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The Use of Mussels in Environmental Toxicology

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Editorial
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Editorial

The continuous global increasing in terms of industrialization and urbanization has produced a severe impact in various environments and related biota. Hence, the anthropogenic activities are to blame for the release of high pollution levels into various environmental compartments (soil, air, and water). Particularly among the aquatic environments, the marine coastal areas, like the harbours, suffer the harmful effects of this continuous discharge of toxic compounds. In these enclosed areas, the constant pollutant emission leads to a reduction of water quality, with low level of oxygen and biodiversity [1]. Therefore the measurement of the various pollutants effects and the development of related remediation strategies for these impacted sites become fundamental tasks for the international environmental risk management [2]. In this scenario, the purpose of a multidisciplinary scientific field, like the environmental toxicology, is to assess the effect of potential harmful agents (biological, chemical, physical), often revealed in the various environmental media (soil, air, water) on living organisms [3].

In several ecotoxicological studies, different species were employed to investigate the impact of various contaminants detected in marine environment. The list of employed species comprise fishes [4-6], invertebrates like echinoderms [7,8] and polychaetes [9], as well as huge cetaceans like whales [10]. All these research emphasized the tendency of several pollutants to cause significant alteration in the various biological processes, weakening the health and survival rate of the biota.

Among the organisms already mentioned, the mussels (Mollusca, Bivalvia) represent surely ones of the most widely applied species in the environmental toxicology [2,11], since they exhibit most of the main features of bioindicators, e.g. global spread, good knowledge of their biology, easy to collect and high sensitivity to stress condition [11-13]. Mussels, which include both freshwater and saltwater species, are small invertebrates with two shells called valves and a basic and well-known anatomy [14]. Due their filter-feeding habits, they can easily interact with every kind of chemical compound dissolved in the water, even in low concentrations. As confirmed by different authors [15-17] the bioaccumulation of harmful compound in the various tissues is common in these species. Moreover, they are sessile organism with a wide diffusion throughout the different geographies, and as a result, they may be employed on a worldwide scale to assess the environmental situation of specific points in areas affected by anthropogenic pollution [13]. For all these reasons, they are widely used in biomonitoring programs, guaranteeing the increase of knowledge regarding the biological alterations induced by the harmful stressors, detectable in the polluted areas [18-21]. Furthermore, because of their small size and low biological complexity, they may be easily housed for laboratory studies. The use of acclimated mussels in laboratory tests allows to gather more information about specific stressful conditions, both biotic and abiotic. In these experimental conditions, it was possible to estimate the impact of different abiotic stress, such as chemical compounds or particles [16,22-24], changes in the level of oxygen, temperature and salinity [25-29] but also biotic stress, like the exposure to bacteria [30-32]. The easiness with which they may be maintained under controlled condition, like tanks or aquaria, allows their use for more particular and elaborate experiments. Hence several authors [33-36] used the mussels to assess the efficacy of recovery strategies against petrochemical pollutant by mesocosm scale-up experiments. In general, a mesocosm is an experimental setup that may integrate the complexity of an environmental experiment with the controllability given by a laboratory setting [37]. The biological responses in mussels, elicited by the experimental conditions reproduced in the mesocosms, allow to provide useful information for optimizing recovery methods against polluted areas. The use of mussels under the aforementioned conditions demonstrates their applicability in the different environmental research fields.

The variety of pollutants in the natural environment is able to elicit a wide range of reactions in the species. Therefore it is important to assess this plethora of biological responses (biomarker) to better elucidate the real impact on the various biological processes [38].

In all the several experimental conditions adopted, it was demonstrated how the different stress conditions may cause disparate types of alterations in the mussels, which can be detected using a multi-biomarker approach. As just observed in various research [6,9,39], the ability of pollutants to provoke several morphological alterations in the aquatic organisms is a very common effect as much as the tissue morphology assay became a standard endpoint in the environmental toxicology, widely applied also on mussels [1,20]. In these species, exposure to various kinds of contaminants is able to induce significant impairment in different important tissues, like gills [1,20,23,40], digestive gland [19,36,41-44] or gonad [24,45-56]. The tissue injury in mussels are revealable by histological [20,30] and ultrastructure [36,42] analysis.

