alkaline category (>7.5). The prevalence of neutral pH suggests excellent circumstances for irrigation and crop growth.

The neutral to mildly alkaline composition of Ground Water may be linked to the dissolution of carbonate and bicarbonate minerals in the aquifer system. Slight alkalinity reported in some regions may arise from continual irrigation, fertilizer application and buildup of soluble salts in Ground Water. Similar results were reported by (Nageswara Rao *et al*., 2022), who observed that ground water in agricultural regions generally remains within permissible pH limits due to the buffering action of aquifer materials and geochemical processes

3.2 Electrical Conductivity (EC)

Electrical conductivity results differed widely among Ground Water samples, indicating diversity in soluble salt concentration. Based on EC classification, the majority of Ground Water samples belonged to C_3 class (high salinity water), although a limited number of samples were categorized under C_2 (medium salinity) and C_4 (extremely high salinity) classes.

Out of the total Ground Water samples studied, almost 60–70 per cent of samples were classed into C_3 class, showing dominance of high salinity fluids in the research area. Around 15–25 per cent samples belonged to C_2 category, while a lower proportion of samples fell into C_4 class. The prevalence of C_3 class suggests slight salinity hazard, suggesting that Ground Water can be used for irrigation with suitable management measures.

Higher electrical conductivity (EC) values observed in certain locations may result from intensive agricultural practices, excessive use of fertilisers, inadequate drainage conditions and the accumulation of salts in Ground Water. Singh *et al*. (2015) indicate that elevated EC values in agricultural Ground Water are primarily linked to long-term irrigation practices and the accumulation of geogenic salts. Comparable observations regarding salinity hazards and irrigation suitability were reported by (Houatmia *et al*., 2016 and Gugulothu *et al*., 2022).

3.3 Sodium Adsorption Ratio (SAR)

The SAR results revealed that the majority of Ground Water samples belonged to S_1 class (low sodium danger), indicating the suitability of Ground Water for irrigation usages. More than 90 per cent of Ground Water samples were classified under S_1 category, whereas only a few samples belonged to S_2 class indicating moderate sodium hazard.

Low SAR values indicate the dominance of calcium and magnesium ions over sodium ions in Ground Water, which helps conserve soil permeability and good soil structure. Similar observations were reported by (Laxman *et al*., 2021; Naidu *et al*., 2020 and Pal *et al*., 2018). who noted that irrigation water with low SAR values can safely be utilized without producing sodicity hazard.

3.4 Residual Sodium Carbonate (RSC)

Based on RSC classification, the majority of Ground Water samples were grouped into A_1 class (<1.25 meL^{-1}), suggesting safe water suitable for irrigation purposes. Approximately 75–85 per cent of Ground Water samples were classified under safe category, however a smaller portion of samples belonged to A_2 (marginal) and A_3 (unsuitable) categories.

Higher RSC values observed in specific places suggest that bicarbonate and carbonate concentrations predominate calcium and magnesium ions. Waters with high RSC may precipitate calcium and magnesium, increasing the accumulation of salt in soils and producing alkalinity problem Kaledhonkar *et al*. (2019) and kaledhonkar *et al*. (2020). recorded similar findings, indicating that Ground Water with a high bicarbonate concentration lowers soil permeability and has a detrimental impact on crop development.

3.5 Total Dissolved Solids (TDS)

TDS in Ground Water samples is the total concentration of dissolved inorganic salts and small organic materials. TDS levels varied among locations, indicating changes in soluble salt content. A significant portion of samples were in the moderate to high salinity range. Chirala had comparably higher TDS levels due to coastal influence and extensive agricultural activity, whereas Vejendla and Tenali had considerably lower TDS concentrations, indicating greater suitability for irrigation. Moderate to high TDS readings suggest minor to moderate salinity problems that could affect soil yield if irrigation water is being used indefinitely without adequate management. Similar observations were reported by Marghade *et al*. (2020), who attributed variations in ground water quality to geochemical process, mineral weathering and the dissolution of soluble salts, which significantly influence the concentration of dissolved constituents in ground water

