Differences in SEM–AVS and TEL–PEL predictions of sediment impacts from metals in a coastal lagoon (NW Adriatic)

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Abstract

Sediments from a coastal lagoon (Pialassa Baiona, Italy) were examined for potential metal impacts on aquatic biota by comparing sediment chemistry data with two sediment quality guideline (SQG) values: the ratio of simultaneously extractable metals to acid volatile sulfides (SEM-AVS), and Threshold- and Probable Effects Level (TEL–PEL) values.

The SEM/ AVS ratio was found to be < 1 at all areas located near and far the anthropic disturbance (area 1). The AVS–SEM method predicted that sediments would have fewer effects due to high AVS-forming metal sulfide complexes, reducing trace metal bioavailability. These results indicated that adverse effects on aquatic biota should rarely occur.
TEL–PELs predicted that Zn is likely to cause adverse effects in the area closed the anthropic disturbance (area 1), but not in other areas far from the disturbance and under the sea influence (areas 2, 3 and 4).
These somewhat contradictory predictions demonstrate the importance of validating the results of either these methods with other biological measures before making any management or regulatory decisions of point and non point sources of pollution.

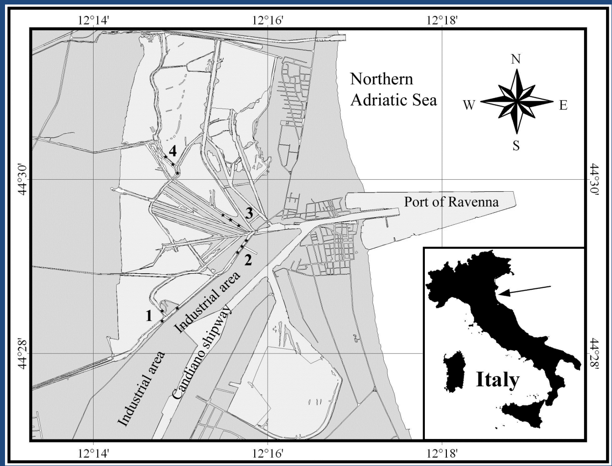

Figure 1. Map of Pialassa Baiona lagoon, showing sampling sites (stars) within areas labelled by numbers (Geographic coordinates, European Datum 1950)

Sampling design

ÅAn orthogonal-hierarchical sampling design was applied to analyse the potential effect of natural and anthropogenic disturbance on the spatial distribution of analysed metals. Four areas (labelled 1, 2, 3 and 4) were selected combining the distance from industrial inputs (near and far) and the distance from the sea (near and far). Two areas were located near to the anthropogenic disturbance, along the southern edge of the lagoon (areas 1 and 2), and two areas were located northward, far from the impacted area (areas 3 and 4), on the other hand, two areas were near the seaward channels confluence (area 2 and 3) and the others were landward (areas 1 and 4).

ÅThree sites were randomly selected for each area and three sediment replicate samples (top 5 cm) were collected in May 2010 at each site by means of a Wildco® box corer.

Materials and Methods

ÅThe general procedure for measuring Acid Volatile Sulfides (AVS) was based on Allen et al. (1993). Absorbance was measured at 670 nm using a HATCH Model DR2010 spectrophotometer.

ÅSimultaneously Extracted Metals (SEM: Cd, Cu, Ni, Pb and Zn) were measured in the 50 ml aliquot removed from the sediment extract. These metals are weakly associated with the sediments, i.e., they are not incorporated in crystalline matrices, and are removed in the AVS acid treatment .

ÅSediment samples underwent microwave-assisted dissolution with HNO3/HCl (1:3 v/v) to determine pseudo-total content of target metals (Cd, Cu, Ni, Pb and Zn).

ÅPseudo-total metals and SEM were analyzed with graphite furnace atomic absorption spectroscopy (GF-AAS) for Cd, Cu, Ni and Pb, and with flame AAS for Zn (Perkin Elmer Model A Analyst 100).

