Groundwater Quality Evaluation for Drinking and Irrigation Purposes in Parts of Athoor Taluk, Dindigul District, Tamil Nadu, India

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Abstract
Groundwater is a basic need for every human being to survive on this earth and satisfy the drinking and irrigation needs in parts of Athoor Taluk, Dindigul District. The research evaluates and interprets groundwater quality using various methods like Piper, Gibbs, water quality index and irrigation indices. Twenty groundwater samples were collected around the study area, analysed for the physicochemical parameters, and the contaminants were mapped using inverse distance weighting methods. The concentration levels of 90% TH, 25% Ca2+, 25% Mg2+, 95% K+, 80% Cl-, 95% SO42- and 80% HCO3-are noticed exceed the permissible limits for drinking purposes. The piper plot indicates the dominant water type is calcium-magnesium-chloride-sulphate, suggesting alkaline earths strong dominance, and the Gibbs reveals rock-dominance due to silicates and carbonate weathering. The WQI ranges between 100-200, with 55% of the water falling in the poor category, which requires treatment, and the remaining WQI ranges between 50-100, with 45% falling in the good category and can be used for drinking. Irrigation indices like Na%, KR, and SAR indicate suitability for agricultural purposes with minor sodium hazards. In the future, this area needs to be studied seasonally to locate the quality deterioration regions for water management.

Keywords: Groundwater Quality, Water Quality Index, Irrigation Indices, Physicochemical Parameters, IDW Mapping, Hydrogeochemical Analysis.

Introduction

Groundwater is the most important natural resource used for drinking and irrigation purposes in Athoor Taluk, Dindigul district. The factors that are declining in water quality are population growth, agricultural contamination, and over-extraction. However, groundwater cannot be optimally used and sustained unless the quality of groundwater is carefully assessed (Sadat-Noori et al., 2014; Yadav et al., 2015). This resource is under increasing pressure due to over-extraction and contamination, which pose significant challenges to water security, public health, and environmental sustainability (Babuji et al., 2023; Pizzi et al., 2020).In the research area,groundwater chemistry and its interpretation in terms of WQI and spatial mapping have not been attempted so far.

The objectives of this study are as follows: 1) to assess the physicochemical parameters and compare them with WHO standards; 2) to interpret Piper and Gibbs to identify water type and the dominant factor affecting groundwater chemistry. 3) To interpret the Water Quality Index for drinking suitability. 4) To check suitability for irrigation using indices like Na%, KR and SAR.

Review of Literature

Geochemical characterization of groundwater in different environments was reported and described in many areas, including India and other parts of the world (Pragadeeshwaran et al., 2025;Alharbi, 2018; Ledesma-Ruiz et al., 2015; Singaraja et al., 2014; Subramani et al., 2010).Most of the global inhabitants rely on groundwater for daily use. In regions like arid and semi-arid, it has become the main water supply for domestic, agriculture and industrial purposes (Kom, et al., 2022).The latest advances in remote sensing and geographical information technologies have provided very useful methods of surveying and identifying various aspects of watershed terrain behaviour, and also the integrated modelling approach utilizing the parameters controlling soil erosion is an effective means of practical assessment of soil erosion hazard (Arulbalaji & Gurugnanam, 2014, 2016; Bagyaraj et al., 2014; Gurugnanam et al., 2008; Kom et al., 2023; Nijagunappa et al., 2007;Arulbalaji & Gurugnanam, 2014b; Arulbalaji & Gurugnanam, 2014a). In the study area, the groundwater faces more stress due to over-extraction of groundwater, agricultural runoff and limited recharge of aquifers. However, in the research area, no combined study of hydrogeochemical interpretation through Piper and Gibbs with WQI and spatial mapping has been conducted so far. Identifying the gap is essential to understanding groundwater chemistry and also to ensuring sustainable use.

