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Sediment Chronologies with ^{210}Po and ^{137}Cs as fundamental tools for Environmental Forensic Studies: examples from Italy

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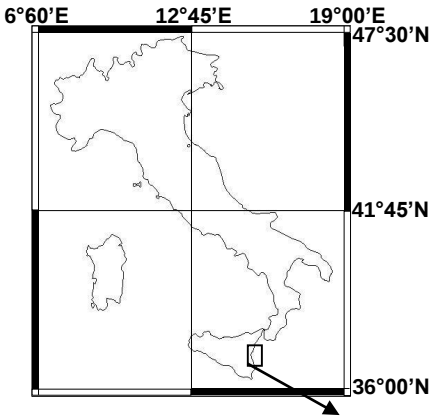
WHY?

- Accreting aquatic sediments are extremely important sources of information when dealing with the reconstruction of past events.
- In recent (100-150 years) time intervals, the identification of geochronological benchmarks allows the comparison between historical information and observed changes along the core profile.
- This might be requested in environmental forensic studies that aim at recognizing, for example, when environmental pollution started in a specific place, how it changed, and, eventually, who has to be held responsible for it.
- The chronological dating provided by the ^{210}Po technique through alpha counting and its external confirmation by gamma measurements of the artificial radiotracer ^{137}Cs are necessary background information in order to correctly assess fluxes and inputs of pollutants in sedimentary records and provide scientific evidences to support decision makers.



WHERE?

The Augusta Bay

A semi-enclosed natural basin covering an area of approximately 4000 ha along the eastern coast of Sicily (Ionian Sea, southern Italy).

The **Augusta Harbor** is its northern sector that was sheltered in the early 1960s with the construction of artificial breakwaters (see picture).

Due to its confinement, the hydrodynamic regime of the harbor is scarce, and favors the accumulation of nutrients and pollutants in sediments and the occurrence of eutrophication episodes. **The harbor hosts one of the most important ports of the Mediterranean Sea, and many industries are located along its western part, including petroleum and petro-chemical plants.**

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WHERE?

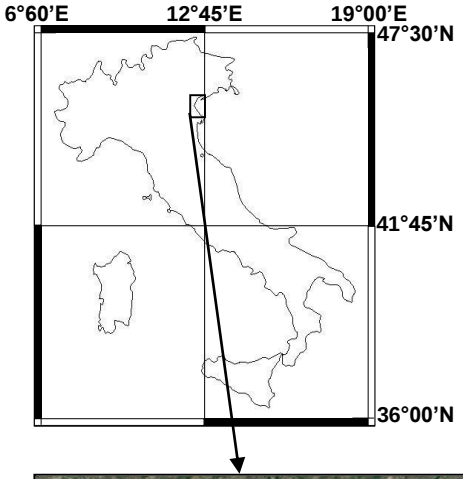
The Augusta Bay

The industrial development started in the 1950s with the construction of oil refineries and proceeded in the 1960s with the onset of a Mercury Cell Chlor-Alkali Plant (MCCAP). Sediment dredging, disposal, and partial nourishment of the western coast have further modified the pristine environment of the bay.

Since the 1970s the area has become internationally recognized as a polluted environment. Specifically, mercury contamination from the MCCAP in the southern sector of the Augusta Harbor has produced sediment concentrations beyond international threshold values. In the 1980s the demercurization and waste treatment plants started working and discharged treated wastewater outside the harbor.
In the early 2000s, scientific evidence became necessary to support legal investigations against the industries that caused the pollution and who could potentially be expected to contribute to remediation costs. In 2003, researchers from CNR-ISMAR Bologna started work to provide such evidence.

WHERE?

The Venice Lagoon



The Venice Lagoon is a unique shallow aquatic ecosystem whose complex morphology has been profoundly modified over time by human interventions. In particular, during the last century it has experienced a general degradation with the deepening of tidal flats and the reduction of salt marsh areas. In addition, the development of economic activities on the mainland have led to further changes

The 1st Industrial Area of Porto Marghera was built at the beginning of the 20th century, while the 2nd developed after World War 2. Further human modifications included canals' excavations, the trans-lagoon bridge's construction and the realization of the MOSE's barriers that protect the city of Venice from high tides through isolation from the adjacent Adriatic Sea

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WHERE?