Results and Discussion

ÅThe SEM/AVS ratio was found to be < 1 at all areas located near and far the anthropic disturbance. The AVS–SEM method predicted that Cd, Cu, Ni, Pb and Zn in sediments form insoluble-metal sulfides that are unavailable to sediment dwelling organisms (Figure 2).

ÅThe basis of the AVS-SEM model is that the dissolved concentrations of divalent metals (Cd, Cu, Ni, Pb and Zn) in pore water are controlled by the molar ratio of reactive metals (SEM) to the AVS in sediment through the formation of an insoluble metal sulfide complex (Rickard and Morse, 2005). When the ratio of the molar concentrations of ∑SEM to AVS is > 1, the SEM can exist in pore water and may be available and thus exert toxicity to benthic organisms (Lee et al., 2000).

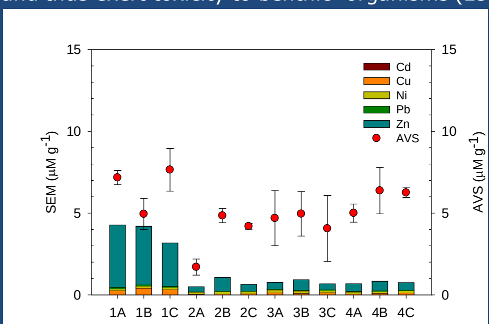

Figure 2. Average Concentrations (± SD) of Acid-Volatile-Sulfide and Sum of Simultaneously Extracted Metals (Cd, Cu, Ni, Pb and Zn).

ÅTEL–PELs predicted that Zn rather than Cd, Cu, Pb, Ni is likely to cause adverse effects in the area closed the anthropic disturbance (area 1), but not in other areas far from the disturbance and under the sea influence (areas 2, 3 and 4) (Figure 3).

ÅThreshold- and Probable Effect Levels (TEL-PEL) are empirical SQGs that indicate the sediment chemical concentrations at which toxicity may begin to be observed, and above which adverse effects are expected, respectively.

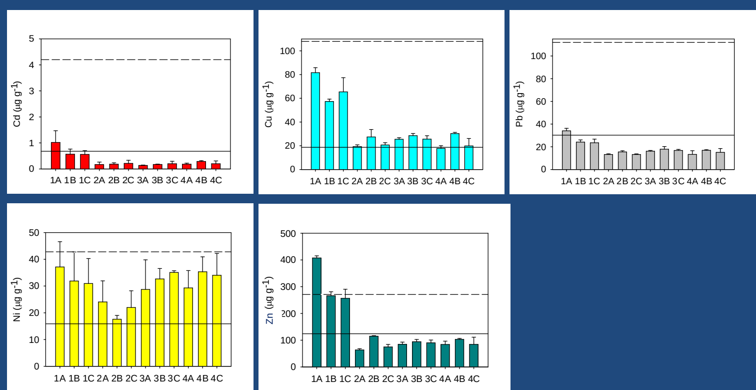

Figure 3. Mean (+ s.e.) metal concentrations in sediments from Pialassa Baiona lagoon. 'Threshold effect level' (TEL) and 'Probable effect levels' (PEL) for benthic organisms (Buchman, 2008) were reported for comparisons (μg/g).

References

Allen, H.E., Fu, G., Deng, B., 1993. Analysis of acid-volatile sulfide (AVS) and simultaneously extracted metals (SEM) for the estimation of potential toxicity in aquatic sediments. *Environmental Toxicology and Chemistry* 12, 1441-1453; Lee, B.-G., Lee, J.-S., Luoma, S.N., Choi, H.J., Koh, C.-H., 2000. Influence of acid volatile sulfide and metal concentrations on metal bioavailability to marine invertebrates in contaminated sediments. *Environmental Science and Technology* 34, 4517-4523; Rickard, D., Morse, J.W., 2005. Acid volatile sulfide (AVS). *Marine Chemistry* 97, 141-197.