

Assessment of the Coastal Marchica Watershed through Ecotoxicological Indices of Trace Elements in Superficial Sediments

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Abstract. This study analyses the seasonal distribution in the superficial sediments of the Marchica watershed of trace and major elements, grain size, and total organic carbon. Samples were taken during the wet and dry seasons of 2018 in the mainstream valleys carrying the discharges to the Marchica Lagoon. Ecotoxicological indices (Enrichment Factor, Contamination Factor, Pollution-Load Index) and sediment-quality guidelines were used to evaluate the ecotoxicological risk. The results revealed during both wet and dry seasons contamination by lead in all stream valleys. The northwest stream valley, characterized by some industrial activities, and the stream valley crossing the abandoned mine were the most polluted by zinc and copper. Minimal pollution for Cr, Co, and Ba was found during both the wet and dry seasons. Despite the restoration actions achieved around the Ramsar site of Marchica lagoon during the last decades, the watershed continues to have a negative impact on this ecosystem. Therefore, an environmental management strategy is necessary, taking into account the rehabilitation of the abandoned mining sites, the rational use of pesticides and fertilizers in agriculture, and the environmental responsibility of industrial companies, especially those installed before the implementation of the national law on environmental impact studies.

1 Introduction

Watersheds surrounding the coastal lagoons have experienced intense urbanization in recent years due to the ecosystem services offered by these ecosystems. However, this urbanization accompanied by the intensification of human activities around coastal lagoons has impacted their structure and function and compromised their ecological integrity [1-2]. Sediment flows in rivers reflect natural or human-induced changes in their watersheds [3]. The characterization of terrestrial sediment inputs to the seas is essential for watershed managers because of the harmful effects of sediments on nearshore marine ecosystems [4].

The Marchica watershed constitutes an example with a population of approximately 400 000 from cities around the Ramsar site of the Marchica lagoon. The watershed covers an area of 700 km² and is formed by four morphological structures, the volcanic massif of Gourougou in the northwest, the massif of Beni Boulfrouf in the west; the Kebdana massif in the south; and the Bouarg plain in the southwest [5, 6].

The hydrographic network of the Marchica watershed is composed of several stream valleys called wadis, the majority of which have important contributions during rainy periods [7]. The geochemical assessment of the sediment inputs from the Marchica watershed, which are the main sources of pollution in the Marchica Lagoon, is crucial for protecting this Ramsar site and conserving its biodiversity.

2 Objectives

The objectives of this study are to assess Marchica watershed sediment characteristics through:

1. analysis of the seasonal distribution of trace elements (Pb, Cu, Zn, Cr, Co, Ba), major elements, grain size, and total organic carbon in the superficial sediments of the Marchica watershed;
2. ecological risk assessment of trace elements in superficial sediments;
3. identification of highly polluted areas.

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3 Methodology

Superficial sediments (0.5 cm) were sampled during the wet (March) and dry (July) seasons of 2018 in the main wadis of the Marchica watershed carrying the discharges to the Marchica lagoon through a representative station for each one (Fig. 1). The climate is Mediterranean with hot and dry summers and mild and rainy winters.

Major elements analysis was carried out using Bruker S1 Turbo SD hand-held X-ray fluorescence (HHXRF) spectrometer. Trace elements analysis were realized by an Agilent 4200 microwave plasma atomic emission spectrometer (MP-AES). Granulometry analysis was measured by a laser particle size analyzer (Malvern Mastersizer 2000) and Total organic carbon analysis by a LECO carbon analyzer. Analysis details are given in [8].

Enrichment Factor (EF) [9], Contamination Factor (CF) [10] and Pollution-Load Index (PLI) [11] were studied for trace elements (TEs) to access ecological risk:

$$EF = (CTEs/CFe)_{Sample} / (CTEs/CFe)_{Background} \quad (1)$$

$$CF = CTEs_{Sample} / CTEs_{Background} \quad (2)$$

$$PLI = (CF1 \times CF2 \times CF3 \times \dots \times CFn)^{1/n} \quad (3)$$

Normalization using iron was calculated to quantify the anthropogenic metal pollution from the natural variability of trace elements, and reference values were taken from Rudnick and Gao (2003) [12]. Sediment concentrations were compared with sediment-quality guidelines (SQGs) for freshwater ecosystems to evaluate the ecotoxicological risk as reported by Macdonald et al. (2000) [13].



Fig. 1. Map of Coastal Marchica Watershed.

4 Results

4.1 Granulometry and TOC

The granulometric distribution sediment in the Marchica watershed showed that all sampling stations were classified as muddy sand facies during the wet season and sandy mud during the dry season except the first station, which was classified as sand during the wet season.

The TOC sediment results ranged from 0.70% to 4.58% during the wet season and from 1.82% to 10.10% during the dry season.

4.2 Major and Trace Elements

The average concentrations of major elements (%) during the wet and dry seasons showed the following pattern Si (17.63) > Ca (13.64) > Al (4.54) > Fe (3.90) > K (1.88) > Ti (0.39) > P (0.16) > Mn (0.04).

The average concentrations of trace elements (mg/kg) during the wet and dry seasons showed the following pattern Ba (450.81) > Zn (149.66) > Pb (144.9116) > Cr (50.04) > Cu (36.47) > Co (9.78).

5 Discussion

The ecotoxicological risk assessment used with SQGs and assessing the indices (EF, CF, and PLI) (Fig. 2, 3, and 4) revealed contamination by lead in all streams during wet and dry seasons valleys. The northwest stream valley, characterized by some industrial activities, and the stream valley crossing the abandoned mine sites were the most polluted by zinc and copper. Cr, Co, and Ba were found to be at minimal pollution during both the wet and dry seasons.