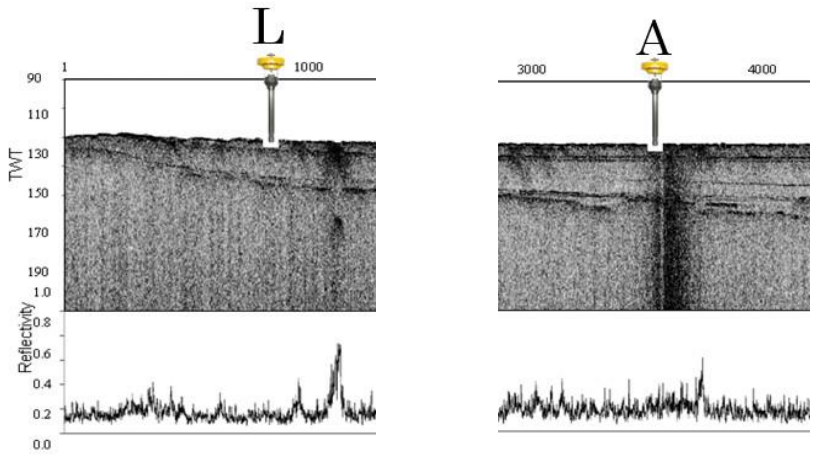
The Venice Lagoon

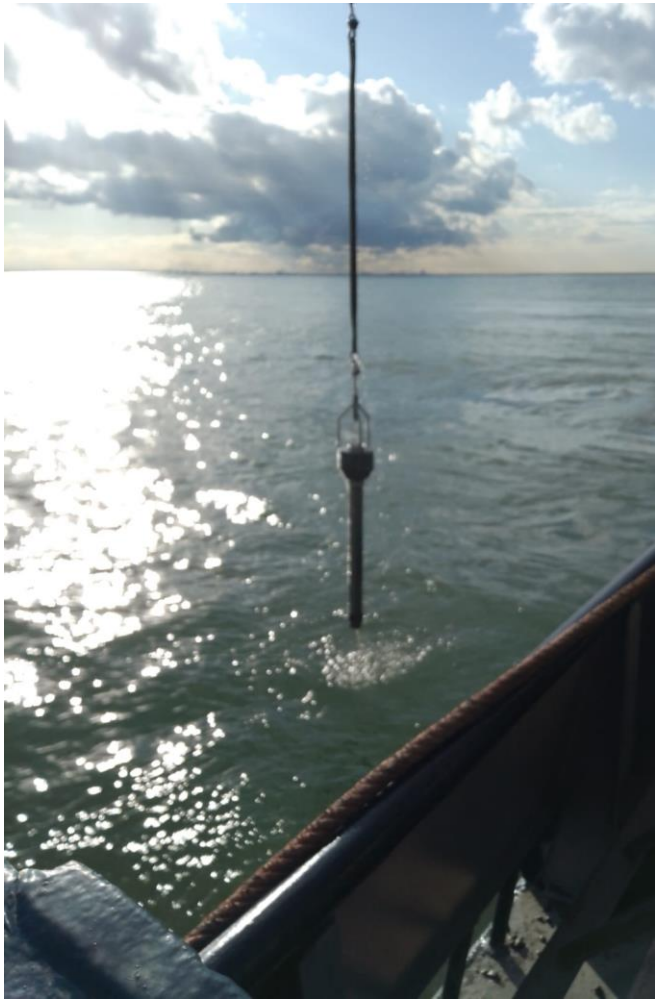
Until the 1970s, Porto Marghera was one of the most important industrial areas in Italy. The contamination of lagoon waters and sediments began soon after the first economic development, when industrial, urban, and agricultural discharges were disposed freely into the lagoon. The situation became so serious that, at the end of the 1990s, a trial against managers of the petrochemical plants began. The defendants were charged with pollution and environmental disaster by polychlorodiphenyl dioxins and furans (PCDD/Fs) in the industrial area of Porto Marghera and in the whole Venice Lagoon. The main subject of the lawsuit was the production of vinyl-chloride monomer (VCM) that, at that time, was considered the principal industrial source of PCDD/Fs in this region. Researchers from CNR-ISMAR Bologna were involved to provide scientific evidences.