The hydrochemical analysis using prior methods such as trilinear plots, Gibbs plot, and Salinity diagram are extensively used approaches to identify source, quality and influencing factors that are responsible for groundwater alteration (Adimalla, 2020; Gaikwad et al., 2020; Magesh et al., 2017; Panaskar et al., 2016).

Study Area

The study area is located in the Athoor Taluk, Dindigul district, and the coordinates of the study area are10°20’0″- 10°20’0″N and 77°52’30″ - 77°55’0″Eas given in the Fig.1.This region is primarily from the agricultural background, and the geology of this area is migmatite & Charnockite category.

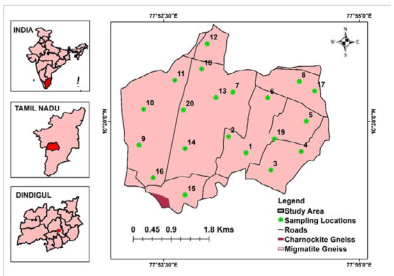


Figure 1 Study Area Map

Methodology

During post-monsoon 2025, 20 groundwater samples from borewells were collected around the study area. The samples were collected using polypropylene bottles, and before collecting, the bottles were washed thoroughly. The pipes were pumped for 5 – 10 minutes to prevent the contaminants from entering the pipes. These samples were transported to the lab and stored at 4°C. The physical parameters were analyzed in the spot using handheld instruments, and the major cations and anions were analysed using standard recommended methods (APHA, 2017). The total hardness of CaCO3 was calculated using the following equation (1):

$$TH = 2.497 \times [Ca^{2+}] + 4.118 \times [Mg^{2+}] \quad (1)$$

The calculated ionic balance error is within the desirable range of ± 10%, as shown in equation (2):

$$IBE (\%) = \{(\Sigma \text{ Cations} - \Sigma \text{ Anions}) / (\Sigma \text{ Cations} + \Sigma \text{ Anions})\} \times 100 \quad (2)$$

Groundwater Quality Index (GWQI)

The groundwater quality index was calculated using the weighted arithmetic index method to evaluate water quality (Tyagi et al., 2013). GWQI is the easiest and most accurate method for calculating the water quality index for a particular location, as shown in Eqs. 3-6.

For each parameter, the relative weight (W_i) was calculated using Eq.3 below:

$$W_i = w_i / \sum^{n}_{i} w_i \quad (3)$$

The quality rating (qi) for each parameter was determined using Eq.4, the formula:

$$Q_i = (V_i - V\{ideal\} / V\{standard\} - V\{ideal\}) \times 100 \quad (4)$$

"Vi is the parameter's observed value", "Videal is the parameter's ideal value", and $V_{Standard}$ (WHO, 2017) is the permissible value of the parameter. Each parameter is given a relative weight (W_i). The formula used to calculate the subindex (S_i) of each parameter is as follows: Eq.5:

$$S_i = W_i \times q_i \quad (5)$$

The WQI is obtained by all sub-indices and calculated using Eq.6, and is as follows:

$$WQI = \sum S_i / \sum W_i \quad (6)$$

∑Wi is obtained by adding the sum of all the calculated relative weights, and ∑Si is the sum of all calculated sub-indices (Pragadeeshwaran et al., 2025). The WQI is classified into "Excellent < 50, Good 50 -100, Poor 100 – 200, Very Poor 200 – 300, and unsuitable for drinking > 300" to evaluate water quality (Ahirvar et al., 2023).

Spatial using IDW

The Inverse Distance Weighting (IDW) method in ArcGIS was used to map the spatial variation of groundwater quality. It estimates unknown values from nearby measured points, giving greater weight to closer locations. With a power parameter of 2, IDW provides accurate interpolation for irregular groundwater data, especially in hard rock terrains (Arulbalaji & Gurugnanam, 2014, 2016; Gurugnanam et al., 2008; Kom et al., 2023; Nijagunappa et al., 2007; Bagyaraj et al., 2014; Arulbalaji & Gurugnanam, 2014a; Arulbalaji & Gurugnanam, 2014b).