In several cases, histological impairments have often associated with functional alterations. The gills, for example, perform a wide range of activities (gas exchange, osmoregulation, uptake of nutrients), which are regulated by a neurotransmission system (serotoninergic and cholinergic) [18,17]. In the cholinergic system, the acetylcholinesterase (AChE) is a key enzyme [48] in the neuronal signalling. Its activity, measurable by spectrophotometric analysis, can be influenced by various classes of pollutant, as observed in several aquatic species [5,9,49] and in different species of bivalves [20,22,50-53]. The AChE assay proved to be a useful endpoint for evaluating the neurotoxicity of several environmental contaminants. In regards to the gonads, the tissue impairments can be induced by some classes of pollutants, such as the endocrine disrupting compounds (EDCs). The EDCs can affect the reproductive activity at several levels, such as gonad maturation and gamete development [54]. In regards to this final point, mussel gonads, like those of other aquatic animals [55,56], may be used to assess the impact of the environmental challenges on reproduction [45,57].

The stress conditions can harm biota reproductive activities by affecting also the embryonic development. Hence compared to adults, aquatic species in their early life stages are more sensitive to stressors [58], resulting in a decrease of the biota survival rate [39]. Although in embryotoxicity tests fishes, in particular zebrafish (*Danio rerio*), are the wide used species [59-61], the use of mussels [62-66] provides a viable option in this specific field of the environmental toxicology.

It is well known how exposure to environmental challenges can provoke the rise of reactive oxygen species (ROS) and oxidative stress in the aquatic organisms [67,68]. Therefore the assay of the antioxidant activity for mitigating this stress condition has become an extremely common endpoint in the ecotoxicology [9,69-71]. Also, in mussels changes in the antioxidant enzymes activities (catalase, glutathione peroxidase, superoxide dismutase and glutathione *S*-transferase) can be revealed by using spectrophotometric techniques. The use of these approach permit to enlarge the knowledge regarding the pro-oxidant effect of several contaminants [22,72-75] in an aquatic organism model like the mussel.

Other common targets for the stressors in biological systems can be the gene and protein expression [76]. The use of PCR technique and western blotting permit to estimate the gene transcription and protein synthesis in different aquatic species, exposed to chemical compounds [7,39,77-79]. Also the various biological pathways in mussels, exposed to various types of biotic and abiotic stress [20,25,26,30,35,57,80,81] showed a good susceptibility in terms of gene and protein expression.

As aforementioned, the responses to external factors can be extremely complex, involving multiple metabolic pathways [38]. The use of "-omics" methodologies such as proteomics, transcriptomics, and metabolomics facilitated the development of the "systems biology," which can investigate numerous biological processes as interconnected and interactive systems [82,83]. In particular, metabolomics, based on the study of endogenous, low molecular weight metabolites (<1000 Da), is one of the pivotal technique for the application of the "systems biology" in the environmental toxicology [84]. The use of protonic nuclear magnetic resonance spectroscopy (^{1}H-NMR) permit to successfully investigate the alteration of metabolomic profiles in several aquatic organisms exposed to different environmental challenges [6,85-88]. In mussels, NMR-based metabolomics proven to be a very sensitive tool analysing the baseline levels of metabolites in various tissues, both qualitatively and quantitatively [85]. In ecotoxicology, ^{1}H-NMR has undoubtedly contributed to further elucidating the impacts of pollutants on the metabolic profile recorded on these bivalves used in various experimental plans. Hence, metabolomics was successfully employed on mussels in biomonitoring programmes [1,18,89], under controlled

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laboratory condition during exposure to various stress condition [16,54,90,91] and in mesocosm experiment [35,36,92].

In light of the wide range of experimental approaches and methods of investigation used on this species, mussels have proven to be excellent organisms in the field of environmental toxicology. Thus, it is reasonable to expect in the future their further employment in this area of research in order to continue contributing significantly to the understanding of the environmental impact of various anthropogenic stressors in aquatic invertebrates.

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