HOW?

The Augusta Bay

The sampling strategy for the definition of Hg contamination in sediment cores was designed according to seismic data, bottom reflectivities, and historical information retrieved from local public and private archives relative to the dredging and dumping areas. Sediment cores were collected with the gravity corer SW-104, patented by CNR and especially designed to preserve undisturbed sediment–water interfaces.





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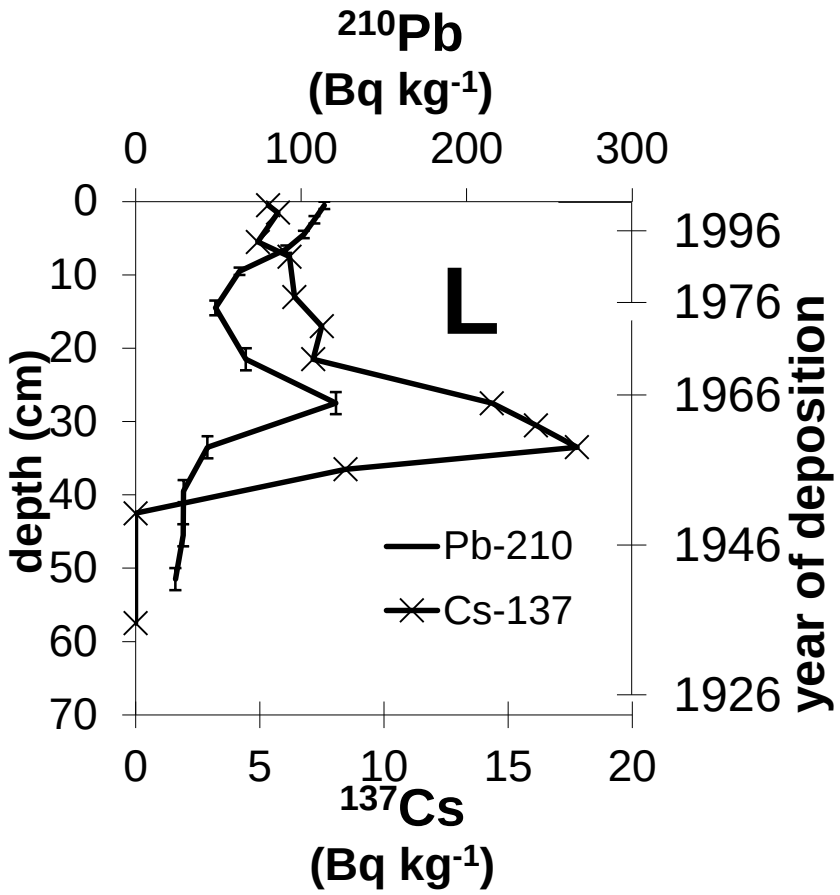
HOW?

