Sediment and Water physicochemical characterization of Marchica Lagoon (Oriental Rif, Morocco)

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Abstract. This study primarily focuses on the environmental assessment of the Marchica lagoon ecosystem. The objective of this research was to determine the ecological effects associated with the development, especially the opening of a new inlet, of the Marchica lagoon on the physicochemical parameters of its liquid phase, geochemical characteristics, as well as the distribution and content of sedimentary substrates. Two sampling campaigns were conducted in February 2023 and May 2023 within the Marchica lagoon to perform a detailed characterization of water physicochemical parameters, including temperature, pH, salinity, turbidity, dissolved oxygen, and chlorophyll. Additionally, a sedimentological and geochemical analysis of collected sediment samples was performed. The results highlight significant variations in these parameters, both in terms of location and temporal variations. Results of the sedimentological and geochemical study of the sediments are also included for a comprehensive understanding of the impact of management development on the lagoon's ecosystem.
keywords: Marchica lagoon, Physiochemical characterization, water characterization, Sediment

1 Introduction

The lagoon ecosystems, as coastal wetlands, frequently house diverse biodiversity. The Marchica Lagoon exemplifies an ecosystem of significant environmental importance due to its rich variety of plant and animal species, contributing to its exceptional biological richness [1]. Furthermore, it plays a vital role for local communities by providing essential resources for their livelihoods [2]. In the effort to gain a better understanding of this complex and fragile environment, an in-depth study has been undertaken. This study aims to characterize the Marchica lagoon by examining the spatial and seasonal variations of its water physicochemical parameters [3]. It also includes a detailed analysis of the properties of surface sediments within the lagoon. To achieve this, two sampling campaigns were conducted in February and May 2023. Water physiochemical parameters, such as temperature, pH, salinity, turbidity, dissolved oxygen, and chlorophyll concentration, were studied to better comprehend water quality variations. Simultaneously, sediment samples were collected at each station for a comprehensive analysis of their composition and geochemical characteristics.

2 Methodology

2.1 Study Area

The Marchica Lagoon is located on the northeast coast of Morocco, stretching Cape of Three Forks (northwest of Beni Ansar) and Kariat Arkman (Fig.1). This lagoon ecosystem appears as a vast oval water body, covering an area of 115 km², extending parallel to the coast in a northwest to southeast direction. It measures 25 km in length, 7.5 km in width, and reaches a maximum depth of 8 meters. The Marchica Lagoon is separated from the Mediterranean Sea by a barrier island known as the "lido." This lido stretches for 25 km in length and is 300 to 400 meters wide, except in its southeast part where it widens to 1.7 km. It connects to the Mediterranean Sea through a passage locally referred to as "boccana," allowing water exchange between the lagoon and the sea [4]. It is characterized by the presence of four distinct structural domains [5]: the Gourougou massif located in the northwest of the lagoon, the Bni Bou-Ifrour massif oriented east-northeast to west-southwest, the Bou-Arg plain, and the Kebdana massif.

2.2 Sample Collection

Two marine water sampling campaigns were conducted within the Marchica lagoon, with technical assistance from the Fishing Laboratory team at the Regional Centre of the National Institute of Fisheries Research (INRH). These sampling missions took place in February and May 2023, encompassing a sampling network of 17 stations. At each sampling station, in-situ measurements of environmental parameters were collected at the same depth using the YSI proDSS Multi-Parameter Water Quality Meter, which included water temperature, salinity, dissolved oxygen, turbidity, pH, and chlorophyll concentration. Simultaneously, sediment samples were collected from each station using specialized sediment samplers for a comprehensive sedimentological and geochemical analysis.

