CORALLINA SP. AND *PATELLA CAERULEA* (LINNAEUS, 1758) AS QUANTITATIVE BIOLOGICAL INDICATORS FOR TRACE METALS IN THE TUNISIAN COASTAL WATERS

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Abstract
The concentrations of trace metals (Fe, Mn, Cu, Cd, Cr, Ni, Al, Pb) were measured in two marine organisms of environmental relevance: red algae (*Corallina sp*.) and mollusk limpet (*Patella caerulea* Linnaeus, 1758). The samples were collected at two coastal stations located in the north coasts of Tunisia (Bizerta Channel: CB and La Goulette harbour: LG). These areas are influenced by anthropogenic activities (harbour, industrial and urban wastes). Metal concentrations measured in the limpet indicate that the area of Bizerta Channel was the most polluted. We found high variability of metal bioaccumulation among the two species analysed. The order of metal accumulation in the red algae was Al>Fe>Mn>Pb-Cu>Ni>Cr>Cd, while in the limpet the order was Fe>Al>Mn>Cu>Pb-Ni>Cr>Cd.

Keywords: Algae, Mollusca, Metals, Tunisian Plateau

Marine organisms can be used as monitors to give information on concentrations of trace metal in the surrounding environment. Especially, macroalgae and limpet species are usually used to indicate heavy metal levels in coastal waters throughout the world [1].There have been made numerous studies on the trace metal concentrations of the bivalve and gastropod molluscs in the Tunisian marine environment, but limited information exists on the content of the trace metals in algae of the Tunisian coastal waters. In benthic food webs, marine algae are key links and they act as time-integrators of pollution [2]. Their sedentary nature is another reason why marine algae species are well fitted as monitor organisms in heavy metal monitoring.
The aim of the present study was to determine the levels of Fe, Mn, Cu, Cd, Cr, Ni, Al, Pb in red algae *Corallina sp.* and the limpet *Patella caerulea*, sampled seasonally during 2006-2007, from two different stations in the north coasts of Tunisia (Bizerta Channel: CB and La Goulette harbour: LG). Algal samples and between 30 and 40 specimens of *P. caerulea* were handpicked in the tidal zone from the two studied sites. Organisms were depurate and soft tissues were dried, pulverized and mineralized. Heavy metals analyses were performed in the limpet and algae samples according to the methods described by AOAC [3] and Riget et al. [4].

Tab. 1. Mean concentrations of metals in tissues of *P. caerulea* and *Corallina sp*. collected from the north coasts of Tunisia since summer 2006 until the spring 2007. [a] $mg.g^{-1}$

	Fe[a]	Mn	Cu	Cd	Cr	Ni	Al[a]	Pb
Stations	The mean metal concentrations in *P. caerulea* ($\mu g.g^{-1}$ dry weigh)							
CB	2.59±0.18	5.14±0.83	5.59±0.47	1.63±0.27	2.78±0.59	3.43±0.8	0.40±0.03	3.51±0.67
LG	1.86±0.17	10.76±2.49	9.29±1.43	0.78±0.24	1.00±0.36	3.00±1.12	0.35±0.06	3.61±0.8
	The mean metal concentrations in *Corallina sp.* ($\mu g.g^{-1}$ dry weigh)							
CB	2.29±0.96	36.55±12.68	8.43±3.17	0.76±0.2	2.21±0.92	2.90±0.6	2.53±1.41	7.79±5.68
LG	2.52±1.14	60.80±16.16	13.15±9.62	0.78±0.27	1.28±0.7	2.51±1.49	4.11±1.55	9.26±5.41

The mean heavy metal concentrations determined in *P. caerulea* and *Corallina sp*. are shown in Table 1. Results revealed that in CB station, concentrations of Fe, Cu, Cd, Cr and Ni are significantly higher (ANOVA, $P<0.05$) in soft tissues of *P. caerulea* than in *Corallina sp*., otherwise, in *Corallina sp.*, the rates of Mn, Al and Pb are significantly higher than in *P. caerulea* (ANOVA, $P<0.05$). However, in LG station, except the Cd and the Ni, the mean concentrations of all metals are significantly higher than the rates found in tissues of *Corallina sp*. than in those of *P. caerulea* (ANOVA, $P<0.05$).
In the present study, comparison between stations for the concentrations for all metals revealed that the highest values of the heavy metal in *Corallina sp*. were found at LG station for Fe, Mn, Cu, Cd, Al and Pb (Table 1). However, the highest values in the limpet were found at CB station for Fe, Cd, Cr, Ni and Al.
High concentrations of trace metals registered in CB and LG stations are probably related to the degree of water contamination. High levels of heavy metals in the limpet registered in CB station are caused by wastewater discharges and by the important maritime activities in this area. This zone is also submitted to the impact of industrial activities which cause atmospheric and chemical aquatic pollution [5]. In LG station, the high concentrations in Fe, Mn, Cu, Cd, Al and Pb in tissues of the red algae could be explained by the fact that this station is located at the trade fishing harbour characterized by the important port activity. Besides, this station receives wastes from ships, industrial, urban and agriculture effluents from closed areas via Medjerda Wadi, Khlij channel and Meliane Wadi [6].
The patterns of heavy metal accumulation rates in decreasing order were Al>Fe>Mn>Pb-Cu>Ni>Cr>Cd in the red algae and Fe>Al>Mn>Cu>Pb-Ni>Cr>Cd in The limpet, where Pb, Cu and Ni were changeable in their order at different stations. The observed variation in metal levels in these marine organisms at different stations may be related to the environmental conditions of the area and to the physiological conditions of biota regarding the metal.

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