The Augusta Bay



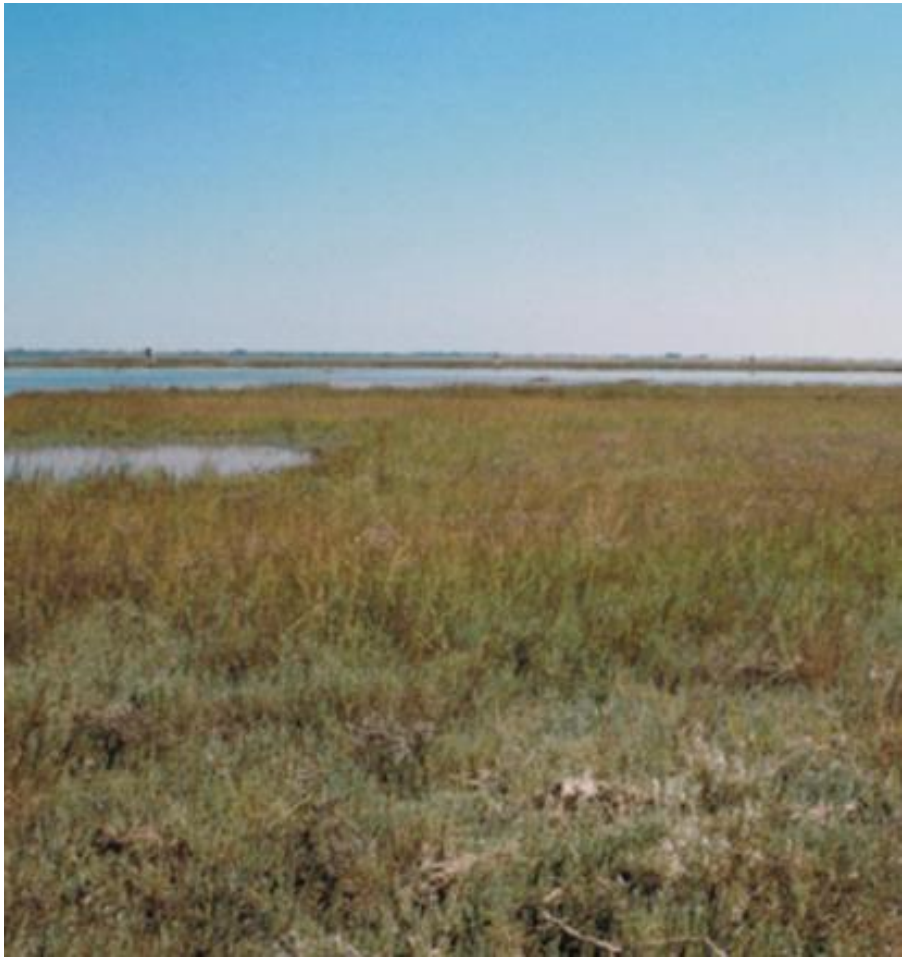
Sediment cores were scanned for magnetic susceptibility and X-radiographed, then extruded and carefully sectioned in 1–3 cm intervals. They were analysed for bulk dry density, organic matter content, mineral composition, grain size, Hg and hexachlorobenzene (HCB).

The definition of a reliable sedimentation chronology was fundamental for the research's purposes. It was obtained through the comparison of results from both alpha spectrometry of ^{210}Po for ^{210}Pb determinations (assuming secular equilibrium) and non-destructive gamma spectrometry for ^{137}Cs.

HOW?

The Venice Lagoon

The vast amount of scientific and historical literature relative to the environmental status of the lagoon was reviewed in order to identify those locations that could represent the many different aspects of this area. For this reason, samples were collected in different years in submerged lagoon sites and industrial canals but a particular attention was devoted to salt marsh areas.



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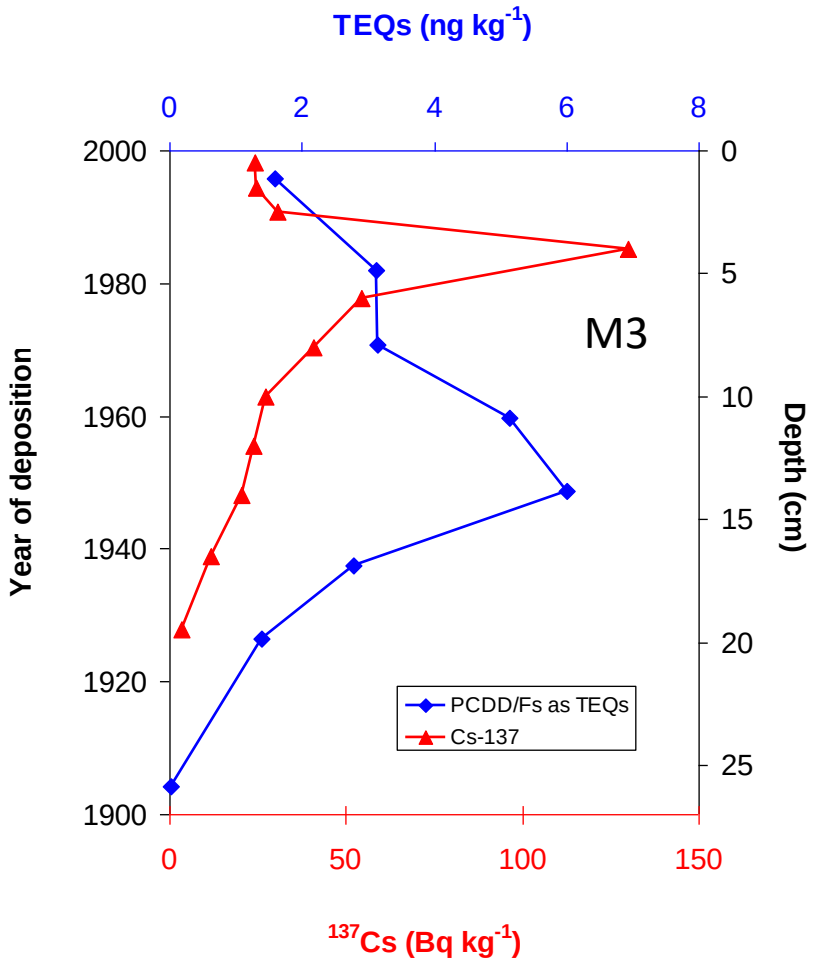
HOW?