2.3 Data Processing

The processing of data collected during the sampling campaigns was a crucial step in our study. In-situ measurements of environmental parameters, including water temperature, salinity, dissolved oxygen, turbidity, pH, and chlorophyll, generated a dataset that was both rich and complex. Additionally, after subjecting the sediment samples to granulometric and geochemical analysis, the results were processed using the GRADISTAT version 8.0 software to calculate the sediment parameters of the lagoon. For the analysis of water-related data, as well as sedimentological and geochemical analysis, we employed the powerful tool known as Ocean Data View (ODV) version 5.6.7. This software enabled us to systematically visualize, process, and analyse our data by creating spatial distribution maps, greatly facilitating result interpretation.

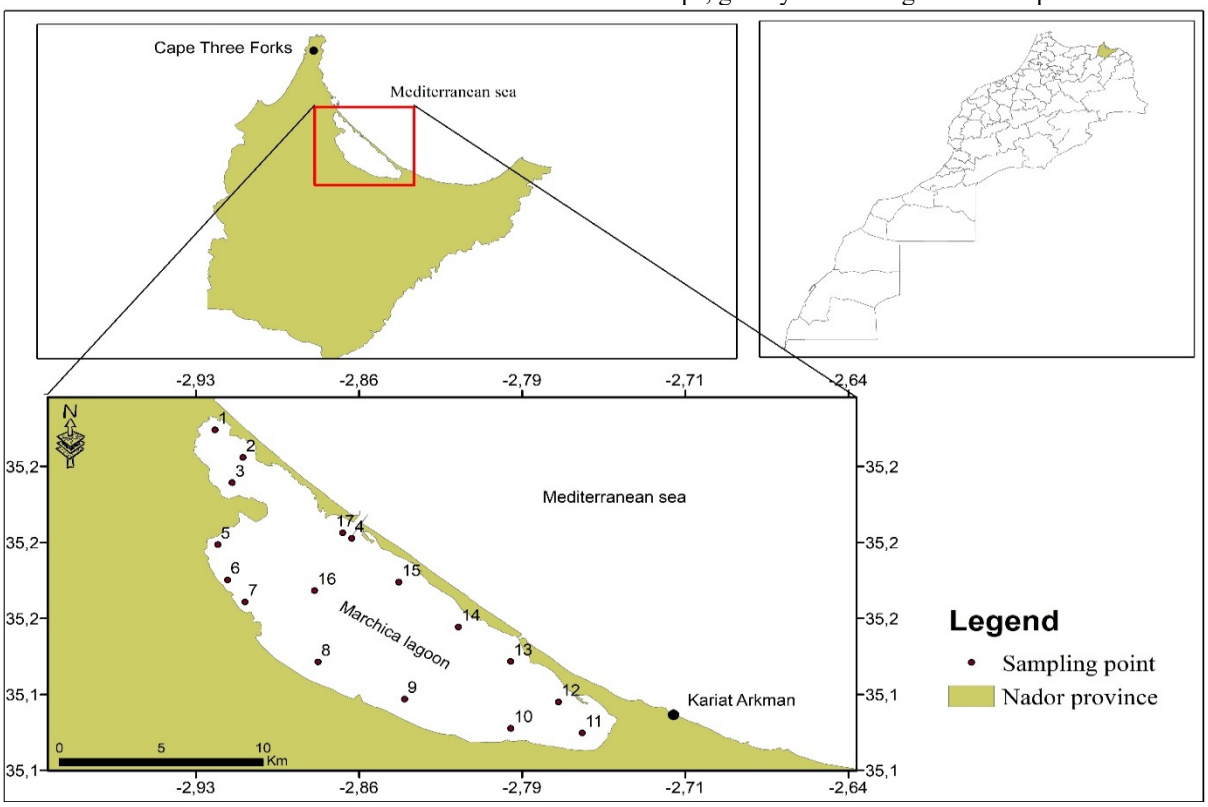

Fig.1. The geographical location Map of Marchica lagoon.

