Heavy Metal Bioaccumulation in Brown Algae *Cystoseira compressa* in Algerian Coasts, Mediterranean Sea (Benfares. R et al)

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Abstract
This study was undertaken to investigate and assess trace metal (Cd, Pb, Cr, and Hg) concentrations in the *Cystoseira compressa* algae from the coastal city of Bou Ismaïl (Algeria). Spatial and temporal variations in the concentrations of these heavy metals were studied in the following three sampling sites: site 1 and site 2 were major wastewater discharge zones and site 3 was located close to areas with high industrial activity. Seawater, sediments and algae in the wastewater from the three sites were submitted to physico-chemical analyses to determine the concentrations of heavy metals and the level of pollution in the region. The results revealed that site 1 (designed as desalination) and site 2 (designed as industrial waste) were non-compliant, which was attributed to heavy loads of heavy metals and wastewater discharged by industrial activity and absence of regular treatment. Site 3 (designed as cove koali), on the other hand, was noted to represent a reference site. Overall, the results provided evidence for the heavy metal bioaccumulation of algae from the genus Cystoseira and their efficiency for use as biomarkers of pollution in coastal areas.
Keywords Pollution . *Cystoseira compressa* . Concentration . Heavy metals . Sediment

The Study Sites

Brown algae were collected from three sites (desalination and industrial waste stations) located on the coast of the Bay of Bou Ismaïl . The sites were selected due to their richness in algal populations and proximity to zones of industrial activity. The seawater, sediments and brown algae *Cystoseira compressa* from the three different sites were used to evaluate the flow of effluents and their impacts on the receiving marine environment.
Atomic absorption spectroscopic analysis was performed by a Perkin Elmer Analyst 700 atomic absorption spectrometer equipped with a flame, furnace, and cold vapor system connected to the ISAF, a mechanism that allowed for the analysis of the evaporation reaction of the mixture of mercury, HCl, Sn (II) Cl2, and the sample. The carrier gas was argon, an inert gas that does not react with the test solutions.

Results and Discussion

The changes recorded for trace metals (Cd, Pb, Cr, and Hg) in sediments are presented in Fig. 1c. The changes recorded for heavy metals (Cd, Pb, Cr, and Hg) in algae are illustrated in Figs. 1d.

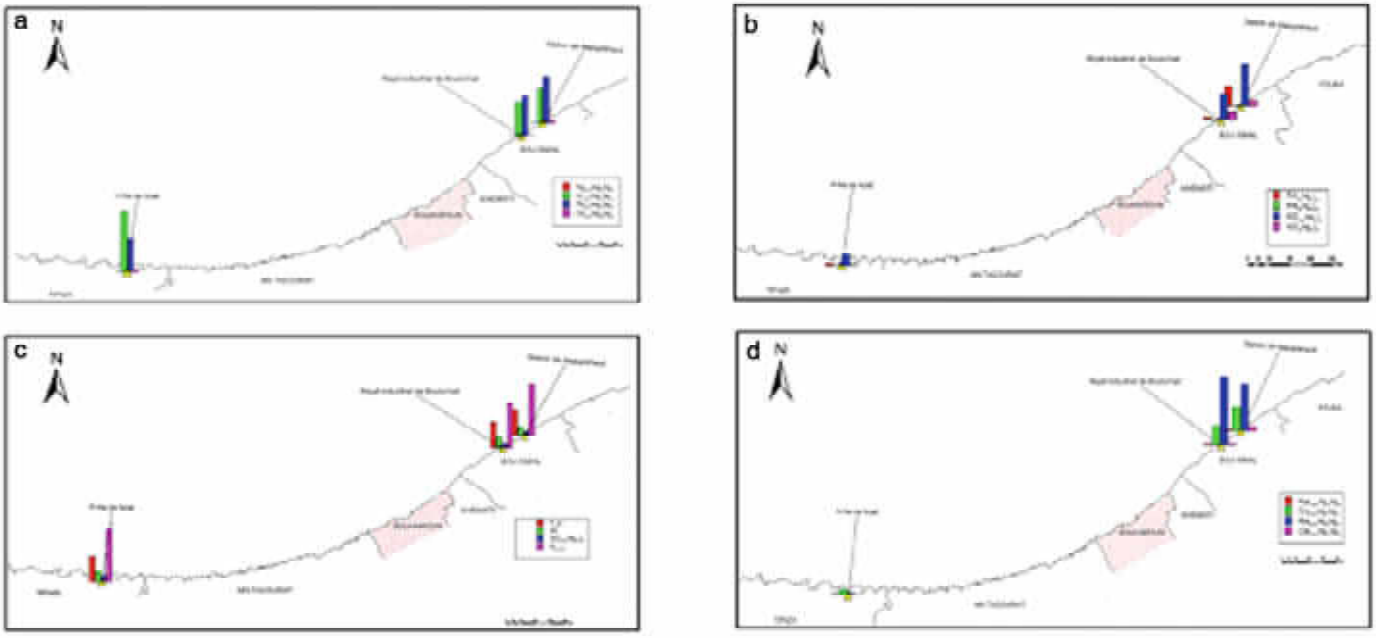

Fig. 1 a Spatial variation of physico-chemical parameters in the study area; b Spatial variation of nutrients in the study area; c Spatial distribution of heavy metals in the sediment; and d Spatial distribution of heavy metals in seaweed

Several algal species are widely used as bio-indicators of metal contamination in various parts of the world (Campanella et al. 2001). The results of the present study provided estimates on the range of lead and chromium values in the algae under investigation. The values recorded for lead in *Cystoseira compressa* taken from the uncontaminated site 3 ranged between 0 and 0.3 mg kg−1 dry weight, where as the lead values recorded at the heavily contaminated site 1 and site 2 varied between 2.6 and 5.1 mg kg−1 dry weight. These results on the levels of lead stored in *Cystoseira compressa* indicated that while cove Koali was only slightly contaminated by lead, sites 1 and 2 were heavily polluted by lead. The ranges of mean concentrations of chromium measured in *Cystoseira compressa*, from noncontaminated sites, were 0.1 to 0.5 mg kg−1 dry weight, and those from polluted sites ranged from 1.1 to 1.9 mg kg−1 dry weight. According to the data described in previous reports (Morgan et al. 2003; Shiber and Washburn 1979), particularly for the Cd, Cu, Fe, Mn and Zn metal contents, and using these new values as a guide, it became clear that most stations in the city of Boulsmaïl can be considered as having high levels of contamination and, hence, severe pollution by metal trace element (ETM). The significant levels of cadmium obtained in the algae collected could be attributed to the abundance of this metal in the industrial effluent emissions (Kaimoussi et al. 2002, 2004). Although the content of metals in algae was subject to large variations, a trend towards higher levels of mercury than other metals was observed along the coast of the town of Boulsmaïl, which is in agreement with previous studies using algae. While
several studies reported on seasonal variations of heavy metals in algae, other studies reported on the absence of such variations (Benguedda et al. 2011). Among the studied species, *Cystoseira compressa* was noted to vary significantly during the period of sampling, with each species showing a specific metal variation model.

Conclusions

The results obtained in the study of bioaccumulation, and bio-monitoring of metals by the brown seaweed Cystoseiracompressa led to the following conclusions: *Cystoseira compressa* is a heavy metal bioaccumulative and tolerant bioindicator of heavy metal pollution. The algae showed high levels of tolerance in increased ETM at the two sites (the desalination and industrial waste station) which were noted to be relatively polluted. The analysis of the sediments showed the presence of high heavy metal contents at sites 1 and 2. Overall, the accumulation in algae was more intense than in sediments.