3.6 Permeability Index (PI)

The Permeability Index (PI) emerged to determine the effect of irrigation water on soil permeability. Most Ground Water samples were classed as Class I or Class II, suggesting good to moderate suitable for irrigation. Higher PI levels indicate favorable conditions for sustaining soil permeability, while lower PI values may necessitate cautious management to avoid long-term damage of soil structure. Similar results were reported by Subbaiah *et al*. (2020) for ground water used for irrigation in Andhra Pradesh.

3.7 Overall Irrigation Water Quality

The overall assessment of Ground Water quality of study area indicated that the majority of Ground Water samples collected from the Vadlamudi, Vejendla, Guntur, Vijayawada, Chirala, and Tenali regions were appropriate for irrigation, with certain areas having slight to moderate salt issues. Most Ground Water samples were classified as neutral pH, C_3 salinity class, S_1 sodium hazard class, and A_1 safe RSC category. Similar conclusions were drawn by Rao *et al*. (2023) and Rajendran *et al*. (2025), who found that ground water resources in their study areas were largely appropriate for irrigation and crop production.

The findings showed that salinity, rather than sodicity, is the most important limiting factor affecting Ground Water quality in the studied area. As a result, adopting integrated soil and water management practices such as concurrent use of surface and Ground Water, periodic leaching, efficient drainage systems, gypsum application and cultivation of salt-tolerant crops is critical for long-term soil productivity and sustainable agricultural production.

Table 1. Classification based on EC

S. No.	Place	No. of Samples	C1 (0.1–0.25)	%	C2 (0.25–0.75)	%	C3 (0.75–2.25)	%	C4 (>2.25)	%
1	Vadlamudi	5	0	0.0	1	20.0	3	60.0	1	20.0
2	Vejendla	5	0	0.0	1	20.0	4	80.0	0	0.0
3	Guntur	6	0	0.0	1	16.7	3	50.0	2	33.3
4	Vijayawada	6	1	16.7	1	16.7	4	66.6	0	0.0
5	Chirala	5	0	0.0	0	0.0	2	40.0	3	60.0
6	Tenali	5	0	0.0	1	20.0	4	80.0	0	0.0
Total		32	1	3.1	5	15.6	20	62.5	6	18.8

Table 2. Classification based on SAR

S. No.	Place	No. of Samples	S1 (<10)	%	S2 (10–18)	%	S3 (18–26)	%	S4 (>26)	%
1	Vadlamudi	5	5	100.0	0	0.0	0	0.0	0	0.0
2	Vejendla	5	5	100.0	0	0.0	0	0.0	0	0.0
3	Guntur	6	5	83.3	1	16.7	0	0.0	0	0.0
4	Vijayawada	6	6	100.0	0	0.0	0	0.0	0	0.0
5	Chirala	5	3	60.0	1	20.0	1	20.0	0	0.0
6	Tenali	5	5	100.0	0	0.0	0	0.0	0	0.0
Total		32	29	90.6	2	6.3	1	3.1	0	0.0

Table 3. Classification based on RSC

S. No.	Place	No. of Samples	A1 Safe (<1.25)	%	A2 Marginal (1.25–2.5)	%	A3 Harmful (>2.5)	%
1	Vadlamudi	5	4	80.0	1	20.0	0	0.0
2	Vejendla	5	5	100.0	0	0.0	0	0.0
3	Guntur	6	4	66.7	1	16.7	1	16.7
4	Vijayawada	6	5	83.3	1	16.7	0	0.0
5	Chirala	5	2	40.0	1	20.0	2	40.0
6	Tenali	5	5	100.0	0	0.0	0	0.0
Total		32	25	78.1	4	12.5	3	9.4