3 Results and Discussion

3.1 Water physicochemistry

The analysis of data collected during the February sampling campaigns revealed significant variations in the physicochemical parameters of the Marchica Lagoon. For a clearer visualization, we generated maps for each parameter (Fig. 2) representing the spatial variation of water temperature, salinity, dissolved oxygen, turbidity, pH, and chlorophyll. Let's begin with the temperature, where a significant variation is observed throughout the lagoon. Lower temperatures are recorded near the passage, where seawater comes into contact with the lagoon, while higher temperatures are observed upstream along the continental shoreline. Regarding salinity, a concentration variation is observed ranging between 35.67 psu and 39.94 psu, with higher concentrations near the passage, where there is contact with seawater. As for dissolved oxygen levels, they vary between 5.17 and 12.12 mg/L, with lower concentrations upstream in the lagoon and higher concentrations near the passage and the continental shoreline. These variations may be linked to biological productivity and decomposition processes. In terms of water pH, variations are observed between 7.4 and 8.2, with the highest value recorded at stations near the passage and slightly acidic values at stations near the continent. Regarding chlorophyll variation, significant differences are also observed in various stations, with higher concentrations at stations near Kariat Arkman on the southeast coast of the lagoon. Finally, turbidity has shown notable differences, with higher values near the continental shoreline, especially between Bouaarg and

Atalayun, particularly in the vicinity of the purification station.

The temporal variation of physicochemical parameters of Marchica Lagoon water during the month of May is represented in Fig. 3. Let's begin by discussing water temperature. In February, the water temperature in the Marchica Lagoon was noticeably lower than what was observed in May. This seasonal variation is primarily attributed to meteorological conditions, with the winter season bringing cooler temperatures. The proximity to the passage also influenced this variation, with the lowest temperatures recorded at this location in February due to the influx of colder seawater. Moving on to salinity, the data shows a seasonal variation with higher concentrations in May. This is largely due to increased evaporation in the summer, concentrating salts in the water, as well as the inflow of seawater in contact with the lagoon. Regarding dissolved oxygen, concentrations also vary seasonally [6]. In February, lower concentrations were recorded upstream in the lagoon, while in May, concentrations were slightly higher at various stations ranging from upstream in the lagoon to the passage. These variations may be influenced by increased biological productivity in May and decomposition processes. As for water pH, a slight but significant variation is observed between the two sampling months. In February, slightly more acidic values were recorded at stations near the continent, while in May, stations near the passage exhibited slightly higher values. These variations may be linked to water biogeochemistry and the influence of local ecosystems. Chlorophyll concentration showed notable seasonal variations, with higher levels in May. This increase in chlorophyll in May suggests increased biological productivity and higher nutrient availability, particularly due to warmer conditions and the growing season. Finally, turbidity also exhibited notable differences between the two months, with higher values near the continental shoreline, especially between Bouaarg and Atalayun, particularly in February. This could be attributed to construction activities, soil erosion, or freshwater inflow [2].

