Sediment characterization of the Augusta harbour (Sicily, Italy): modern benthic foraminifera in relation to grain-size and sediment geochemistry

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Introduction: The increasing anthropogenic impact on the marine coastal areas makes necessary the identification of new ecological indicators to support the evaluation of environmental quality together with chemical and physical aspects. Benthic foraminifera have been recently considered for application under EU legislation, after the standardization of sampling and analytical methods [1].
Aim of this study is to define the environmental assessment of the Augusta harbour taking into account the chemical and physical characteristics of the sediment together with the environmental degradation shown by foraminifera in terms of species distribution, diversity, density and the presence of deformed specimens.

Methods: Grain-size, metals and trace elements, (Al, As, Cd, Cr, Cu, Fe, Hg, Ni, Pb, Zn and V), organic contaminants (PAHs and PCBs), Organic Carbon and foraminifera were analyzed in 37 superficial sediment samples collected in the Augusta harbour [2]. Hierarchical Cluster Analysis (HCA) and Principal Component Analysis (PCA) were applied to the analytical results.

Results: The chemical data, also after a comparison with the ER-L and ER-M values [3], showed a significant environmental contamination due to Hg and PCBs, with the highest concentrations (1191 mg/kg and 0.83 mg/kg, respectively) located in the southern sector of the harbour.

Fig. 1: *Distribution of Hg And PCBs in the Augusta Harbour. ER-L and ER-M values were considered as a reference for potential adverse effects* [3].

The analyses of foraminifera, by means of HCA, show three distinct assemblages with one of these corresponding to the most polluted southern area. In particular, it has *Rosalina bradyi* and *Quinqueloculina lata* as prevailing species and shows a reduced diversity and density with respect to the assemblage found in less polluted areas.

Discussion: The high similarity of the Hg and PCBs distribution patterns pointed out how their source is attributable to industrial plants located in the southern sector and, specifically, to the activity of a chlor-alkali plant with mercury cells which was established in the early 1960s and operated until 2005.

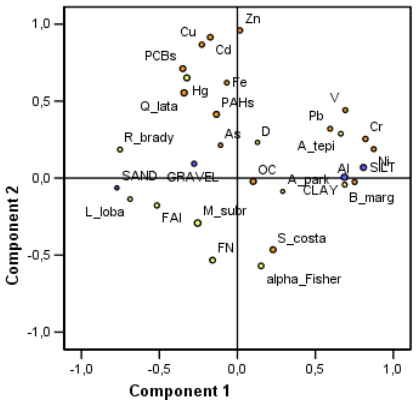

Fig. 2: *PCA applied on biotic and abiotic data.*

The statistical analysis (PCA) applied on biotic and abiotic data highlighted that the decreased diversity and density of the assemblage, found in the most polluted sector, is referable to Hg and PCBs pollution. Moreover, although most of the prevailing species, included *R. bradyi*, appeared conditioned by sediment grain-size, *Q. lata* was correlated with the main pollutants, showing a pollution-tolerant character as well as in previous studies [4].
This research highlighted how sediment texture and pollutants influenced the distribution of foraminifera and how the anthropogenic stress worked on them with clear effects. It also represents how they can be used as important environmental indicators in the assessment of the quality of the marine environment, according to the Water Framework Directive.

References:
[1] Schönfeld et al. (2012) *Mar. Micropal.* **94-95**:1-13; [2] Bergamin et al. (2009) *Mar. Poll. Bull.* **59**:245-256; [3] Long et al. (1995) *Environ Manage.* **19**:81-97; [4] Romano et al. (2009) *Mar. Poll. Bull.* **59**:234-244.