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Ecological quality assessment of estuarine macrobenthic communities using an integrative approach

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ABSTRACT

Macrobenthic communities play a crucial role in the functioning of estuarine ecosystems and serve as bio-indicators of environmental quality. This study assessed the ecological quality of an estuarine system using the AMBI and M-AMBI indices. The following parameters were considered: (i) environmental factors (total organic matter, organic carbon, grain size, calcium carbonate), (ii) sediment trace metals (Pb, Zn, Cu, Cr, Co, Ni, Hg, Li, As), (iii) species composition (morphological and molecular identification), and (iv) anthropogenic activities. The results demonstrated notable differences between study areas, reflecting hydrodynamic processes and human activities. The AMBI index indicated that all areas exhibited conditions classified as "slightly disturbed." However, the composition of the ecological groups and M-AMBI results differed according to the identification method. This approach allowed for a more complete understanding of communities, by integrating the influence of anthropogenic activities on the sediment and macrobenthic communities, highlighting the importance of using both identification methodologies.

1. Introduction

Anthropogenic activities have increasingly degraded water and marine ecosystems, presenting a major challenge for our society. Estuaries represent complex environments, harbouring biodiversity while supporting human activities, such as, housing, manufacturing, maritime trade and fishing (Kennish, 2016; Snelgrove, 1999; Snelgrove et al., 1997). These activities often conflict with biodiversity conservation, leading to environmental degradation (Kennish, 1992; Gaston et al., 1998; Chapman and Wang, 2001; Cardoso et al., 2012; Mil-Homens et al., 2014; Cuevas et al., 2018). Monitoring these activities impacts is essential for diagnosing ecosystem degradation and implementing effective environmental management measures (Caeiro et al., 2017; Freitas et al., 2008; Goulding et al., 2021).

The Sado Estuary, located on the west coast of Portugal, is one of the largest estuaries areas in Europe and the second largest in Portugal. The northern part of the estuary contains an industry belt with pollution sources such as pulp and paper production, pesticides, fertilizers, aquacultures, and shipyards (Caeiro et al., 2005). This industrial activity subjects the northern area to significant environmental pressures, affecting local biodiversity (Freitas et al., 2008). Conversely, the southern part is characterized by intensive agriculture, such as rice fields and traditional salt pans, alongside aquaculture (Caeiro et al., 2005; Pereira et al., 2000). The hydrodynamics of the Sado estuary promotes sediment accumulation, leading to the persistence of contaminants such as trace metals, acting as both a sink and a source of pollution (Mil-Homens et al., 2014; Piló et al., 2016). These contaminants originate from effluents, runoff, leachates, industrial and agricultural activities, as

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