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An ecotoxicological analysis of the sediment quality in a European Atlantic harbor emphasizes the current limitations of the Water Framework Directive

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ABSTRACT

The “PortoNovo” project was developed to standardize the methodologies for water quality management in the port areas of coastal Atlantic regions to improve the Water Frame Directive (WFD) for these specific water bodies. Under this scope, water and sediment samples were collected from five sites within the Port of Aveiro, Portugal. According to the physical and chemical parameters that were analyzed (i.e., metals, total organic carbon, polychlorinated biphenyls and polycyclic aromatic hydrocarbons), the sediments were not considered at risk based on European sediment quality laws. However, the bioassays that were performed on the sediment samples (Microtox®) and the standardized acute toxicity test using the marine rotifer, *Brachionus plicatilis*, on sediment elutriates revealed higher toxicity levels. The use of bioassays to assess sediment quality clearly complements more conservative approaches and highlights current gaps within the WFD. The approach presented here can be easily transferred to other port areas for more reliable water quality management.

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1. Introduction

Coastal port areas have a massive economic and social impact on society because marine transportation is extremely valuable for network and cargo distribution. However, environmental protection should not be disregarded, and the sustainable exploitation of these coastal areas must be clearly considered. Port pollution is, indeed, a concern that has been and remains under discussion and evaluation. These discussions focus on the main activities and sources that are responsible for pollution, policies and recommendations (Goulielmos, 2000; Bailey and Solomon, 2004; Darbra et al., 2009). Currently, there is an urgent need to improve environmental data monitoring techniques because the implementation of continuous monitoring programs is crucial for understanding the environmental impacts of port activities (Darbra et al., 2009). Ports are bordered by huge water bodies, such as oceans, rivers and estuaries, and the water quality of these areas is one of the main environmental concerns for their sustainable operation.

According to the European Water Framework Directive (WFD) (Council Directive 2000/60/EC), these water bodies are classified as heavily modified water bodies (HMWB) because they continuously suffer from severe physical and chemical modifications due to anthropogenic activities. The directive establishes a framework

for the protection of surficial and ground waters. Its main objective is to achieve a ‘good ecological status’ for all European water bodies until 2015 (Council Directive 2000/60/EC; Borja et al., 2006), with the exception of HMWB, where the ecological status assessment is based on achieving a ‘good ecological potential’ (Council Directive 2000/60/EC; Borja and Elliott, 2007).

One of the issues that deserves special attention in evaluating the water quality of aquatic systems is the interaction of heavy metals and other potential hazards with the sediment (DelValls et al., 1998). The sediment is a depository compartment that can absorb and release contaminants and influence the overlying water and its quality (Valdés et al., 2005; Alagarsamy, 2006). In addition, there are several organisms that inhabit this compartment, play an important role in environmental processes and may display social and/or economic value. These organisms can be negatively affected by the interactions between the sediment and the water column (Quintino et al., 1995). The accumulation, distribution and increase in contamination in sediments are predominantly influenced by anthropogenic activities (Huang and Lin, 2003; Chen et al., 2007). Port areas are rich in industrial and naval activities, and several contaminants, such as metals, PCBs and PAHs, are known to be present in ports worldwide (Birch and Taylor, 1999; Chen et al., 2007; Jones et al., 2005; Morillo et al., 2004). In fact, high concentrations of PAHs in the environment are mainly a consequence of anthropogenic sources, such as industrial and domestic wastes or petroleum handling (Boonyatumanond et al., 2006; Soclo et al., 2000). Metals are also continuously introduced in industrialized coastal and estuarine regions through anthropogenic actions (Zhang et al., 2007).

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Therefore, port areas are excellent locations to monitor these human impacts on the environment (Fatoki and Mathabatha, 2001).

This research was developed under the scope of the European project PortoNovo – “Water Quality in Harbors”, the goal of which is to standardize the methodologies used to manage water quality in port areas of the north-eastern Atlantic and to help improve and implement the WFD for these specific water bodies (HMWB). The PortoNovo project involved different universities and institutions, as well as the collaboration of ports from six European countries: Portugal, Spain, France, Ireland and the United Kingdom. Previous studies have also addressed the development of methodologies to evaluate risk assessment in harbors in an attempt to achieve sustainable development of these areas, including the following two projects. (1) The Ecoport project, “Towards A Sustainable Transport Network”, was developed by the Valencia Port Authority and conducted at the Valencia Port (Peris-Mora et al., 2005) with the objective of designing a system of sustainable management indicators for further application in other ports in Spain and Europe. Port activities were analyzed, and seventeen environmental indicators and their potential environmental impacts were identified (e.g., inner port water quality, which considers spills or leaks from the transfer of oil products and bulk liquids from vessel

to lorry). (2) The Pearl project’s (“Port Environmental Information Collector”) main results were described in an investigation by Darbra et al. (2009), based on data collected from 26 European ports, to underscore the importance of environmental monitoring and support the development of a port environmental management system. Thus, so far, an ecotoxicological approach has not been considered when evaluating the water and sediment quality that results from environmental management activities in areas under port jurisdiction. Nonetheless, there are several studies addressing the environmental status of marine/estuarine environments based on ecotoxicological bioassays that clearly indicate the relevance of this type of approach (Costa et al., 1998; Nendza, 2002; Narracci et al., 2009).

