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Short communication: PHYSIOLOGICAL RESPONSE OF MARINE ORGANISMS TO POLYCYCLIC AROMATIC HYDROCARBONS POLLUTION AS USEFUL TOOLS FOR BIOMONITORING

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ABSTRACT

The continuous development of oil exploration and exploitation leads to the need to highlight the early effects of hydrocarbons, especially polycyclic aromatic hydrocarbons on marine organisms. In this regard, there are worldwide biomonitoring programs that aim to assess the effects of polycyclic aromatic hydrocarbons.

The physiological response of marine organisms is investigated both at functionally (reproductive, respiratory, cardiovascular and neurological disorders), tissular, cellular and molecular levels (histopathological evaluation, DNA damage, cytochrome P4501A, ethoxy resorufin-O-deethylase (EROD)). This paper reviews the changes induced by polycyclic aromatic hydrocarbons in marine organisms and their potential to be used as suitable biomarkers to assess the health of aquatic ecosystems.

Key-Words: biomonitoring, physiological response, polycyclic aromatic hydrocarbons, marine organisms, sea water

AIMS AND BACKGROUND

Millions of tons of oil are spilled in aquatic environments every decade, and this oil has the potential to greatly impact marine populations. Spilled oil may sink using a diffusion process or as bulky fractions or may be driven coastward. The continuous development of oil exploration and exploitation leads to the need to highlight the early effects of hydrocarbons, especially polycyclic aromatic hydrocarbons on marine organisms. Therefore, the assessment of the consequences of oil pollution in the Black Sea, especially in its coastal waters, is an important issue for the ecological status of the marine ecosystem.

RESULTS AND DISCUSSION

In order to perform this evaluation, the literature has been studied and the advantages and disadvantages of using PAHs-induced physiological responses in marine organisms have been analyzed. Polycyclic aromatic hydrocarbons (PAHs) are a class of organic compounds containing two or more fused benzene rings with various structural configurations (Prabhu and Phale, 2003), where the rings could be in linear, angular, or clustered arrangements (Lundestedt, 2003). PAHs are lipophilic, have low vapor pressure and low water solubility, as well as high melting and boiling points (Skupinska *et al.,* 2004).

Concentrations of PAHs in the aquatic environment are generally highest in sediment, intermediate in biota and lowest in the water column (Canadian Council of Ministers of the Environment (CCME) 1999, 2008). They accumulate in sediments because they tend to be absorbed by the particulate matter that settle at the bottom of aquatic ecosystems (Juhasz and Naidu, 2000; Perelo, 2010) and are often encountered in more significant concentrations in water bodies close to point sources of contamination (Juhasz and Naidu, 2000). When dissolved in the aquatic environment, PAHs can have the ability to bioaccumulate, bio magnify and can disrupt normal physiological functions to living organisms and ecosystems.

One of the most relevant considerations for bioaccumulation of PAHs in aquatic species is the amount of accumulated PAHs that is efficiently metabolized. For species that have the capacity to efficiently metabolize PAHs, they may accumulate large amounts of PAHs compounds, exhibit effects, but not contain measurable levels of the parent compounds, therefore simply measurement of PAHs levels is not relevant for estimating the pollution level. Mutagenic metabolites may however be formed, which may be more toxic than the parent compounds (Meador, 2008).

PAHs have great potential to bind to cellular proteins and DNA, often generating toxic effects. The resulting biochemical disruption and cell damage can lead to mutations, developmental malformations, tumors, and cancer (Kim *et al.,* 2013). They can act as endocrine disruptors (ED) by mimicking or antagonizing the action of hormones that occur naturally, thereby impacting the regulation of vital life processes, including development, growth, metabolism, and reproduction (Pittinger *et al.,* 1987; Hellou *et al.,* 2006; Roldán-Wong *et al.,* 2020; Pulster *et al.,* 2019).

The absorption, distribution and toxicity of PAHs depend on several factors, including the species, route of exposure and physicochemical characteristics (CCME 1999; Ramesh *et al.,* 2004).

Biomonitoring or biological monitoring can be defined as the systematic use of biological responses to assess changes in the environment. The physiological response of marine organisms is investigated both at functionally, tissular, cellular and molecular levels. Immediately as a chemical enters the body of an organism, physiological and biochemical responses are triggered. The organism could show resistance to these aggressors or could be poisoned. Within these responses, irreversible biochemical changes are the most critical in the body of organisms. Biochemical parameters used as biomarkers are those involved in metabolism pathways or cell functions.