Irrigation Indices

The Kelly ratio (KR), sodium percentage (Na%), and sodium adsorption ratio (SAR) were used to determine irrigation suitability using Equations (7) - (9):

$$KR = Na^{+} / (Ca^{2} + Mg^{2}) \quad (7)$$

$$\%Na = Na^{+} / (Ca^{2} + Mg^{2} + Na^{+} + K^{+}) \quad (8)$$

$$SAR = Na^{+} / \sqrt{((Ca^{2+} + Mg^{2+}) / 2)} \quad (9)$$

Results and Discussion

The results of the present study are given in Table 1.

Table 1 Statistical Outlines of Physicochemical Parameters

Parameters	Min	Max	Permissible		% of Samples Exceed the Limit
			Most Desirable	Not Permissible	
pH	6.5	7.9	6.5–8.5	<6.5 and >8.5	-
EC(µS/cm)	55	570	<1500	>1500	-
TDS (mg/L)	55	570	<500	>1500	-
TH(mg/L)	250	1650	<100	>500	90
Ca^{2+}(mg/L)	32	370	<75	>200	25
Mg^{2+}(mg/L)	29.16	250	<50	>150	25
Na^{+}(mg/L)	14.1	130.4	<200	>200	-

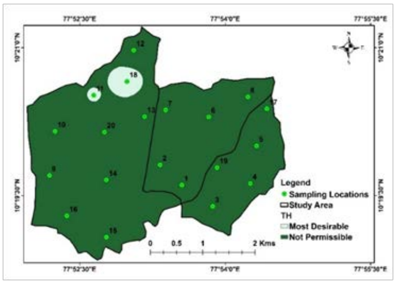
K^+(mg/L)	6.9	32.6	<10	>10	95
Cl^-(mg/L)	17.7	1302	<250	>250	80
NO_3^-(mg/L)	10	25	<45	>45	-
SO_4^{2}–(mg/L)	310	897	<400	>400	95
HCO_3^-(mg/L)	224	1317	<300	>600	50

Physical Parameters.

The pH ranges from 6.5 to 7.9, indicating that none of the samples exceeds the permissible limit in Table 1. The EC and TDS vary from 55 to 570, indicating none exceed the permissible limit.