The Venice Lagoon



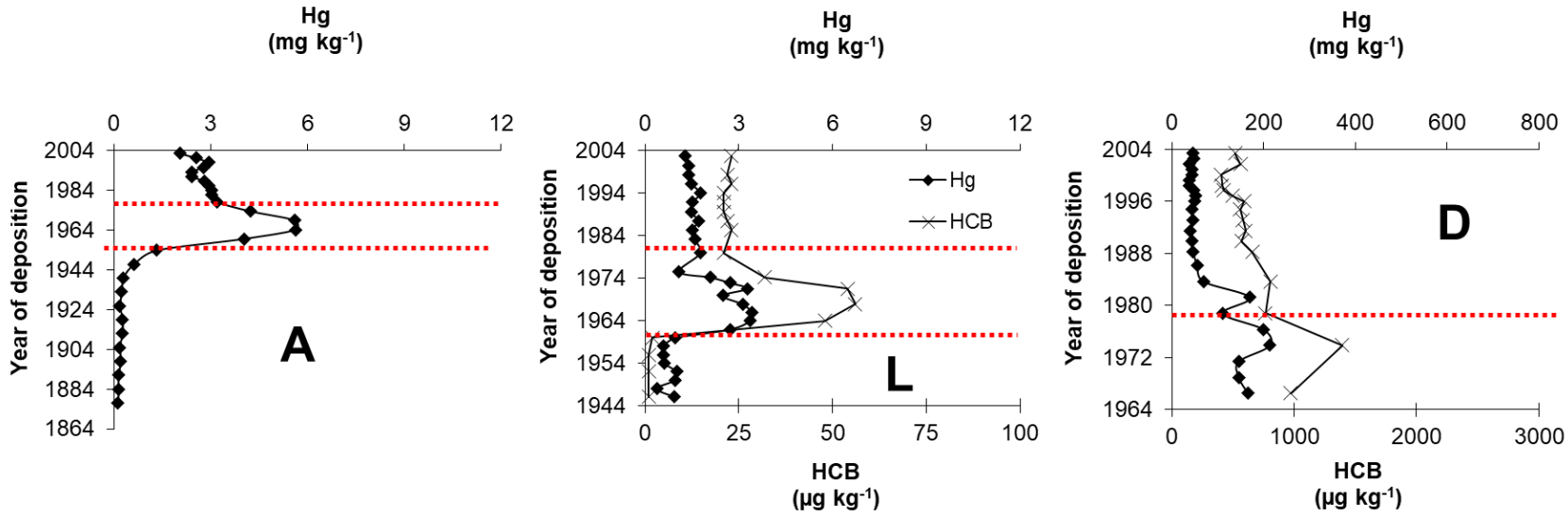
In addition to ancillary parameters such as those already described for the Augusta Bay (i.e. magnetic susceptibility, bulk dry density, organic matter content, mineral composition, and grain size), also PCDD/Fs and other organic and inorganic compounds were measured in the collected sediments.

Also in this case the chronology of pollutants' inputs was addressed with the use of ^{210}Po alpha spectrometry and ^{137}Cs non-destructive gamma spectrometry.