Table 4. Classification based on TDS

S. No.	Place	No. of Samples	500–2000 mg/L (%)	>2000 mg/L (%)
1	Vadlamudi	5	80	20
2	Vejendla	5	100	0
3	Guntur	6	66.7	33.3
4	Vijayawada	6	83.3	0
5	Chirala	5	40	60
6	Tenali	5	100	0
Total		32	62.5	18.8

Table 5. Classification based on PI

S. No.	Place	No. of Samples	Class I (%)	Class II (%)	Class III (%)
1	Vadlamudi	5	60	40	0
2	Vejendla	5	80	20	0
3	Guntur	6	50	50	0
4	Vijayawada	6	66.7	33.3	0
5	Chirala	5	40	60	0
6	Tenali	5	80	20	0
Total		32	62.5	37.5	0

4. Conclusion

The current study revealed that Ground Water quality in selected agricultural regions of coastal Andhra Pradesh is generally suitable for irrigation, with some outliers in coastal and intensively cultivated areas. The majority of Ground Water samples were medium to high in salinity, with a moderate sodium hazard, indicating the need for careful management to prevent long-term soil degradation.

Scientific irrigation management, regular Ground Water monitoring, and appropriate drainage management are crucial to maintaining soil fertility and crop productivity in the region. Farmers, academics, and policymakers could all benefit from the study's results on sustainable Ground Water use and irrigation management in coastal Andhra Pradesh.

The higher EC and TDS values recorded in coastal areas such as Chirala show the influence of seawater intrusion and salt deposition. While the overall irrigation the suitability of Ground Water remains excellent, persistent use of saline water may greatly impair soil structure, nutrient availability, and crop performance.

Therefore, regular monitoring of Ground Water quality, adoption of operational irrigation practices, proper drainage management, and the use of salt-tolerant crops are crucial for supporting soil health and agricultural productivity. The findings of this study give significant baseline information for designing sustainable irrigation and Ground Water management techniques in the coastal agro-ecosystems of Andhra Pradesh.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Competing Interests

Authors have declared that no competing interests exist.

References

Adimalla, N., & Qian, H. (2023). Groundwater quality and contamination: An application of GIS. *Environmental Earth Sciences, 82*(18), 423. https://doi.org/10.1007/s12665-023-11109-5

Ahada, C. P. S., & Suthar, S. (2017). Hydrochemistry of groundwater in North Rajasthan, India: Chemical and multivariate analysis. *Environmental Earth Sciences, 76*(5), 203. https://doi.org/10.1007/s12665-017-6496-x

Ayers, R. S., & Westcot, D. W. (1985). *Water quality for agriculture*. FAO Irrigation and Drainage Paper 29. https://www.fao.org/3/t0234e/t0234e00.htm

Central Ground Water Board. (2025). *Annual ground water quality report 2025*. Ministry of Jal Shakti, Government of India. https://cgwb.gov.in/cgwbpnm/public/uploads/documents/1764833633531847433file.pdf

Chidambaram, S., Prasanna, M. V., Venkatramanan, S., Nepolian, M., Pradeep, K., Panda, B., Thivya, C., & Thilagavathi, R. (2022). Groundwater quality assessment for irrigation by adopting new suitability plot and spatial analysis based on fuzzy logic technique. *Environmental Research, 204*, 111729. https://doi.org/10.1016/j.envres.2021.111729

Dimple, Mittal, H. K., Singh, P. K., Yadav, K. K., Bhakar, S. R., & Rajput, J. (2022). Groundwater quality parameters for irrigation utilization: A review. *Indian Journal of Agricultural Sciences, 92*(7), 803–810. https://doi.org/10.56093/ijas.v92i7.114186

Doneen, L. D. (1964). *Notes on water quality in agriculture*. Department of Water Science and Engineering, University of California, Davis.

