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Groundwater quality assessment for irrigation uses in the Nabeul-Hammamet region, Tunisia: Insights from the AGREEMed project

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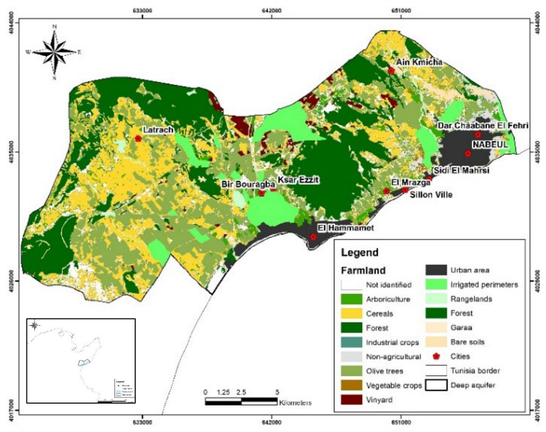
INTRODUCTION

In arid and semi-arid regions, maintaining adequate water availability and quality for irrigation is a major challenge, primarily due to groundwater salinity [1]. This problem is further exacerbated by the increasing water demand from agriculture, which places additional pressure on already limited resources [2]. Regular assessment and careful monitoring of groundwater are therefore essential to evaluate its suitability for irrigation and ensure compliance with water quality standards.

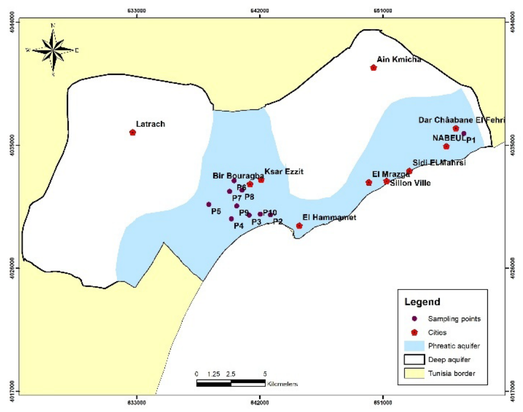
METHODOLOGY

Study area

The Nabeul-Hammamet basin is located in the Cap Bon peninsula in northeastern Tunisia. It covers approximately 450 km². The region has a semi-arid to arid climate. Urban expansion and intensive agricultural development have significantly increased the demand for groundwater



Water sampling and analysis



Groundwater was sampled in April 2024 from 10 wells. Physico-chemical parameters (EC and pH) and major cations (Ca^{2+}, Na^{+}, Mg^{2+}, K^{+}, NH_4^{+}) and anions (NO_3^{-}, SO_4^{2-}, Cl^{-}, NO_2^{-}) were analyzed in the Wastewater and Environment Laboratory (CERTE).

Irrigation indices

Index Full Name- Unit	Formula	Classes
SAR Sodium Adsorption Ratio- meq/L	$SAR = \frac{Na^+}{\sqrt{(Ca^{2+} + Mg^{2+})/2}}$	SAR<10 excellent, 10<SAR<18 good, 18<SAR<26 doubtful, SAR>26 unsuitable
Na (%) Percent Sodium- %	$Na(\%) = \frac{Na^+ \times 100}{Na^+ + Ca^{2+} + Mg^{2+} + K^+}$	<20%: excellent, 20-40%: good, 40-60%: permissible: 60–80%: doubtful, >80%: unsuitable
KR Kelly's Ratio	$KR = \frac{Na^+}{Ca^{2+} + Mg^{2+}}$	KR<1: suitable for irrigation KR>1: unsuitable for irrigation
MH Magnesium Hazard- %	$MH = \frac{Mg^{2+} \times 100}{Ca^{2+} + Mg^{2+}}$	MH<50: water suitable for irrigation, MH>50: water unsuitable for irrigation
PS Potential Salinity- meq/L	$PS = Cl^- + 0.5 \times SO_4^{2-}$	PS<3: suitable for irrigation
IRWQI Irrigation water quality Index	Composite Index [3]	IWQI<50: no restriction, 51-100: slight restrictions, 101-200: moderate restrictions, IWQI>200: severe restrictions

Multivariate statistical analysis

- Correlation analysis (CA)
- Principal component analysis (PCA)