Chemical Parameters

The total hardness varied from 250 to 1650, indicating that 90% of the samples exceeded the most desirable limit as given in Table1. The spatial map indicates that most of the study area falls within the permissible limit, as given in Fig.2a. Charnockite comprises significant feldspar, quartz, and mica concentrations. It contains minerals such as plagioclase and biotite, which can release calcium ($Ca2^{+}$) and magnesium ($Mg2^{+}$) ions into groundwater over decades. Migmatite is a type of rock created by partially melting granitic rocks, which frequently mix solid rock and molten material(Pragadeeshwaran et al., 2025). Migmatite rocks can contain minerals enriched in calcium and magnesium, such as calcite or dolomite, contributing to the water's high hardness (Pragadeeshwaran et al., 2025). The calcium ranges from 32 to 370, indicating that 25% of samples exceed the permissible limit as given in Table1. The spatial map indicates that northern, south-western and south-eastern parts exceed the permissible limit as given in Fig.2b. These are due to the lithological composition of the migmatite terrain, which comprises abundant calcium-bearing silicate and carbonates such as plagioclase feldspar and amphibole. The continuous long-term water-rock interaction promotes these minerals' dissolution and increases calcium concentration (Gugulothu et al., 2022; Srinivasamoorthy et al., 2014).The magnesium ranges from 29 to 250, indicating that 25% of samples exceed the permissible limit as given in the Table.1.1 The spatial map indicates that the south-western and eastern parts exceed the most desirable limit as given in Fig.2c. These are due to weathering and dissolution of ferromagnesian minerals such as biotite, pyroxene and hornblende in migmatites. These release magnesium ions during long-term water-rock interaction in hard rock aquifers (Kukillaya & Narayanan, 2014). The sodium ranges from 14 to 130, indicating that none of the samples exceeds the most desirable limit, as shown in Table 1. The potassium ranges from 6 to 32, indicating that 95% of samples exceed the most desirable limit as given in Table1. The spatial map indicates that mostof the study area exceeds the permissible limit as given in Fig.2d. Elevated concentration is due to weathering and dissolution of potassium-based bearing minerals such as muscovite, biotite and feldspars in migmatites. These release potassium into groundwater due to long-term water-rock interactions in hard rock aquifers (Pragadeeshwaran et al., 2025). The chloride ranges from 17 to 1302, indicating that 80% exceeds the most desirable limit as given in Table.1. The spatial map indicates that majority of the study area exceeds the most desirable limit as given in Fig.2e. Elevated chloride are due to dissolution of chloride bearing minerals in migmatites and also from anthropogeic sources like domestic sewage, agricultural runoff and waste disposal (Sodomon et al., 2025). The nitrate ranges from 10 to 15, indicating that none of the samples exceeds the most desirable limit as shown in Table 1. The sulphate ranges from 310 to 897, indicating that 95% of samples exceeds the permissible limit as given in Table.1. The spatial map indicates that majority of study area exceeds the most desirable limit as given in Fig.2f. Geogenic sources like oxidation of sulphide minerals in migmatites and also the anthropogenic sources like sewage disposal, fertilizers and industrial effluents are the reason for elevated sulphate concentration (Kayode et al., 2024).The bicarbonate ranges from 224 to 1317, indicating that 50% of samples exceed the most desirable limit as given in Table1.The spatial map indicates that the southern, northeastern and western parts exceed the most desirable limit as given in Fig.2g. These are influenced by geogenic processes like dissolution of carbonate minerals and weathering of feldspar-rich, which releases bicarbonate ions into groundwater during long-term water-rock interactions (Pragadeeshwaran et al., 2025).



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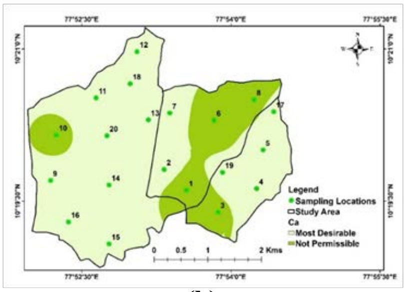

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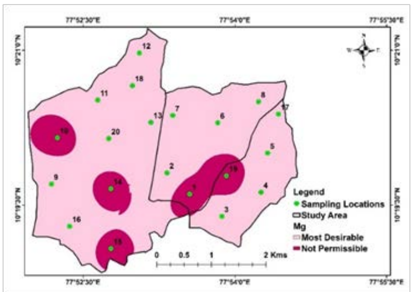

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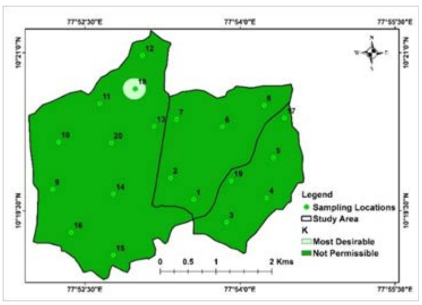

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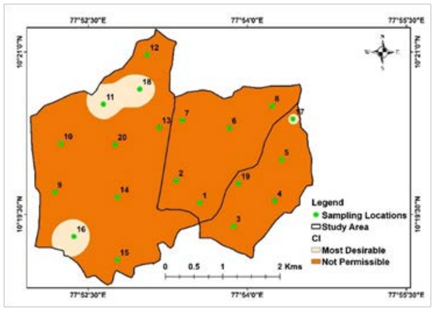

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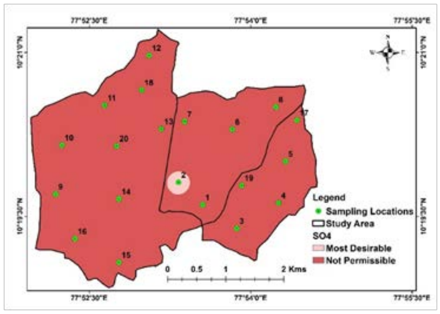

