Application of weighted criteria and integrated approach to assess sediment quality in marine and freshwater ecosystems

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Introduction: Sediment quality assessment is a crucial activity for dredging and management options.
Italian legislation (Environment Ministry Decree 173/2016) requires that sediment quality class is assigned following the integration of chemical and ecotoxicological characteristics. The novelty is the elaboration of chemical and ecotoxicological data using weighted criteria, rather than the pass to fail approach. The chemical classification evaluates number, magnitude and typology of pollutants exceeding action levels, while the indexing of ecotoxicological responses is based on the relevance of measured endpoints, tested matrix, time of exposure, magnitude and statistical difference of effects compared to specific thresholds for all the assays of the battery [1]. The model provides synthetic hazard indices for chemical and ecotoxicological data, before their integration in a sediment quality class associated with specific management options. With a similar architecture and weighted criteria new LOEs were developed for both marine and freshwater sediments in a conceptual and software-assisted WOE model (Freshqualsoft model).
Methods: For marine sediments, additional LOEs elaborated for *in situ* evaluations were those concerning bioaccumulation, biomarker responses and benthic communities. For quality assessment of freshwater sediments, logical flow charts were converted into mathematical algorithms to elaborate 9 different LOEs, i.e. chemical characterization of sediments and water column, bioaccumulation and biomarkers in typical bioindicator organisms, ecotoxicological bioassays, macro-invertebrates, diatom community, macrophytes and synthetic assessments on fluvial functionality. The hazard quotients elaborated from individual LOEs are integrated in a risk index with increasing weight according to the ecological relevance of various LOEs.
Results: Several case studies were used to validate the presented WOE model for marine sediments [2,3] both ex-situ and in-situ (with new LOEs). The freshwater model was applied to elaborate data for all the lines of evidence already available for Cecina catchments highlighting the usefulness of an integrated evaluation of different types of data. This is the first case study in which the results obtained by different Institutions and campaigns on 9 typologies of investigation are elaborated through a holistic model that provides quantitative hazard indices for each LOE (Figure 1): their final integration, summarized in a WOE risk index represents a further novelty in respect to individual, unrelated reports.

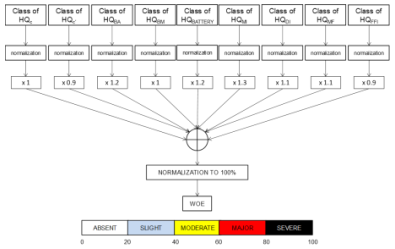

Fig. 1: Flow chart for WOE integration of various LOEs for Risk calculation.

Discussion: The application of WOE methodologies is in line with the European Water Framework Directive 2000/60/CE and Marine Strategy Framework Directory which require member states to evaluate and classify the ecological status of water bodies integrating different quality elements. The integration of data obtained by multidisciplinary approaches represents an undisputed added value compared to the analysis of individual LOEs, and better supports complex processes of ecological risk assessment. The development of software tools as Sediqualsoft 109® and FreshQualSoft provides an important advantage in processing and subsequent integration of large datasets for different typologies of environmental data. Among the main advantages, the LOEs can be used alone or in an integrative approach with an increased sensitivity and ability to discriminate between different conditions. The developed model is versatile, easy to update or adapt to local situations, also to heavily modified and artificial water bodies, representing an important component in a more comprehensive process of risk assessment and "site-oriented" management decisions.
References: [1] Piva et al. (2011) *Chemosphere* **83**:474-485; [2] Benedetti et al. (2012) *Environ. Int.* **38**:17-28; [3] Regoli et al. (2014) *Mar. Environ. Res.* **96**:192-104.