

Damming and Drought Impacts on Sediment Quality and Trace Metal Distribution in River-Lagoon Transitional System: Case Study of the Medjerda- Ghar El Melh Region

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ABSTRACT

River-lagoon transitional systems in semi-arid regions are highly dynamic environments where fluvial, marine, and climatic processes interact to control sediment transport, geochemical cycling, and contaminant distribution. Understanding their sediment geochemistry is essential for evaluating the vulnerability of land and marine ecosystems under increasing anthropogenic pressures and climate-driven stressors, such as damming, reduced freshwater inflow, seawater intrusion, and prolonged drought. While these interactions are well characterized in several transitional systems, they remain poorly understood in North African rivers characterized by high interannual flow variability. To achieve this objective, we perform a comprehensive assessment of the distribution and geochemical behavior of major elements and trace metals in surface sediments along the Medjerda River-Ghar El Melh Lagoon continuum, a crucial transitional system in North Africa that links fluvial and marine environments. Our measurements focus on the quality of subsurface sediment collected from six riverine sites along the Medjerda River and from thirteen lagoonal sites within Ghar El Melh Lagoon. All samples were analyzed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) to determine their elemental composition. Geochemical analyses reveal that major elements in the sediments are dominated by calcium (Ca), aluminum (Al), iron (Fe), potassium (K), and sodium (Na), with concentrations ranging from 43,352 to 166,330 $\mu\text{g/g}$ for Ca, 7,590 to 83,094 $\mu\text{g/g}$ for Al, 13,136 to 45,859 $\mu\text{g/g}$ for Fe, 5,120 to 23,919 $\mu\text{g/g}$ for K, and 1,393 to 27,988 $\mu\text{g/g}$ for Na. These patterns reflect a combination of lithogenic inputs from river catchments, evaporitic contributions related to lagoonal salinity, and marine influences, illustrating the complex sediment sourcing along the continuum. Trace metals, including chromium (Cr: 34-116 $\mu\text{g/g}$), nickel (Ni: 12-37 $\mu\text{g/g}$), copper (Cu: 7-24 $\mu\text{g/g}$), and lead (Pb: 16-61 $\mu\text{g/g}$) were compared to NOAA sediment quality guidelines (ERL and ERM). The concentrations of Cd, Cu, and Zn remain below ERL thresholds, whereas Pb, Ni, As, and Cr slightly exceed them, indicating moderate contamination. Furthermore, upstream damming since 1981, river disconnection, and the recent prolonged drought (2017-2023) under arid conditions have increased marine intrusion, reduced terrigenous inputs, and favored evaporitic enrichment due to extended residence times in the lagoon. The combined anthropogenic and climatic pressures are modifying sediment quality and geochemical processes, thereby increasing the lagoon's susceptibility to environmental changes. Sediments along the Medjerda-Ghar El Melh Lagoon continuum exhibit increasing marine influence and moderate metal enrichment, underscoring the necessity for integrated river-to-coast-adapted management.

Keywords: Sediment geochemistry, Lagoon; North African river, Anthropogenic impact and Coastal ecosystem.