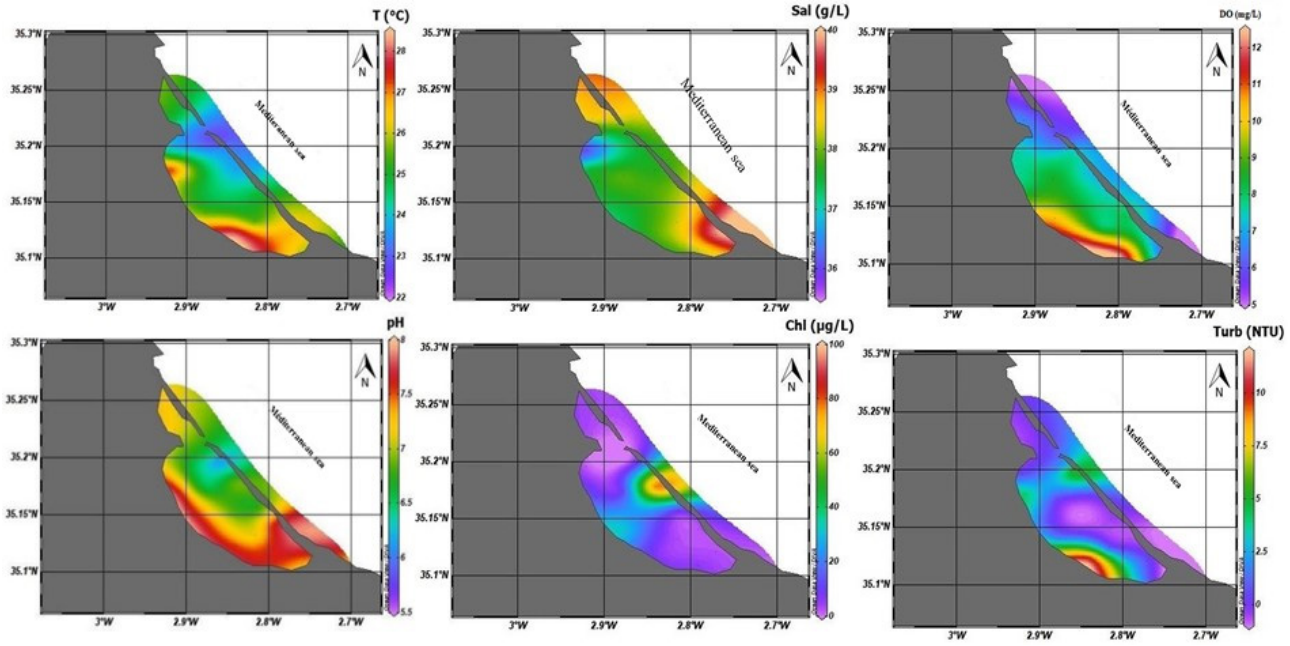

Fig.2. Variation of physicochemical properties of water in Marchica Lagoon during February 2023.

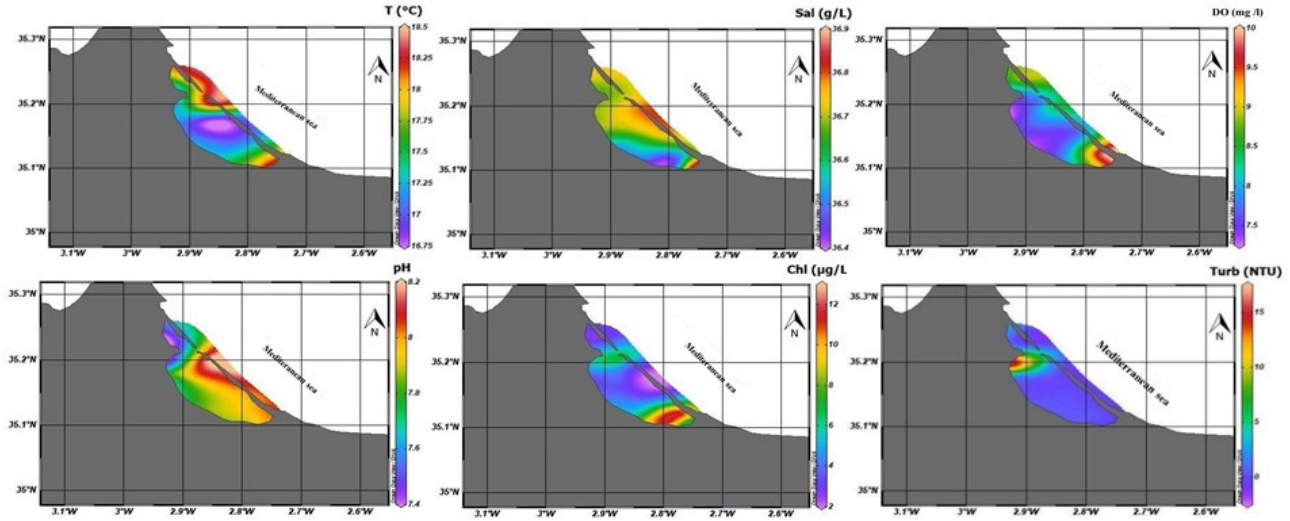

Fig.3. Variation of Physicochemical Properties of Water in Marchica Lagoon during May 2023.