Gugulothu, S., Subbarao, N., Das, R., & Dhakate, R. (2022). Geochemical evaluation of groundwater and suitability of groundwater quality for irrigation purpose in an agricultural region of South India. *Applied Water Science, 12*(6), 142. https://doi.org/10.1007/s13201-022-01583-w

Hem, J. D. (1985). *Study and interpretation of the chemical characteristics of natural water* (3rd ed.). U.S. Geological Survey Water-Supply Paper 2254. https://doi.org/10.3133/wsp2254

Houatmia, F., Azouzi, R., Charef, A., & Bedir, M. (2016). Assessment of groundwater quality for irrigation and drinking purposes and identification of hydrogeochemical mechanisms evolution in Northeastern, Tunisia. *Environmental Earth Sciences, 75*, 746. https://doi.org/10.1007/s12665-016-5441-8

Jackson, M. L. (1973). *Soil chemical analysis*. Prentice-Hall of India Pvt. Ltd.

Jagadeesh, N., Naik, V. G., & Ramanaidu, K. (2024). Groundwater quality assessment for drinking and irrigation purposes in Tadimarri Mandal, Sri Sathya Sai District, Andhra Pradesh using water quality index and geospatial techniques. *Journal of Remote Sensing & GIS, 15*(3), 1–19. https://journals.stmjournals.com/jorsg/index

Kaledhonkar, M. J., Meena, B. L., & Sharma, P. C. (2019). Reclamation and nutrient management for salt-affected soils. *Indian Journal of Fertilisers, 15*(5), 566–575. https://krishi.icar.gov.in/jspui/handle/123456789/24691

Kaledhonkar, M. J., Singh, A. K., Singh, R., & Meena, B. L. (2020). Management of saline water irrigation in water stress arid regions. In P. Masilamani, K. Arulmozhiselvan, & P. Balasubramaniam (Eds.), *Technological advances in enhancing productivity of salt affected soils* (pp. 69–82). Today & Tomorrow's Printers and Publishers. https://ttpp.in/

Karanth, K. R. (1987). *Ground water assessment, development, and management*. Tata McGraw-Hill Publishing Company Limited. https://books.google.com/books/about/Ground_Water_Assessment_Development_and.html?id=v_pRAAAAMAAJ

Laxman, D. K., Ratnakar, D., Sakram, G., & Srinivas, B. (2021). Hydrochemical appraisal of groundwater quality for drinking and agricultural utility in a granitic terrain of Maheshwaram area of Ranga Reddy district, Telangana State, India. *HydroResearch, 4*, 11–23. https://doi.org/10.1016/j.hydres.2021.02.002

Marghade, D., Malpe, D. B., & Subba Rao, N. (2015). Identification of controlling processes of groundwater quality in a developing urban area using principal component analysis. *Environmental Earth Sciences, 74*(7), 5919–5933. https://doi.org/10.1007/s12665-015-4616-z

Marghade, D., Malpe, D. B., & Subba Rao, N. (2021). Applications of geochemical and multivariate statistical approaches for the evaluation of groundwater quality and human health risks in a semi-arid region of eastern Maharashtra, India. *Environmental Geochemistry and Health, 43*(2), 683–703. https://doi.org/10.1007/s10653-019-00478-1

Marghade, D., Malpe, D. B., Subba Rao, N., & Sunitha, B. (2020). Geochemical assessment of fluoride enriched groundwater and health implications from a part of Yavtmal District, India. *Human and Ecological Risk Assessment: An International Journal, 26*(3), 673–694. https://doi.org/10.1080/10807039.2018.1528862

Mukate, S. V., Panaskar, D. B., Wagh, V. M., & Baker, S. J. (2020). Understanding the influence of industrial and agricultural land uses on groundwater quality in semiarid region of Solapur, India. *Environment, Development and Sustainability, 22*(4), 3207–3238. https://doi.org/10.1007/s10668-019-00342-3