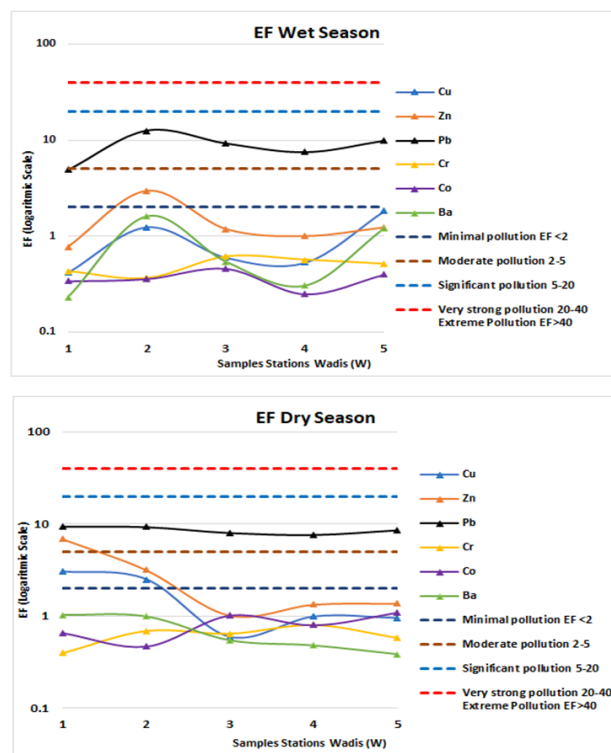


Fig. 2. Wet and dry enrichment factor.

In fact, the Marchica watershed drains rainwater from its four morphological structures by conveying wastewater from various industrial and mining activities through the main wadis that reach the Marchica lagoon, as reported by ABHM (2009) [7]. Some industries with main activities related to the steel industry were installed before implementing the national law on environmental impact studies and the discharge of their industrial waters without prior treatment, as reported by LNEBP /BBN (2016) [14]. The irrigated agriculture of the Bouarg plain often uses excessive quantities of fertilizers, as reported by Re et al. (2014) [15] and Snoussi (2004) [16]. The iron ore deposit, part of which has been intensively exploited and

abandoned without rehabilitation, can generate the production of acid mine drainage and the release of trace elements according to Bussi re et al. (2010) [17] and impacts the Marchica lagoon through the Cabaillo wadi as reported by Khafouri and Talbi (2020) [18] and Lakrim et al. (2016) [19].

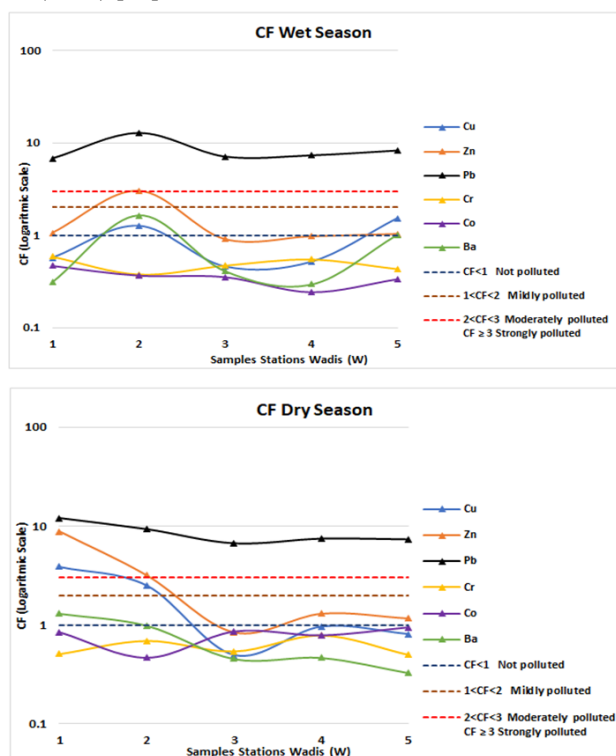


Fig. 3. Wet and dry contamination factor.

Similar pollution was found in the sediments Marchica lagoon during the same period of this study, as reported by Oujidi et al. (2021) [8]. This can confirm that the watershed has negatively impacted the Marchica lagoon despite the restoration actions around this Ramsar site during the last decade.

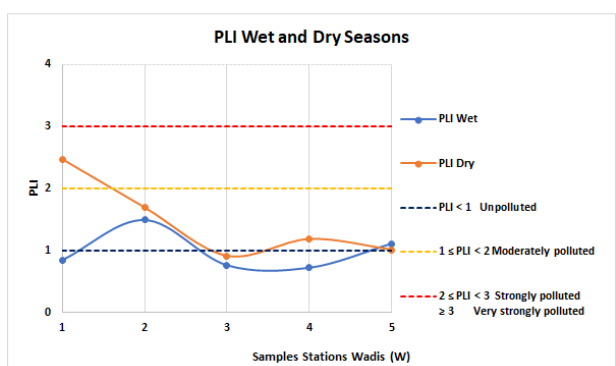


Fig. 4. Wet and dry pollution-load index.

6 Conclusion

This study confirms through the ecotoxicological risk assessment of the trace elements using pollution indices and SQGs, contamination of Marchica watershed by Pb, Zn, and Cu. Therefore, an environmental management strategy is necessary, taking into account the rehabilitation of the abandoned mining sites, the rational use of

pesticides and fertilizers in agriculture, and the environmental responsibility of industrial companies, especially those installed before the implementation of the national law on environmental impact studies.

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