3.2 Sediment dynamic

The sedimentological analysis reveals a significant predominance of silt in the majority of Marchica Lagoon, with the exception of areas located in the northwest and southeast, near the dune cord and the entrance channel, where significant quantities of sand are present (Fig. 4). This distribution is corroborated by granulometric coefficients, including the mean grain size (Fig. 4). Several environmental and geographical factors contribute to this distribution. Areas near the entrance channel from the Mediterranean Sea exhibit a higher proportion of sand due to the direct influence of seawater. The influx of freshwater, local marine currents, coastal erosion, and underwater topography also play a substantial role in this heterogeneous sediment distribution [2].

The geochemical analysis of sediment samples in the Marchica Lagoon reveals significant trends that provide a clear insight into sediment composition (Fig.5). Firstly, the levels of bound water, reflecting the amount of water retained by sediments, are higher in areas rich in silt. This suggests a correlation between the fine silt-rich sediment texture and increased moisture retention, likely due to their fine composition. Regarding organic matter (OM), the highest concentrations are observed in the southeastern extremity of the lagoon. This observation can be associated with the presence of coastal vegetation in this region, as organic matter often originates from vegetation decomposition. Lastly, carbonate levels are higher near the entrance, indicating a significant influence of seawater on these sediments. Carbonates are commonly associated with shell and coral residues, which can be transported by marine currents from the Mediterranean Sea. These results underscore the direct impact of environmental factors, such as sediment texture, coastal vegetation, and marine influences, on the geochemical composition of Marchica Lagoon sediments. They also highlight the importance of understanding these interactions for a comprehensive assessment of the state of this valuable coastal ecosystem [6].

4 Conclusion

This comprehensive environmental study of Marchica Lagoon highlights the significant impact of its development, including the opening of a new inlet, on its physico-chemical and geochemical characteristics. Seasonal variations in physico-chemical parameters, as well as the granulometric and geochemical distribution of sediments, are clearly influenced by complex environmental and geographical factors. The results emphasize the importance of considering these variations for sustainable management of this valuable coastal ecosystem. Future studies should further explore these relationships and implement ecological management practices to preserve the health of Marchica Lagoon.