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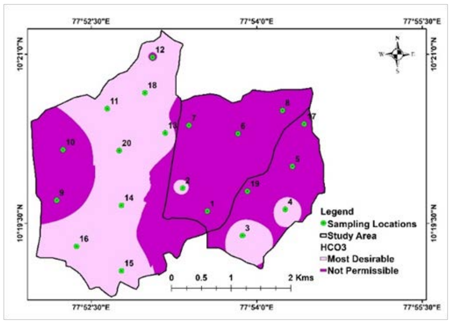


(g)

Figure 2 Spatial maps a) TH, b) Ca, c) Mg, d) K, e) Cl, f) SO4 and g) HCO3

Piper Plot

The piperplot indicates that in the cation plot, most samples shift in magnesium and a few samples shift towards calcium, indicating calcium-magnesium type water. It indicates that groundwater chemistry is dominated by alkaline earths, as given in Fig.3. In the anion plot, most samples shift between chloride and sulphate and a few near bicarbonate; this indicates that strong acids rather than weak acids dominate it. The central plot reveals that the water type is a calcium-magnesium-chloride-sulfate type. These suggest ion-exchange and rock-water interaction and anthropogenic influence like fertilisers and domestic effluents (Lakshmanan et al., 2003).

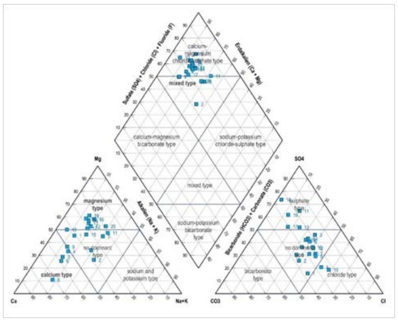
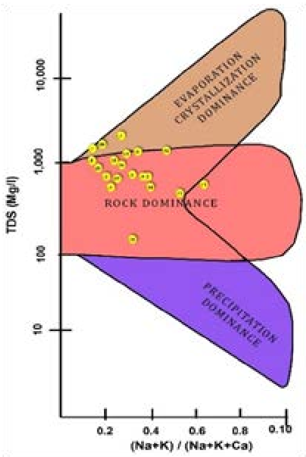


Figure 3 Piper plot

Gibbs

The Gibbs indicates that the majority of the samples are located in a rock-dominance field, suggesting rock-water interaction, such as silicate weathering and carbonate weathering, isa dominant process influencing the groundwater chemistry, as given in Fig.4. A few samples shifted towards evaporation dominance, revealing shallow water table conditions. Some isolated samples were spotted near precipitation dominance, suggesting influence by direct rainfall recharge. These align with similar studies investigated in Indian hard rock aquifers(Krishnamoorthy & Lakshmanan, 2024; Subramani et al., 2005).



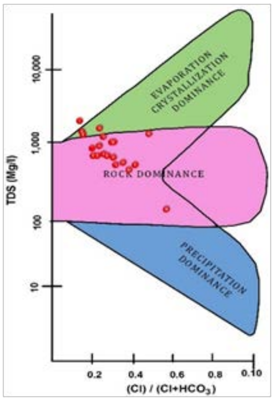


Figure 4 Gibbs Plot

Water Quality Index

The WQI ranges from 68 to 157, indicating that 55% of samples fall in the category of Poor Water, which can be used for drinking with proper treatment (Table2). The remaining 45% of the samples in Good Water can be consumed without any treatment. The spatial map is shown in Fig.5

Table 2 Classification Table for GWQI

GWQI classification range	Water Quality Classification categories	No. of samples	% samples
< 50	Excellent	-	-
50 – 100	Good	9	45
100 - 200	Poor	11	55
200 - 300	Very Poor	-	-
> 300	Unsuitable	-	-
			100

