Solidification/Stabilization of clayey sediments contaminated by heavy metals

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The treatment of brownfield soils contaminated by organic and inorganics pollutants is an increasingly compelling issue. The Italian Institute for the Environmental Protection (ISPRA) has recognized 39 areas severely contaminated by previous industrial activity (SIN – National Interest Sites) that needs important remediation. Besides SIN, many dismissed industrial areas require treatment of soil remediation in other to be eligible to new activities. The landfill disposal of these contaminated sediments is not sustainable both economically and environmentally. Alternative solutions involve technologies of immobilization of pollutants into sediments allowing a safe soil recycling. The European regulatory body for environmental protection recognize immobilization technologies as part of the B.A.T.N.E.E.C. (Best Available Technologies Not Entailing Excessive Costs). Among these technologies, the Solidification/Stabilization (S/S) technology involves the direct solidification of contaminated soils by addition of inorganic binders (e.g. Portland cement) thus encapsulating pollutants into a solid matrix, which should be as more physically and/or chemically stable as possible [2]. The efficiency of physical (solidification) and chemical (fixation) stability critically depends on the interplay between inorganic binder and soil composition. Each contaminated site presents different problems to be faced, requiring specific adjustments to optimize the S/S technology.

The aim of the proposed research project is to optimize the S/S treatment for contaminated soils (Cu, Zn, Cr, Pb, Cd, Hg) composed by clayey sediments containing smectite clay minerals. Swelling clays in soils play a critical role in determining both the efficiency of binding and chemical fixation. After chemical and mineralogical characterization (XRF, XRPD) of contaminated soils, leaching tests will be performed to determine the mobility of heavy metals (ICP-MS). The speciation of particulate trace metals will be assessed by the sequential extraction procedure by Tessier et al. [1]. Different Portland cements and composite Portland cements (containing supplementary cementitious materials) will be tested as binders. Leaching tests will be performed on the selected cement to evaluate their potential release of heavy metals. Given the high numbers of variables involved to optimize the proper S/S formulation, a suitable experimental design will be implemented. Special attention will be devoted to effects of pH on the mobility of heavy metals. Physical confinement of contaminated soils will be characterized at microstructural scale by SEM and tomography measurements. Chemical fixation of contaminants will be improved by maximizing the hydrated cement phases that potentially incorporate metals (e.g ettringite and AFm phases [3]). The ultimate purpose is to clarify the main chemical, physical and geochemical parameters controlling the efficiency of S/S treatment of clayey sediments.

The research project is part of the current research activity on hydraulic binders at the Geoscience Department, University of Padua. The collaborations with the Department of Environmental Sciences, Informatics and Statistics of Ca' Foscari University, and Prof. Roy Wogelius – University of Machester are foreseen.

Available financial resources: Circe funds.

References

[1] “Stabilization/solidification of hazardous, radioactive, and mixed wastes”, Spence and Shi, 2005.

[2] Tessier et al., Analytical Chemistry, 1979.

[3] Bensted et al., World Cement and Technology, 1971.