Globally, many studies have examined the effects of PAHs on aquatic organisms (Varanasi *et al.,* 1989; Harvey, 1997; Beasley and Kneale, 2002; Grotte *et al.,* 2005; Hellou *et al.,* 2006; Hjorth *et al.,* 2007; Petersen *et al.,* 2008).

To assess the polycyclic aromatic hydrocarbons (PAHs), on the marine ecosystem a suite of biomarkers is being extensively used worldwide. These biomarkers are being used to evaluate exposure of various species of sentinel marine organisms (mussels, clams, oysters, snails, fishes, etc.) to and the effect of various contaminants using different molecular approaches [biochemical assays, enzyme linked immuno-sorbent assays (ELISA), spectrophotometric, fluorometric measurement, differential pulsed polarography, liquid chromatography, atomic absorption spectrometry].

Biochemical and physiological parameters are used as biomarkers for contaminants and could be applied to evaluate environmental stress and its effects on aquatic organisms.

A biomarker can be defined as „*the measurements of body fluids, cells, or tissues that indicate in biochemical or cellular terms the presence of contaminants or the magnitude of the host response*„ (Bodin *et al.,* 2004). Biomarkers can be any measurable biomolecules that provide early warning signs of an individual imbalance resulting from exposure to a xenobiotic (Martyniuk *et al.,* 2019; Colin *et al.,* 2016).

Biomarkers at the biochemical level can provide information on the qualitative and quantitative relationships between pollutant exposure and biological responses, and some of them can predict responses at higher levels of biological organization (Hyne and Maher, 2003; Seabra Pereira *et al*., 2014). Such early warnings of marine pollution are extremely important, as early detection will allow corrective measures to be undertaken, avoiding irreversible effects on the entire ecosystem.

Among biomarkers associated with exposure to PAHs, cytochrome P4501A enzyme induction (EROD activity), lysosomal stability, DNA integrity, liver histopathology received special attention for biomonitoring of ecotoxicological impact of PAHs. Also, studies reflect that the oil pollution of marine environment induces multiplicative stress in marine organisms and is accompanied with the generation of ROS (reactive oxygen species). The most used biomarkers for oxidative stress are superoxide dismutase (SOD), catalase (CAT), peroxidase (PER), and glutathione reductase (GR).

Antioxidant enzymes are known as adequate biomarkers for oxidative stress induced by many unfavorable factors. Antioxidant enzyme activities in various tissues and organs of aquatic organisms and their changes are good biomarkers for the organism status in the unfavorable living conditions, and they are used successfully as tools for biomonitoring.

Histologic biomarkers have been extensively used in fish to detect and monitor environmental pollution (Rabitto *et al.*, 2005; Mela *et al.*, 2007). Melano-macrophage centers are pigment-containing cells found only in fish, amphibian, and reptiles (Arciuli *et al.*, 2015). Previous studies have shown that these centers increase in size or frequency in conditions of environmental stress and are considered as reliable biomarkers for water chemical pollution and fish health status (Agius and Roberts, 2003).

Biomarkers are influenced by natural environmental factors such as temperature, salinity, oxygen tension, trophic status as well as size, age, and reproductive condition of the sentinel organisms (Hagger *et al.,* 2006; Holmstrup *et al.*, 2010). It is necessary to establish the range of normal values in sentinel species. In consequence, the use of biomarkers involves the necessity of a better knowledge of their seasonal and natural variability.

Biomarkers of environmental contamination by PAHs in fish seem to vary with species, habitat and environment and are often contradictory (Aguilar *et al*., 2020). Therefore, they need to be species and region-specific to be efficient, especially to detect an impact on species with restricted geographic distribution (Aguilar *et al.,* 2020).

Due to their filter-feeding nature and low enzyme activities, mussels accumulate hydrophobic pollutants in their tissues at considerably high levels so, local mussels give information about the pollution status of a certain site. On the other hand, there was no clear relationship found between the enzyme levels (ethoxy resorufin-O-deethylase, glutathione S-transferase, glutathione reductase) and the pollutant concentrations in mussels. In consequence, integrated biomarker responses were calculated to interpret the overall effect of pollutants (Brooks *et al.,* 2010).

CONCLUSIONS

Monitoring the effects of environmental pollutants on the biota is important since it can demonstrate links between contamination and effects at several levels of biological organization. The use of biomarkers measured at the molecular and cellular level is of great importance as sensitive ‘early warning’ tools for biological effect measurement in environmental quality assessment. The use of biomarkers involves the necessity of a better knowledge of their seasonal and natural variability.

The choice of organism used for biomonitoring is very important. For instance, biomarkers of environmental contamination by PAHs in fish need to be species and region-specific to be efficient. Integrated biomarker responses may be useful to interpret the overall effect of pollutants.

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