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Screening ecological risk assessment for the benthic community in the Venice lagoon (Italy)

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Abstract

According to the risk hypothesis: the sediment as source of potential risk for the benthic community, an Ecological Risk Assessment (ERA) based on the quotient method was undertaken. The exposure of the benthic community to different classes of pollutants (metals, chlorinated organic compounds and polynuclear aromatic hydrocarbons) was inferred by estimating the pollutant stocks in the top 15-cm sediment of the whole Venice lagoon, after application of geostatistic techniques. The risk was calculated by comparing the sediment exposure profiles with the ecotoxicological benchmarks for benthic organisms. Kriging based maps of the spatial distribution of the estimated risk for the benthic community over the whole lagoon were obtained. The highest risk, found in the areas nearest to the sources of contamination (e.g., the industrial district of Porto Marghera and the river mouths), was posed by mercury (40% of the sampling stations showed exposure levels higher than the Probable Effect Level), arsenic and nickel (75% of the sampling stations exceeded the Threshold Effect Level).

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1. Introduction

Ecological Risk Assessment (ERA) is a process used for organising and analysing data, information, assumptions, and uncertainties in order to evaluate the likelihood of adverse ecological effects (Risk Assessment Forum, 1992; Suter, 1993). The ERA procedure applied in this work was developed by the U.S. Environmental Protection Agency (Risk Assessment Forum, 1998) on the basis of the risk analysis guidelines defined by the US. National Academy of Sciences (National Research Council, 1983). This procedure was recognised by the Society of Environmental Toxicology and Chemistry (Ingersoll et al., 1997) and adopted by the international scientific community. It consists of three phases. During the Problem Formulation phase, the risk hypotheses are defined, the assessment endpoints (i.e., the environmental values to be protected) are selected and the conceptual model is created. During the Analysis phase, the exposure conditions and effects are characterised regarding each assessment endpoint. Finally, in the Risk Characterisation phase, a quantitative risk estimation is achieved by combining the exposure evaluation with the effect characterisation.

Ecological Risk Assessment provides environmental decision making support by considering the available scientific information, together with the other factors required (e.g., social, legal, political, or economic) in the selection of a course of action (Risk Assessment Forum, 1998). To this purpose, it is important to achieve a clear understanding and communication of the risks involved for decision makers and stakeholders (Sadar and Shull, 2000). The ERA should therefore be integrated with tools for the spatial elaboration of the experimental data, as well as for the visualisation of the results using thematic maps. Moreover, the spatial elaboration and representation of the data becomes of the utmost importance when managing large geographic areas.

The main objective of the present work was to apply a screening ERA approach to the Venice lagoon. Because of its critical role in the contaminant biomagnification process

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through the trophic chain as well as its direct exposure to the sediment, the benthic community was considered as an assessment endpoint. According to the quotient method proposed by Jones et al. (1999), the ERA was performed by comparing the exposure to sediment contamination with the standard toxicological benchmarks, which subsequently led to a screening ERA.

The second objective was to include in the ERA procedure (Risk Assessment Forum, 1998) the application of the geostatistic techniques and GIS (Geographic Information System) tools, in order to: assess the lagoon benthic organisms' exposure to sediment contaminants estimating the pollutant stock in the top 15 cm of the lagoon sediment (based on a geostatistic analysis of the experimental data); map a preliminary ecological risk index for the benthic community (based on the exposure of the organism to contaminants and contaminant toxicity), which allowed to select the index contaminants (Chemical of Potential Ecological Concern, COPEC) and the reference areas to be considered in a subsequent baseline risk assessment.

1.1. Study area

The Venice lagoon (ca. 550 km^2 wide) is a delicate and fragile transition habitat (ecotone) made up of a great variety of natural environments. This fundamental ecological diversity is threatened continuously by anthropogenic activities. Especially in the course of the last century, major man-made transformations took place: large chemical and metallurgic industrial plants were established at the edge of the lagoon (the Porto Marghera industrial district); a deep canal (Canale dei Petroli) was dug across the lagoon to serve the industrial district; the lagoon outlets were deepened. The most significant effects of these transformations were an increase in pollution and erosion, and a drastic impact on the lagoon ecosystem.

Large amounts of pollutants were discharged into the lagoon and, to a significant extent, accumulated in the sediment. The principal primary contaminant sources were the treated and untreated industrial and municipal effluents, as well as the riverine freshwaters conveyed into the lagoon by rivers containing industrial and municipal sewage, together with the agricultural runoff from a drainage area of approximately 1850 km^2. Nowadays, the surface sediment appears to be the main secondary source of contaminants for the ecosystem.

Sediment pollution represents a potential risk for the benthic and fish communities, whether through direct exposure (e.g., dermal contact and ingestion of water and particulate) or bioaccumulation processes. Moreover, the

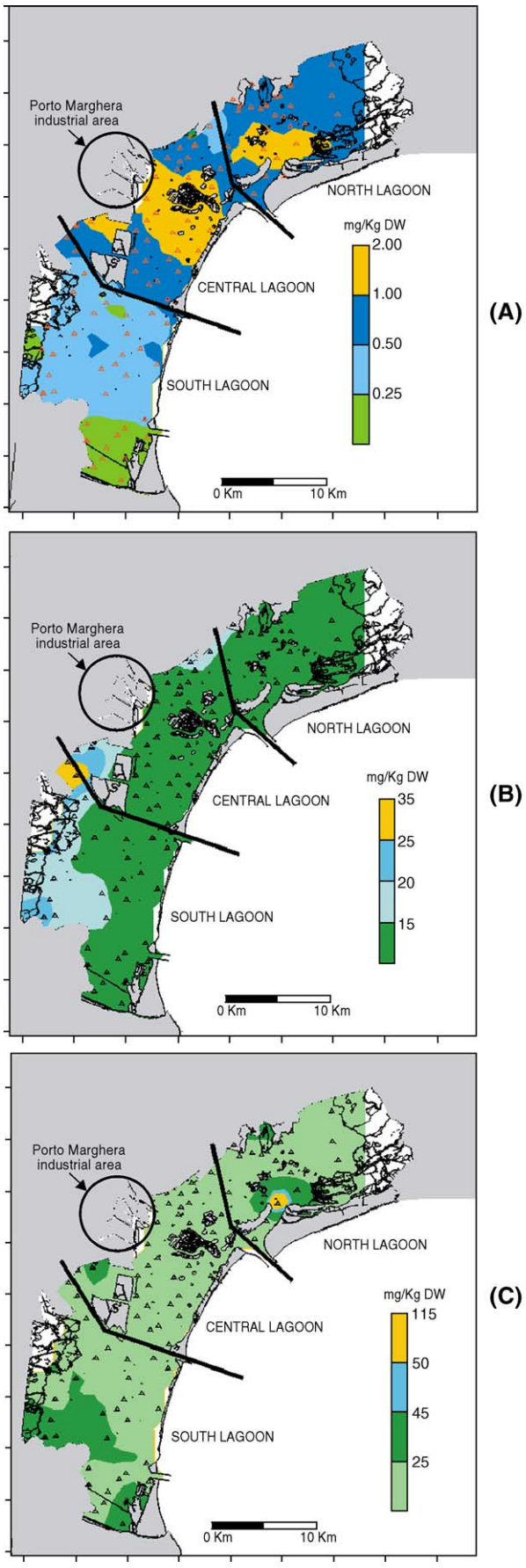

Fig. 1. Kriging interpolation map of mercury (A), arsenic (B) and nickel (C) concentrations in the surface sediment, namely sediment exposure map (DW: dry weight).

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