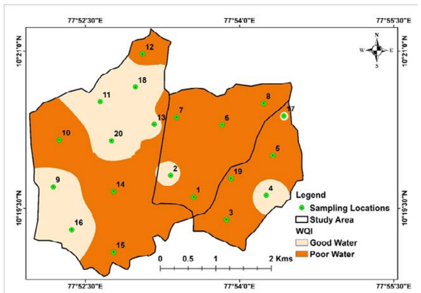


Figure 5 Water Quality Index

Irrigation Suitability

The irrigation suitability is given in Table 3

Table 3 Outline Results of Irrigation Indices

Irrigation Indices	Classification	Range (meq/L)	% of samples
Sodium Percentage (Na%) Wilcox (1955)	Excellent	< 20%	5
	Good	20 – 40%	70
	Permissible	40 – 60%	25
	Doubtful	60 – 80%	-
	Unsuitable	> 80%	-
Kelly's Ratio (KR) Kelly (1940)	Safe	< 1	100
	Unsuitable	> 1	-
	Moderate	1 – 2	-
	High Hazard	> 2	-
Sodium Adsorption Ratio (SAR) (1954)	Excellent	<10	100
	Good	10-18	-
	Doubtful	18-26	-
	Unsuitable	>26	-

Sodium Percentage

The Sodium percentage results show that 70% samples are in the good category, 5% in the excellent category, indicating suitability for irrigation, and 25% in the permissible category, indicating that caution is necessary because of possible sodium dangers (Table3) (Wilcox, 1948). The spatial map of sodium percentage indicates that the northeastern and northern zones are classified as doubtful, as given in Fig.6a.

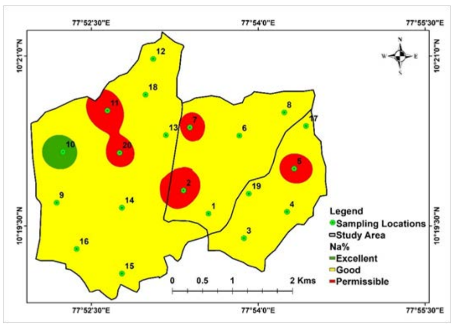


Figure 6 Spatial Map of Na%

Kelly Ratio

The Kelly Ratio result reveals that 90% of the samples are suitable, and the remaining 10% are in the unsuitable category, which might pose a significant cause, as given in Table 3 (Richards, 1954).

Sodium Adsorption Ratio

The Sodium Adsorption Ratio results indicate that 100% of samples fall in the Excellent category, as given in Table 3 (Richards, 1954).

Future Research Directions

- Study seasonal variations in groundwater quality.
- Assess the socio-economic impacts of groundwater use and availability.
- Use models to predict groundwater quality trends under different climate change or management scenarios.

Conclusion

Groundwater in the study area is primarily affected by rock-water interaction and anthropogenic inputs. When compared to physicochemical parameters, the pH, EC, TDS, Na+, NO3- are within the permissible limits for drinking. The piper plot indicates the dominant water type is calcium-magnesium-chloride-sulphate, suggesting alkaline earths strong dominance, and the Gibbs reveals rock-dominance due to silicates and carbonate weathering. The WQI indicates 55% of the water is poor, which requires treatment, and the remaining 45% in the good category and can be used for drinking. Irrigation indices like Na%, KR, and SAR indicate suitability for agricultural purposes with minor sodium hazards. Therefore, continuous monitoring is required to improve the groundwater quality. The artificial recharge zones are to be identified, and continuous recharge will reduce the quality deterioration.

References

Adimalla, N. "Controlling Factors and Mechanism of Groundwater Quality Variation in Semiarid Region of South India: An Approach of Water Quality Index (WQI) and Health Risk Assessment (HRA)." *Environmental Geochemistry and Health*, vol. 42, no. 6, 2020, pp. 1725–1752.

Ahirvar, B. P., et al.. "Hydrogeo-Chemical Characteristics of Groundwater and Seasonal Variation in Coal Mining Area, Madhya Pradesh, India." 2023.

