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Synchrotron microscopic and spectroscopic techniques to reveal the fate of Zn in pioneer plants from abandoned mining sites

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Mining activities generate a large amount of waste materials that are often very unstable and represent a source of pollution. Phytomanagement, in terms of phytostabilization, is considered a suitable method to decrease environmental risks of metal-enriched mine wastes (Parraga-Aguado et al. 2013). This technique employs plants to achieve the surface stabilization of the wastes by acting as a barrier which decreases wind borne dust and water erosion, reduces metal-enriched leaching through metal accumulation in plant roots and provides metal immobilization in the rhizosphere (Robinson et al. 2009; Sun et al. 2016).

Most of the research has focused on the selection of the best spontaneously adapted plant species (endemic pioneer plants) for each specific mining site (Parraga-Aguado et al. 2013), because they may respond better and can survive easily compared to introduced alien species (Bradshaw 1997; Pandey 2015). Pioneer vegetation may improve edaphic conditions by increasing soil nutrient content (Rodríguez et al. 2007) or ameliorating soil acidity (Rufo and de la Fuente 2010), and thus may favor further establishment of other plant species.

The investigation of metal transfer from the geosphere to the vegetal tissues helps to understand the adaptive strategies of plant species and may be useful for soil remediation actions. Synchrotron radiation-based techniques represent the state of the art tools to investigate the microscopic processes occurring in plant-soil systems (Kopittke et al. 2017). X-ray diffraction, X-ray fluorescence and X-ray absorption spectroscopy (XAS), are particularly suited to determine the finest complementary details about the atomic and crystallographic structure, distribution of elements, their chemical speciation and their valence state. Here, we report a review of selected researches performed on different plant species (*Pistacia lentiscus* L., *Euphorbia pithyusa* subsp. *cupanii*, *Phragmites australis*, and *Helichrysum microphyllum* Cambess. subsp. *tyrrhenicum*), growing on metal contaminated substrates in abandoned mining areas in Sardinia (Italy).

Our results demonstrate that these plant species have developed their own adaptation strategy to grow and to survive in polluted environments, making them potential candidates to develop low-cost and self-sustainable vegetative covers aimed at reducing the dispersion of metals in soils and waters around these mine polluted sites.

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