

# Spatial–Temporal Dynamics of Surface Water Quality for Sustainable Irrigation and River Basin Management in the Upper Ziz Basin (Central High Atlas, Morocco)

Fatima Zahrae Benbella <sup>1,\*</sup>, Abdellah El-Hmaidi <sup>1</sup>, Anas El Ouali <sup>2</sup>, Allal Roubil <sup>1</sup>, Habiba Ousmana<sup>1</sup>, Ayse Muhammetoglu <sup>3</sup>, Habib Muhammetoglu <sup>3</sup>, Moulay Hachem Aouragh <sup>1</sup>, Abdelaziz Abdallaoui<sup>4</sup>

<sup>1</sup> Water Science and Environmental Engineering Team, Department of Geology, Faculty of Sciences, Moulay Ismail University, Meknes, Morocco;

<sup>2</sup> Department of Geomorphology and Geomatics, Scientific Institute, Mohammed V University, Rabat, Morocco;

<sup>3</sup> Environmental Engineering Department, Faculty of Chemistry, Akdeniz University, Antalya, Turkey;

<sup>4</sup> Analytical Chemistry and Electrochemistry, Department of Chemistry, Faculty of Sciences, Moulay Ismail University, Meknes, Morocco;

\* Corresponding author's mail: f.benbella@edu.umi.ac.ma

## Abstract

The Upper Ziz watershed, located in central-eastern Morocco, covers approximately 4414 km<sup>2</sup> on predominantly Jurassic formations and is drained by the Upper Ziz River. This study evaluates the physicochemical quality of the river's surface water for irrigation through laboratory analyses, the application of irrigation water quality indices (IWQI, SAR, KR, MH), and Geographic Information System (GIS) techniques. The results indicate generally good water quality at the upstream stations (Rich and Ait Khojmane), whereas a gradual deterioration is observed downstream. This decline is mainly attributed to anthropogenic pressures, including domestic wastewater discharges and agricultural runoff, combined with natural processes such as intense summer evaporation. Seasonal analysis further reveals a significant reduction in water quality during the summer period. The main concerns are related to increasing salinity and sodicity, which may adversely affect soil structure and permeability, thereby limiting the suitability of surface water for irrigation. These findings underscore the importance of continuous monitoring of river water quality and support the implementation of integrated water resources management strategies. They also highlight the need for effective measures to reduce pollution from wastewater discharges and agricultural runoff, contributing to the sustainable management of water resources in the Upper Ziz Basin.

**Keywords:** Surface water quality; Upper Ziz River; Irrigation; GIS