WHAT? (or results)

The Augusta Bay

Sediment chronologies defined for the cores collected in the Augusta Bay and Harbor were of great interest for the purpose of this scientific investigation, since they covered time intervals sufficiently extended to include the industrial setting (early 1960s), its development, and decline (late 1980s)



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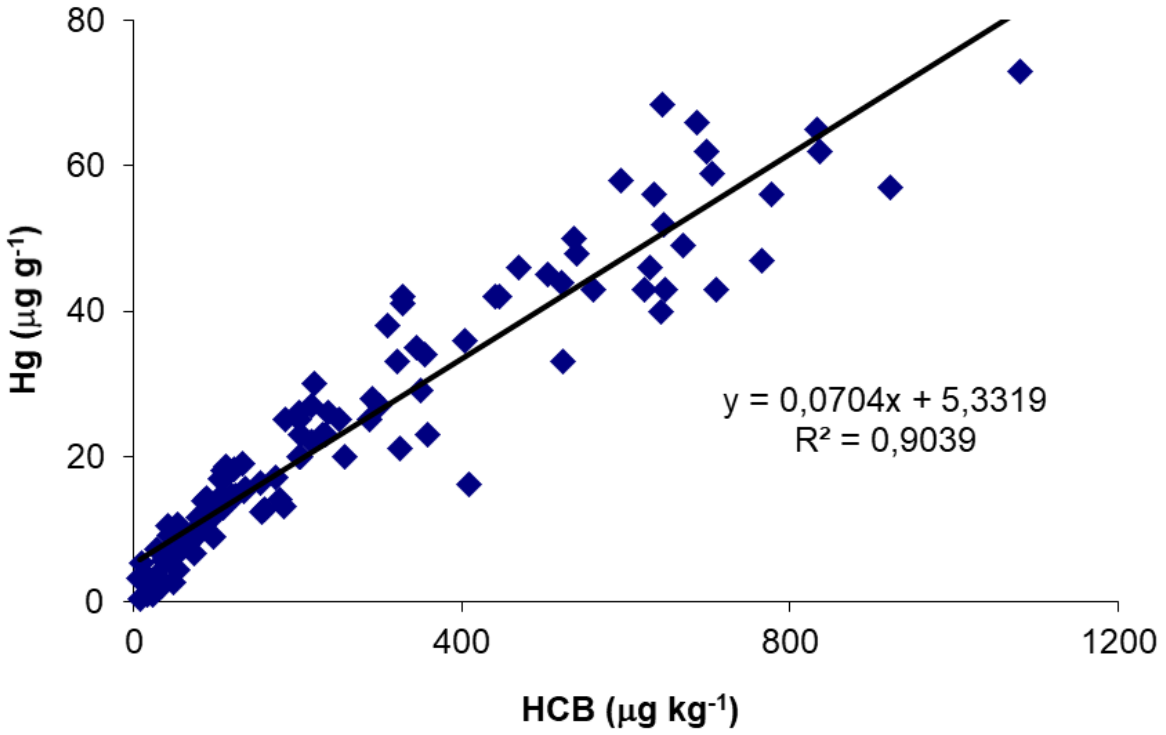
WHAT? (or results)

