METALS IN THE MEDITERRANEAN SEA AND MEASUREMENT OF ORGANISMS' HEALTH CONDITION

Francesco Regoli
Istituto di Biologia e Genetica, Università Politecnica delle Marche, via Ranieri Monte Dago, 60131 Ancona, Italy - f.regoli@univpm.it

Abstract
Marine organisms are widely used in the Mediterranean for monitoring the presence, diffusion and deleterious effects of trace metals of both natural and anthropogenic origin. Different species can be used as bioindicators and the integration of chemical analyses with ecotoxicological responses allows a better assessment of environmental condition. Such an approach is particularly useful in industrialized areas, for management of harbour activities and to evaluate the impact of off-shore exploitation.
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Investigations on trace metals in the Mediterranean Sea are a matter of growing importance for a better assessment of chemical fluxes, anthropogenic impacts and environmental health perspectives. Mediterranean surface waters contain higher basal concentrations of metals compared to those of the open Atlantic, a feature partly related to the oligotrophic, nutrient-depleted conditions of this semi-enclosed basin, but also to the inflow of Altlantic metal-enriched waters through the Strait of Gibraltar [1]. However, direct inputs represent the major source for trace metals in Mediterranean sediments and biota, with highly different situations according to environmental conditions, the origin, kind and duration of the exposure.

Among the natural sources, the geological anomaly of mercury in the Northern Tyrrhenian Sea is responsible for an elevated accumulation of this element by marine organisms and a consequent biomagnification in food webs; in this respect, Mediterranean top predators (i.e. sharks, swordfish and tuna fish) are characterized by significantly higher tissue concentrations of mercury compared to Atlantic counterparts [2].

The Mediterranean coastline is also exposed to a marked human pressure, being highly populated and subjected to increasing tourism, industries, agriculture, fishery, aquaculture, shipping and harbour activities, to cite only a few. Due to the spatial and temporal heterogeneity of such anthropogenic impacts, it is not possible to generalize the environmental condition in the Mediterranean where pristine environments can be very close to highly polluted sites. Marine organisms are widely used to assess the presence and deleterious effects of chemical pollutants and several species have been characterized for their capability to accumulate both organic and inorganic compounds. The choice of the more appropriate sentinel species depends on the aim of the investigations, with examples reported for algae and plants, sponges, bivalves, gastropods, polychaetes, crustaceans and fish [3]. The utility to integrate chemical analyses with molecular, biochemical and cellular biomarkers has been validated in different environmental conditions, including management and remediation of highly polluted petrol-chemical sites, monitoring of harbours during dredging operations, off-shore activities, oil-spills and accidental releases, sustainable use and protection of coastal environments [4-6].

As examples of ongoing applications, we used various organisms as bioindicators in an industrial site. Besides chemical measurements, mussels (both native and translocated), and various fish species (with different feeding habits and trophic positions) were analysed for a wide spectrum of cellular biomarkers, i.e. specific detoxification systems (cytochrome P450, metallothioneins, peroxisomal proliferation, acetylcholinesterase activity), lysosomal destabilization, oxyradical metabolism and antioxidants, oxidative damages and genotoxic effects. An extremely critical environmental condition was demonstrated with the highest mercury concentrations ever measured in Mediterranean organisms, independently of size, diet and trophic position. Contamination was particularly marked in the proximity of a chloro-alkali plant and analyses of biomarkers allowed to reveal also the exposure to hexachlorobenzene. Two years after the closure of the chemical plant, Hg bioavailability was still elevated, but with different effects in mussels and fish according to the feeding strategy [4].

Another hot issue in the Mediterranean is the management of harbour activities which have a great socio-economic importance, but also represent a major environmental concern as potential sources of chemical contamination. In the last ten years, the intensive dredging operations in harbour areas made it necessary to biomonitor both diffusion of contaminants and biological effects in marine organisms. In this respect, mussels are currently used through active caging procedures, carried out before, during and after the dredging and disposal activities; the combined use of chemical analyses and biomarkers allows to characterize differently impacted areas within the harbour basins, generally revealing a complex temporal variability of such disturbance related to the interaction of environmental, anthropogenic and biological factors. A recent investigation in the harbour of Piombino demonstrated that bioaccumulation of trace metals and polycyclic aromatic hydrocarbons significantly increased with the beginning of dredging operations, causing also marked biological alterations in caged mussels; after the end of such activities bioavailability of trace metals showed a different temporal trend compared to PAHs, and the biological disturbance still remained evident [5-6].

A monitoring protocol with caged mussels has been developed also to evaluate the potential impact of off-shore activities and waters discharged in the Adriatic Sea. Native mussels are seasonally collected from a reference site and transplanted to the investigated platforms. Bioaccumulation of trace metals (As, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Zn) in mussel tissues is integrated in a multimarker approach for the early detection of biological responses at several cellular targets. Chemical analyses generally revealed increased levels of Cd and Zn and only limited variations for other elements, partly related to natural fluctuations. Among the biological responses, some antioxidants and lysosomal stability were confirmed as sensitive early warning signals of environmental disturbance, although the overall results allowed to exclude marked biological effects by off-shore activities in the Adriatic Sea [5].

The presented protocols, integrating chemical analyses with a wide array of biological responses in marine organisms, seem to offer a useful and realistic approach for monitoring both the presence and the impact of trace metals and other contaminants in the Mediterranean.

References

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