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Remediation of heavy metal contaminated sites in the Venice lagoon and conterminous areas (Northern Italy)

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The lagoon of Venice and the conterminous land are affected by heavy contamination of anthropogenic origin, and for this reason the whole area has been classified as site of national interest, and must be restored. Heavy metals (As, Cd, Cr, Cu, Hg, Mn, Pb, Sb, Se, Zn) and organic compounds (IPA, PCB, Dioxine) have been identified as the main contaminants at various sites, owing to agriculture and industrial wastes discharged on soils and convoyed to the lagoon. Five case studies of soil remediation are here reported. S. Giuliano is a former palustrine area reclaimed since the 60's with various human transported materials (HTM). In this area, hot spots overpassing the reference limits for residential and green areas have been recorded for Cd, Cu, Pb, Zn and IPA. Campalto is a site bordering the Venice lagoon and subjected to oscillating water level, that enhances metal mobility; diffuse contamination by heavy metals, particularly Pb, has been recorded at this site, utilized since 30 years for military and sport (skate) activities. Marghera is dramatically famous for its numerous factories and for oil refineries that affected the lagoon sediments since the 50's. Sediments proved heavily contaminated by As (up to 137 mgkg-1), Cd (57 mgkg-1), Hg (30mgkg-1), Ni, Pb (700 mgkg-1), Zn (5818 mgkg-1). Murano is a small island where many glass factories (the most famous all over the world) are running since XIII century. Glass is stained with several metals and, moreover, some substances are used to regulate fusion temperature, purity, etc., and therefore the surrounding environment is heavily contaminated by these substances. Mean concentrations of As (429 mgkg-1), Cd (1452 mgkg-1), Pb (749 mgkg-1), Zn (1624 mgkg-1), Se (341 mgkg-1), Sb (74 mgkg-1) widely overpass the reference values for both residential and industrial areas in national guidelines. Molo Serbatoi is a former oil container currently under restoration in the port of Venice. Soil contamination by As, Hg, Zn and IPA was recorded, while groundwater proved to be contaminated by As, Cd, Cr, Hg, Pb, Cu, Se, Ni, Mn, Sb, Fe.
Restoration of the studied sites has been carried out by phytoremediation with native or exotic vegetation (Fragmites australis, Juncus lacustris,Puccinellia palustris, Limonium serotinum, Salicornia glauca, Spartina maritima, Pteris vittata) or cultivated plants (Heliantus annuus, Zea mais, Brassica napus, Brassica juncea).
Results are somewhat contradictory. At S. Giuliano, the exotic fern (Pteris vittata), consistently with data from current literature, showed high ability to accumulate As, particularly in aerial parts. At Campalto, native vegetation proved ineffective for phytoextraction, but suitable for phytostabilization, owing to a root barrier effect. In the lagoon sediments from Marghera, Spartina proved more effective than Fragmites to uptake metals, while cultivated plants could not survive to high heavy metal concentrations. At Murano, Pteris vittata proved highly effective to accumulate As, but also resistant to elevated concentrations of co-existing metals (Cd, Pb, Se, Zn), with clear signals of growth sufference and a drastic reduction of sorption capacity only in the presence of very high Cd concentration. At Molo Serbatoi, phytoremediation could not be applied in absence of a chelating agent (e.g. EDTA), which could enhance metal mobilization: therefore, soil has been stored, selected and finally (the most contaminated part) delivered to a landfill, while groundwater will be remediated by bioremediation techniques.