The Augusta Bay

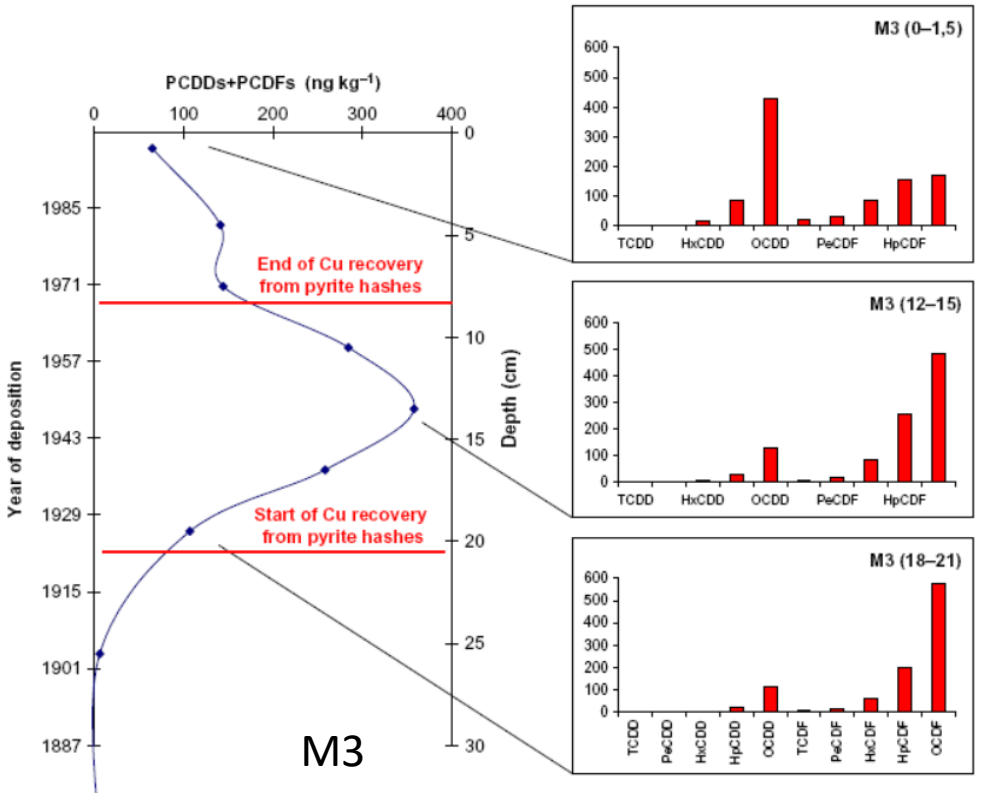


The highly significant correlation observed between Hg and HCB in surficial sediment samples was attributed to the mobilization of polluted sediments deposited in the period 1958–1980 by dredging and/or ship traffic. Direct recent inputs were excluded because HCB productions in the area ceased definitively in the 1980s.

WHAT? (or results)

The Venice Lagoon

Radiochemical chronologies of contaminant profiles retained by salt marsh sediments in the lagoon have shown good correlations with local industrial activity and urbanization, sustaining their use as dating tools.
In addition, homologue profiles distributions for PCDD/Fs helped discriminating among sedimentary levels where industrial inputs (i.e. majority of furans) were prevalent from those where urban sources (i.e. majority of OCDD) prevailed



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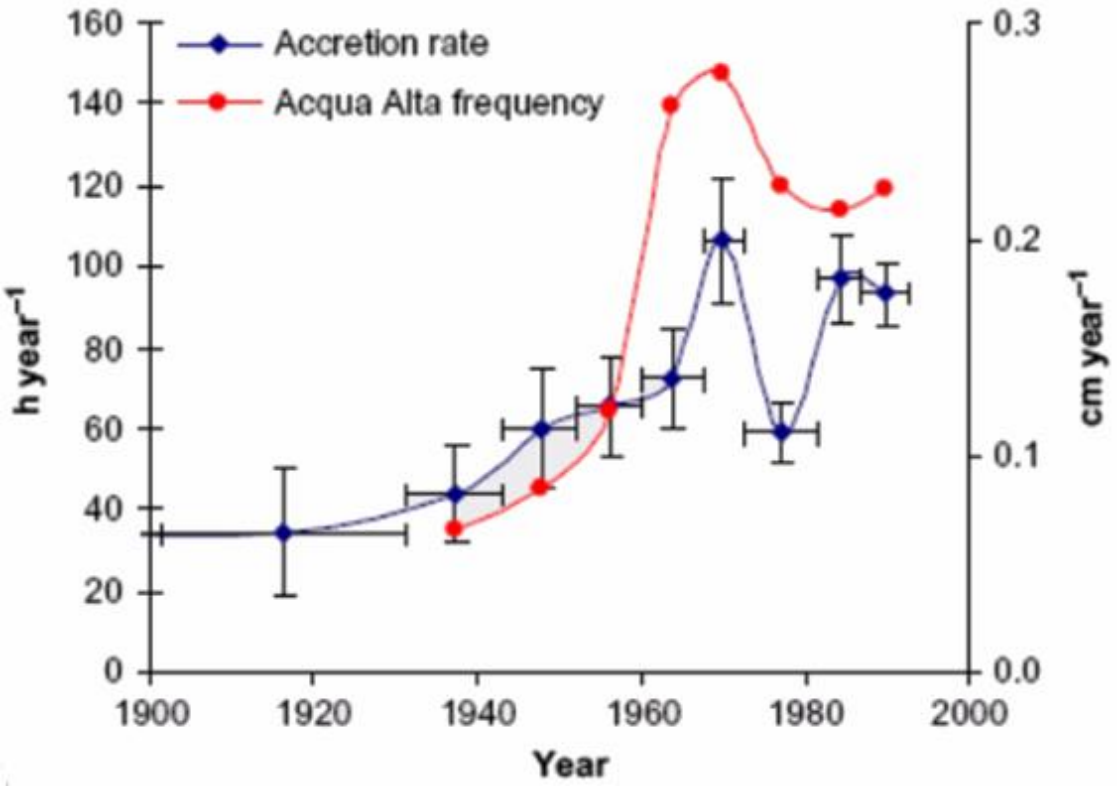
WHAT? (or results)