Within the PortoNovo project and with the goal of implementing an ecotoxicological approach to evaluate water and sediment quality in ports, a collaboration was initiated with the port of Aveiro to improve the WFD for these specific water bodies (HMWB). A biomonitoring campaign was formed in August 2010 to establish and implement reproducible and standardized bioassays to determine the environmental quality status of areas under port jurisdiction, with possible applications for the WFD. To achieve this goal, two standardized bioassays were used: the Microtox® bioassay,

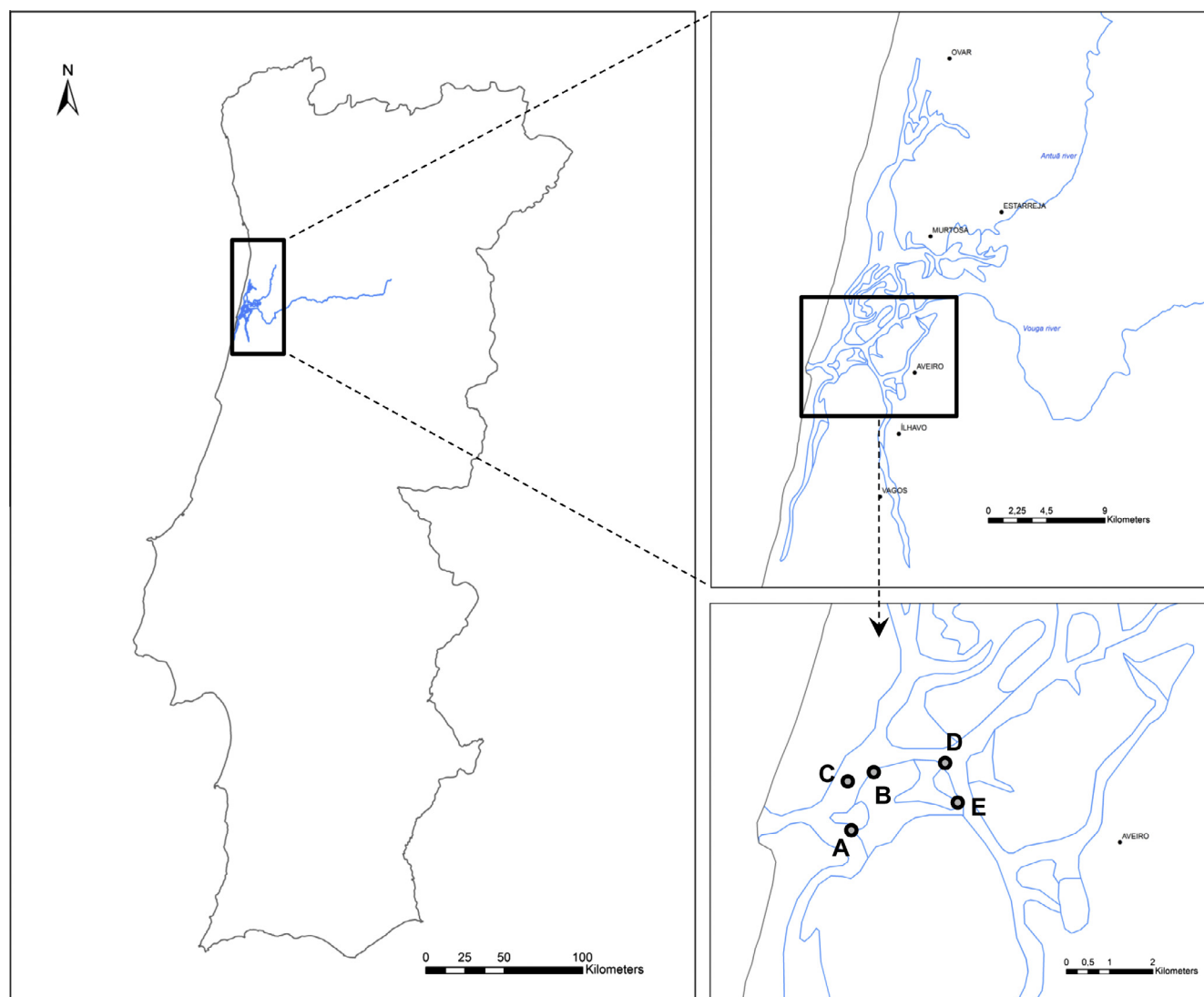


Fig. 1. Ria de Aveiro with the five sampling sites monitored in the Port of Aveiro area: A – Multipurpose North Terminal; B – Liquid Bulk Terminal; C – São Jacinto Bay (reference site); D – Liquid Bulk Terminal; E – Distant Fisheries Port.

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