Alharbi, T. G. "Identification of Hydrogeochemical Processes and Their Influence on Groundwater

Quality for Drinking and Agricultural Usage in Wadi Nisah, Central Saudi Arabia." *Arabian Journal of Geosciences*, vol. 11, no. 13, 2018, p. 359.

American Public Health Association (APHA). Standard Methods for the Examination of Water and Wastewater. 23rd ed., American Public Health Association, 2017.

Arulbalaji, P., and B. Gurugnanam. "Evaluating the Normalized Difference Vegetation Index Using Landsat Data by ENVI in Salem District, Tamil Nadu, India." *International Journal of Development Research*, vol. 4, no. 9, 2014, pp. 1844–1846.

Arulbalaji, P., and B. Gurugnanam. "Geospatial Science for 16 Years of Variation in Land Use/Land Cover Practice Assessment around Salem District, South India." *Journal of Geosciences and Geomatics*, vol. 2, no. 1, 2014, pp. 17–20.

Arulbalaji, P., and B. Gurugnanam. "An Integrated Study to Assess the Groundwater Potential Zone Using Geospatial Tool in Salem District, South India." *Journal of Hydrogeology and Hydrological Engineering*, vol. 7, 2016, p. 2.

Babuji, P., et al. "Human Health Risks Due to Exposure to Water Pollution: A Review." *Water*, vol. 15, no. 14, 2023, p. 2532.

Bagyaraj, M., et al. "Assessment of Soil Erosion Probability in Kodaikanal, India, Using GIS and Remote Sensing." *Disaster Advances*, vol. 7, no. 2, 2014, pp. 36–49.

Gaikwad, S. K., et al. "Assessment of the Groundwater Geochemistry from a Part of West Coast of India Using Statistical Methods and Water Quality Index." *HydroResearch*, vol. 3, 2020, pp. 48–60.

Gugulothu, S., N. et al. "Geochemical Evaluation of Groundwater and Suitability of Groundwater Quality for Irrigation Purpose in an Agricultural Region of South India." *Applied Water Science*, vol. 12, no. 6, 2022, p. 142.

Gurugnanam, B., et al. "Geographic Information Technologies for Hydrogeomorphological Mapping in Parts of Vellar Basin, Central Tamil Nadu." *Geological Society of India*, 2008, pp. 471–478.

Kayode, M. O., et al. "Seasonal Variation of Groundwater Quality in a Basement Complex Geology of Ado Ekiti, Nigeria, Using Water Quality Index Model." *Journal of Umm Al-Qura University for Applied Sciences*, 2024, pp. 1–26.

Kom, K. P., et al. "Sources and Geochemistry of High Fluoride Groundwater in Hard Rock Aquifer of the Semi-Arid Region: A Special Focus on Human Health Risk Assessment." *Total Environment Research Themes*, vol. 5, 2023, p. 100026.

Kom, K. P., et al. "Hydrogeochemical Assessment of Groundwater Quality for Drinking and Irrigation Purposes in Western Coimbatore, South India." *International Journal of Energy and Water Resources*, vol. 6, 2022, pp. 475–494.

Krishnamoorthy, L., and V. R. Lakshmanan. "Hydrogeochemical Evaluation and Multivariate Statistical Analysis of Groundwater for Sustainable Groundwater Quality Management in the Industrial Corridor of Ranipet District, Tamil Nadu, India." *Water, Air, & Soil Pollution*, vol. 235, no. 10, 2024, p. 644.

Kukillaya, J. P., and T. Narayanan. "Role of Weathering of Ferromagnesian Minerals and Surface Water Irrigation in Evolving and Modifying Chemistry of Groundwater in Palakkad District, Kerala, with Special Reference to Its Fluoride Content." *Journal of the Geological Society of India*, vol. 84, no. 5, 2014, pp. 579–589.