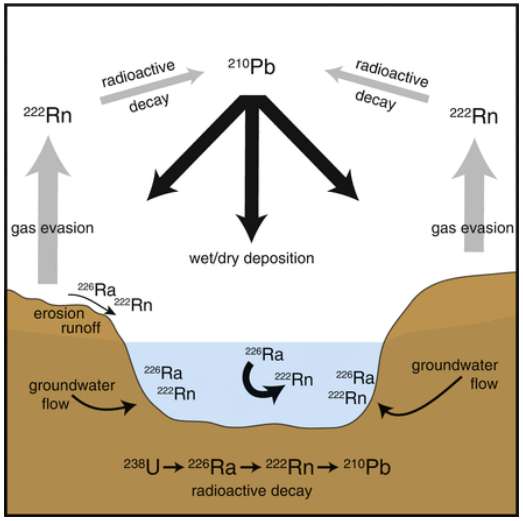
The Venice Lagoon

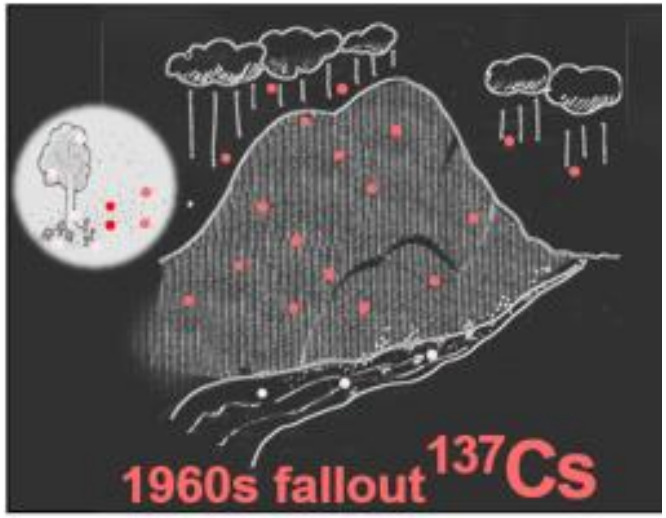


The potential of venetian salt marsh sediments is not limited to pollutants but include other important environmental parameters. Indeed, average accretion rates calculated through excess ^{210}Pb and ^{137}Cs distribution in salt marsh sediment cores are comparable to the long-term average rate of mean Sea Level Rise (SLR) in the lagoon, but changes within the vertical profile might reflect short-term variations in accordance with the cumulative frequency of salt marsh flooding

AND NOW?

The two examples presented come from as many Italian sites heavily impacted by nearby industrial areas (i.d. the Augusta Harbor in Southern Italy and the Venice Lagoon close to Porto Marghera in the Northeastern sector of the country). In both cases, the role of sediment chronologies derived from ^{210}Po and ^{137}Cs profiles was fundamental, without which no coupling of scientific evidence from sediment cores with historical information could have been attained, and no clear view of polluting sources, timings, and mechanisms could therefore have been provided. The approaches developed and the experience acquired could be used in other developing countries that present similar risks of uncontrolled industrialization.





Thank you for your attention

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