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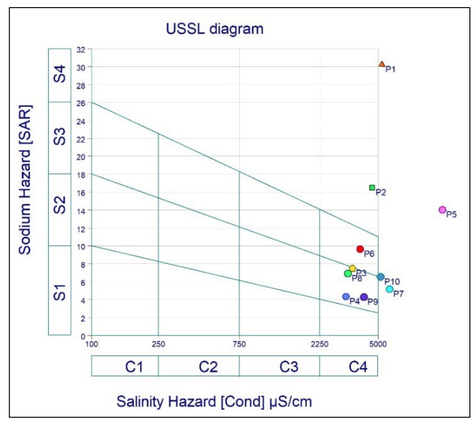
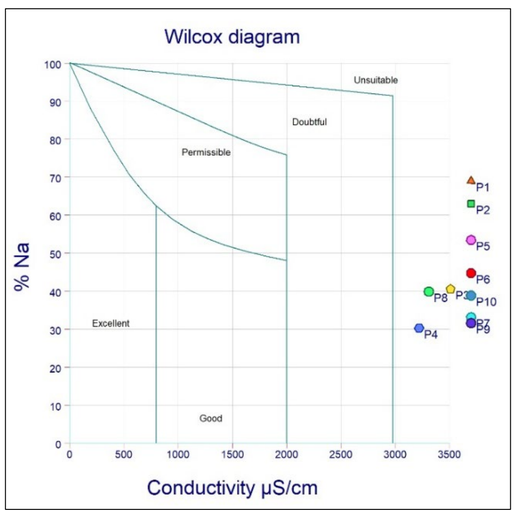
RESULTS AND DISCUSSIONS

USSL diagram: three classes **C4-S4, C4-S3 and C4-S2**, meaning a very high salinity and moderate to very high sodium hazard.

→ Problems for salt-sensitive crops and poorly drained soils.

→ Sodium accumulation, soil permeability and structure degradation





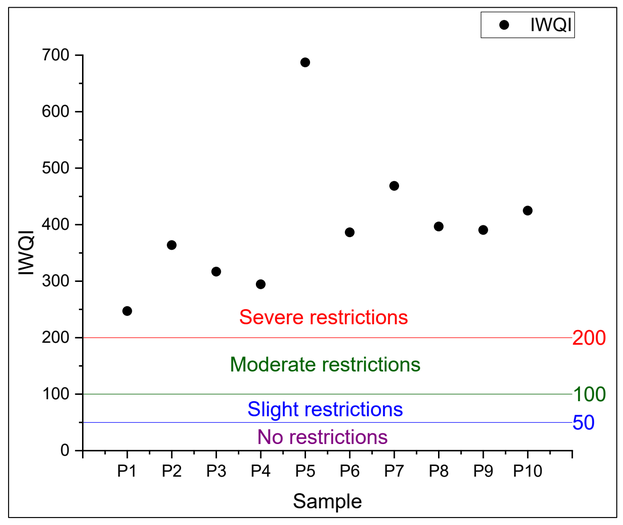
IRWQI: fluctuates between 247 and 687.1, with an average of 397.6.

→ **Very poor water with severe restrictions** of water for irrigation purposes Inadequate plant growth and reducing crop yield

Wilcox diagram: all samples are **unsuitable for irrigation.**

→ High Na% affects soil permeability

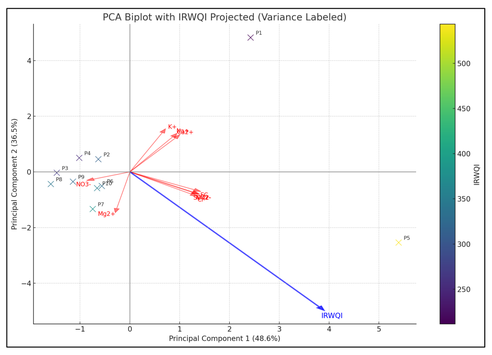
→ Inadequate plant growth and reducing crop yield

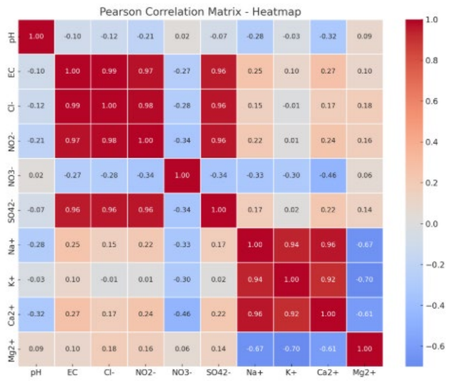


→ Nabeul-Hammamet groundwater **should be treated before irrigation use.**

Multivariate statistical analysis

Groundwater quality in the Nabeul-Hammamet phreatic aquifer is influenced by natural water-rock interactions, saltwater intrusion, and anthropogenic activities such as agriculture runoff and the excessive use of fertilizers.





CONCLUSIONS

This study demonstrates that groundwater in the Nabeul-Hammamet region is highly constrained for irrigation purposes due to elevated salinity and unsuitable water quality indices. The integration of hydrochemical assessment with statistical analyses highlights the dual role of natural processes and human activities in deteriorating groundwater quality. Effective management strategies, including treatment options and sustainable agricultural practices, are urgently required to mitigate risks, preserve water resources, and ensure long-term agricultural sustainability in this semi-arid coastal area.

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