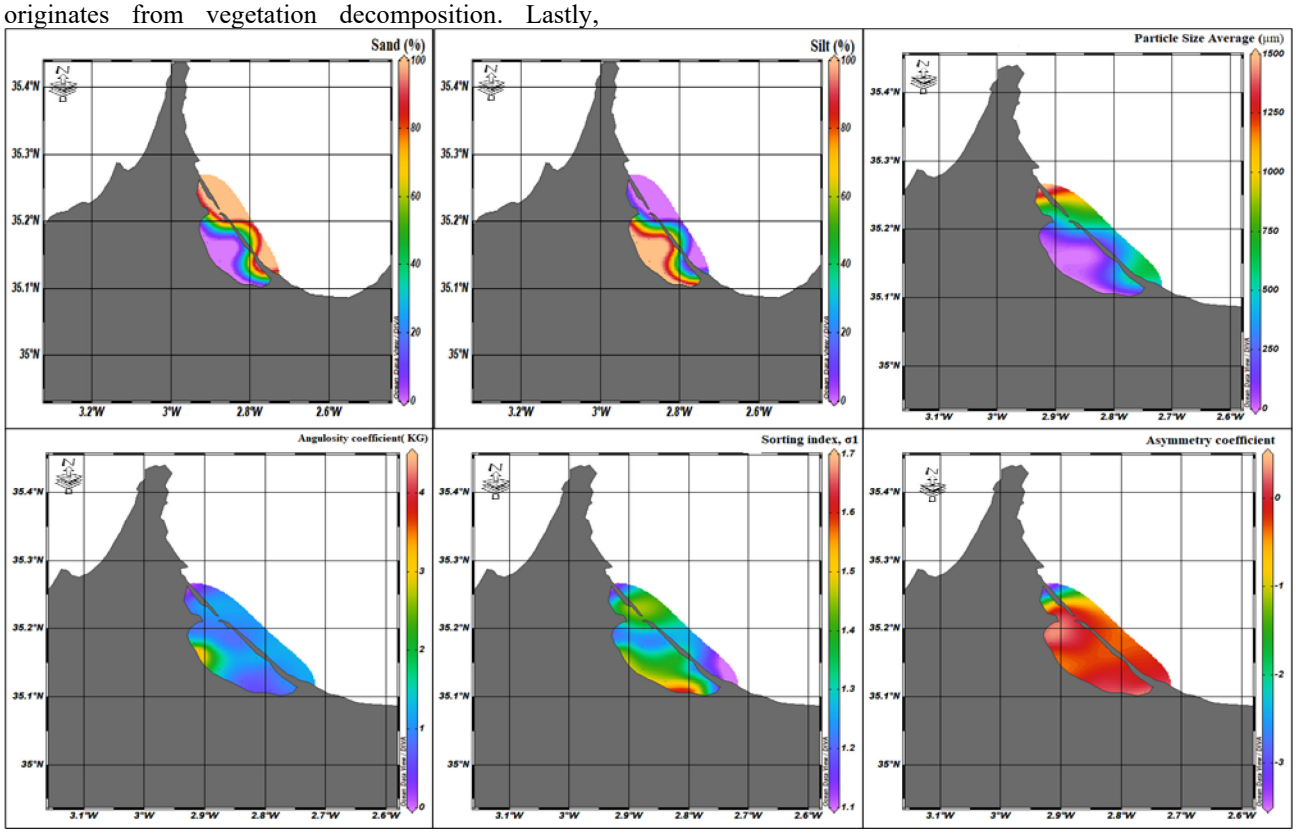

Fig.4. Spatial representation of surface sediment granulometry of the Marchica lagoon

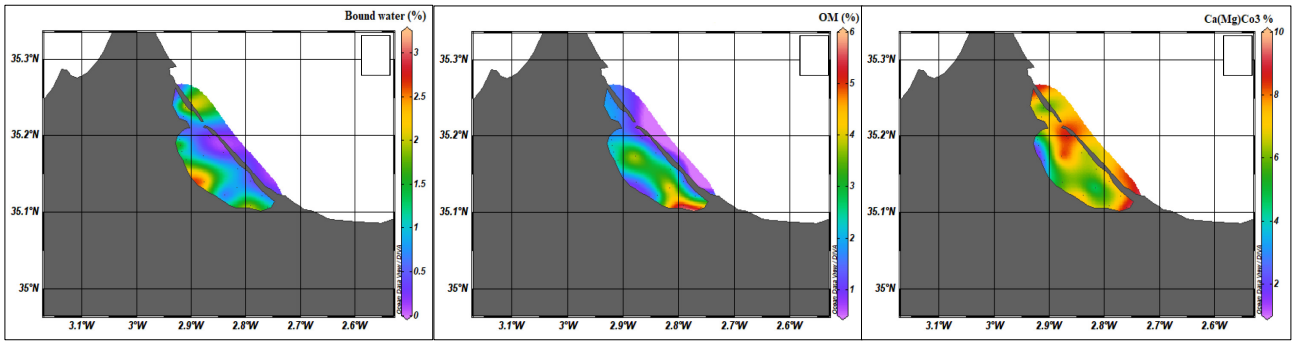

Fig.5. Spatial representation of surface sediment geochemistry of the Marchica lagoon.

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