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Assessment of metals bioaccumulation and bioavailability in mussels *Mytilus galloprovincialis* exposed to outfalls pollution in coastal areas of Casablanca

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ABSTRACT

The present work aims to study the metallic contamination of four sampling sites located nearby major sewage outfalls of the Casablanca coast (Morocco), using indigenous mussels *Mytilus galloprovincialis* as bioindicators of pollution. This research offered the opportunity to study trace metals bioaccumulation mechanisms, which represent a major factor in assessment processes of the pollution effects in coastal ecosystem health. The bioavailability and the bioaccumulation of trace metals (*Cu, Zn, Ni, Pb*) were evaluated in order to compare the metallic contamination in mussels' tissues and find a possible correlation with physiological parameters of this filter feeding species. Our results showed a significant spatiotemporal variation of bioaccumulation, compared to control. A significant correlation coefficient between metals (*Zn* and *Pb*) bioavailability and physiological index (CI) was revealed in mussels from the most polluted location. The seasonal variation of trace metal accumulation was also raised; the highest values recorded during the dry period.

1. Introduction

The coastal ecosystems are sensitive areas subject to increased economic development and ecological population pressure. They suffer from many problems that seriously threaten natural resources, in the absence of protectives laws [1]. The coast line of Casablanca represents an important segment in our national economic because of the industrial and commercial concentration. This coast has known a rapid urbanization and industrialization, during last decades. There are all kinds of industries with high polluting potential; including chemistry, para-chemistry, agri-food, mechanics, metallurgy, textiles and leather. Actually, this anthropogenic pressure is still growing and have a significant environmental impact. They contribute to the discharges of a large kind of toxic elements such as metals into coastal areas. According to recent studies, wastewater discharges follow an exponential trend in Morocco, and about 80% of Casablanca's industries discharge their effluents directly into the sea via the sewers conduit [2]. The characterization of seawater and wastewater of Casablanca coast reveals a severe polluting load, especially with toxic metals such as chromium, lead and mercury [3,4]. The synergistic effects of contaminants on marine ecosystem are imperfectly known [5].

Naturally, metals are found at very low concentrations in aquatic ecosystems. Nevertheless, they have a toxic potentiality to biota above natural charges. Some harmful metals can be hazardous, even in traces levels [6]. Metal contaminants present one of the major environmental concerns. Several studies shown some metals (Cu, Fe, and Mo) to be pro-oxidants and inducers of oxidative stress in mammalian systems and aquatic organisms [7–9]. A considerable interest should be projected in their health risks for human's consummators. Expressly, various marine biocenose possess the ability to concentrate high levels of metals in their tissues and shellfish [10,11]. Many researchers have used bioaccumulative species to assess contamination by metals in marine and estuarine ecosystems [12,13]. It is recognized that sedentary living organisms can fill the role of sentinel species to assess pollution of coastal environments [14–17]. Several published works showed that bivalves can reflect the metals contamination from surrounding area and they do not regulate the level of some metals in their body [18]. In fact, mussels are well known as good bioindicators for metals monitoring [19]. This sensitive filter-feeding species have been used extensively as sentinel organisms, representing reliable tool for biomonitoring metallic pollution in coastal areas [20–22]. Particularly, the mussel *M. galloprovincialis* have been used mainly in the international "Mussel watch" program for monitoring various pollution in the world oceans [23,24].

The aim of the present study is three-fold: (1) to determine the metallic bioavailability and the bioaccumulation of essential elements