Lakshmanan, E., et al. "Major Ion Chemistry and Identification of Hydrogeochemical Processes of Ground Water in a Part of Kancheepuram District, Tamil Nadu, India." *Environmental Geosciences*, vol. 10, no. 4, 2003, pp. 157–166.

Ledesma-Ruiz, R., et al. "Investigation of the Geochemical Evolution of Groundwater under Agricultural Land: A Case Study in Northeastern Mexico." *Journal of Hydrology*, vol. 521, 2015, pp. 410–423.

Magesh, N. S., et al. "Trace Element Concentrations in the Groundwater of the Tamiraparani River Basin, South India: Insights from Human Health Risk and Multivariate Statistical

Techniques." *Chemosphere*, vol. 185, 2017, pp. 468–479.

Nijagunappa, R., et al. "Road Network Analysis of Dehradun City Using High Resolution Satellite Data and GIS." *Journal of the Indian Society of Remote Sensing*, vol. 35, no. 3, 2007, pp. 267–274.

Panaskar, D. B., et al. "Evaluating Groundwater Suitability for the Domestic, Irrigation, and Industrial Purposes in Nanded Tehsil, Maharashtra, India, Using GIS and Statistics." *Arabian Journal of Geosciences*, vol. 9, no. 13, 2016, p. 615.

Pizzi, S., et al. "Management Research and the UN Sustainable Development Goals (SDGs): A Bibliometric Investigation and Systematic Review." *Journal of Cleaner Production*, vol. 276, 2020, p. 124033.

Pragadeeshwaran, Balasubramaniyan G., et al. "Groundwater Quality Beyond Potability: Decoding the Hydrogeochemical Signatures Using Spatial and Statistical Methods in Regions of Dindigul District, Tamil Nadu." *Discover Sustainability*, vol. 6, no. 1, 2025, p. 784.

Richards, L. A. *Diagnosis and Improvement of Saline and Alkali Soils*. Vol. 60, U.S. Government Printing Office, 1954.

Sadat-Noori, S. M., et al. "Groundwater Quality Assessment Using the Water Quality Index and GIS in Saveh-Nobaran Aquifer, Iran." *Environmental Earth Sciences*, vol. 71, no. 9, 2014, pp. 3827–3843.

Singaraja, C., et al. "Statistical Analysis of the Hydrogeochemical Evolution of Groundwater in Hard Rock Coastal Aquifers of Thoothukudi District in Tamil Nadu, India." *Environmental Earth Sciences*, vol. 71, no. 1, 2014, pp. 451–464.

Sodomon, A. K., et al. "Assessment of Hydrogeochemical Evolution of Groundwater from the Basement Aquifer in the Upper Part of Transboundary Mono River Basin, Togo." *Journal of Hydrology: Regional Studies*, vol. 58, 2025, p. 102200.

Srinivasamoorthy, K., et al. "Hydrochemical Characterization and Quality Appraisal of Groundwater from Pungar Sub Basin, Tamilnadu, India." *Journal of King Saud University – Science*, vol. 26, no. 1, 2014, pp. 37–52.

Subramani, T., et al. "Groundwater Quality and Its Suitability for Drinking and Agricultural Use in Chithar River Basin, Tamil Nadu, India." *Environmental Geology*, vol. 47, 2005, pp. 1099–1110.

Subramani, T., et al. "Groundwater Geochemistry and Identification of Hydrogeochemical Processes in a Hard Rock Region, Southern India." *Environmental Monitoring and Assessment*, vol. 162, 2010, pp. 123–137.

Tyagi, S., et al. "Water Quality Assessment in Terms of Water Quality Index." *American Journal of Water Resources*, vol. 1, no. 3, 2013, pp. 34–38.

Wilcox, L. V. *The Quality of Water for Irrigation Use*. 1948.

Yadav, K. K., et al. "Water Quality Assessment of Pahuj River Using Water Quality Index at Unnao Balaji, MP, India." *International Journal of Science, Basic and Applied Research*, vol. 19, no. 1, 2015, pp. 241–250.

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