Nageswara Rao, K., Swarna Latha, P., & Ramesh Kumar, P. V. (2022). Groundwater quality assessment for irrigation use in the Godavari Delta region of east coast India using IRWQI and GIS. *Water Supply, 22*(3), 2612–2629. https://doi.org/10.2166/ws.2021.454

Naidu, M. V. S., Subbaiah, P. V., Radha Krishna, Y., & Kaledhonkar, M. J. (2020). Evaluation of groundwater quality for irrigation in various mandals of Nellore District in Andhra Pradesh. *Journal of the Indian Society of Soil Science, 68*(3), 288–297. https://doi.org/10.5958/0974-0228.2021.00005.0

Pal, S. K., Rajpaul, Ramprakash, Bhat, M. A., & Yadav, S. S. (2018). Assessment of groundwater quality for irrigation use in Firozpur-Jhirka Block in Mewat District of Haryana, North India. *Journal of Soil Salinity and Water Quality, 10*(2), 157–167. https://epubs.icar.org.in/index.php/JSSWQ

Rajendran, S., Sivaprakasam, V., Sathyanarayanan, B., Gunasekaran, S., Periyasami, S., & Jeyasingh, V. (2025). Seasonal hydrogeochemical insights of groundwater quality and its suitability for drinking and irrigational purposes in Pennagaram and Palacode Taluk, Dharmapuri district, Tamil Nadu, India. *Environmental Earth Sciences, 84*(13), 353. https://doi.org/10.1007/s12665-025-12358-2

Rao, K. N., Swarna Latha, P., & Ramesh Kumar, P. V. (2022). Groundwater quality assessment for irrigation use in the Godavari Delta region of east coast India using IRWQI and GIS. *Water Supply, 22*(3), 2612–2629. https://doi.org/10.2166/ws.2021.454

Rao, P. M., Subbaiah, P. V., Rani, Y. S., Rani, P. P., Sambaiah, A., & Kannan, R. (2023). Evaluation of groundwater quality for irrigation—A case study of West Godavari District of Andhra Pradesh. In P. K. Rai (Ed.), *Advances in water resource planning and sustainability* (pp. 239–252). Springer Nature Singapore. https://doi.org/10.1007/978-981-99-3660-1_14

Richards, L. A. (Ed.). (1954). *Diagnosis and improvement of saline and alkali soils* (Agriculture Handbook No. 60). U.S. Department of Agriculture. https://www.ars.usda.gov/ARSUserFiles/20360500/hb60_pdf/hb60complete.pdf

Singh, S., Raju, N. J., & Ramakrishna, C. (2015). Evaluation of groundwater quality and its suitability for domestic and irrigation use in parts of the Chandauli-Varanasi region, Uttar Pradesh, India. *Journal of Water Resource and Protection, 7*(7), 572–587. https://doi.org/10.4236/jwarp.2015.77046

Subba Rao, N. (2018). Groundwater quality from a part of Prakasam District, Andhra Pradesh, India. *Applied Water Science, 8*, 30. https://doi.org/10.1007/s13201-018-0665-2

Subba Rao, N., Dinakar, A., Karuna Kumari, B., Karunanidhi, D., & Kamalesh, T. (2021). Seasonal and spatial variation of groundwater quality vulnerable zones of Yellareddygudem watershed, Nalgonda District, Telangana State, India. *Archives of Environmental Contamination and Toxicology, 80*(1), 11–30. https://doi.org/10.1007/s00244-020-00783-2

Subbaiah, P. V., Naidu, M. V. S., Radha Krishna, Y., Kaledhonkar, M. J., & Meena, B. L. (2020). Groundwater quality assessment for Chittoor District of Andhra Pradesh for irrigation purpose and management options. *Journal of Soil Salinity and Water Quality, 12*(1), 1–14. https://epubs.icar.org.in/index.php/JSSWQ

Willard, H. H., Merritt, L. L., Dean, J. A., & Settle, F. A. (1974). *Instrumental methods of analysis* (5th ed.). D. Van Nostrand Company.

Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/159784