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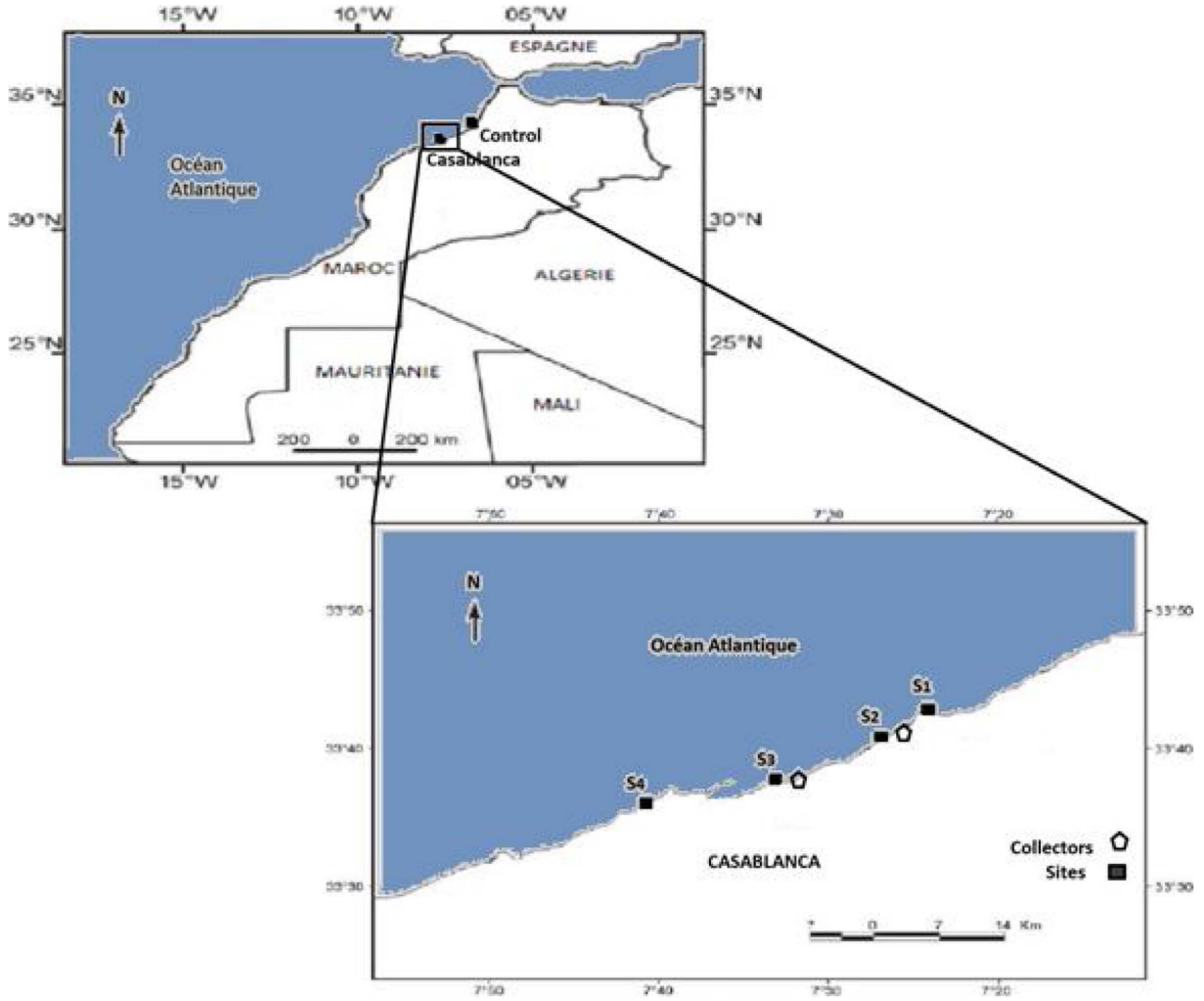

Fig. 1. Study area and sampling stations in Casablanca coast (Morocco).

(Cu, Zn) and toxic elements (Ni, Pb) in three major organs of indigenous mussels *Mytilus galloprovincialis* collected near to sewage discharges with different amounts of metals pollution in Casablanca coast [65]. (2) To compare the metals concentrations and to establish a seasonal assessment of coastal environment quality and contamination gradient between the studied sites. (3) Finally, to evaluate the relationship of mussel's condition index (CI) and metals bioavailability.

2. Materials & methods

2.1. Site description

After a large investigation, four sampling sites were selected in Casablanca coast (Fig. 1). They present different levels and sources of pollution. Their choice is based into the presence of the molds. S1 on the Casablanca's upstream part (Grande Zenâta beach, with a geographical position of NR 33°39′06.7"/W 007°28′48.3"), is located next to petrochemical industry and urban emissary which discharged effluents directly into the sea. S2 is located 3 km south of the first station (Saada beach, to a geographical position N 33°37′23,4"/W 007°31′53,2"). S3 is situated 8 km south of the second station (Okacha seaside, with a geographical position N 33°36′27,9 "/W 007°34′28,3"). S2 and S3 are on the Casablanca's middle part that represent the most industrial activities. Actually, those stations include an effluent tunnel opening directly on the sea. S4 on the Casablanca's downstream part (Sidi Abderrahmane beach, 17 kilometers south of the third site, with a geographic position of N 33°34′52,1 "/W 007°42′41,4"). It is located near a seaside and tourist area which receives low-flow discharge from Lake Sindbad from Oued Bouskoura which is experiencing great eutrophication. The control site was set in small touristic city far-off any pollution (Skhirat beach, with a geographic position of N33° 51′ 36"/W 7° 03′ 00").

2.2. Sampling, sample preservation

Indigenous mussels *M. galloprovincialis* were collected during the year 2011–2012, from intertidal zone at low tide. They were collected in the spring (April-May), summer (July-September), autumn (October-November) and winter (December-January). Fifty mussels were taken from each of the studied sites, washed with seawater and placed in sterile plastic bags. Immediately, the different samples collected were transported in insulated coolers at +4 °C to the laboratory.

2.3. Biometric parameter and physiological indices

Thirty individuals were measured for biometric characterization; shell lengths (maximum anterior-posterior), shell widths (lateral dimension) and shell heights (dorsal-ventral) as described by Fischer et al. (1987) [25], using a Vernier caliper to an accuracy of 0.01 cm. The shell size factor was calculated (Soto et al., 2000) as: SSF [cm^3] = height × length × width

The condition index (CI) was calculated according to the formula