



Restoration of contaminated soils in abandoned mine areas (Tuscany, Italy)

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In Italy ore research and exploitation have been nearly exhausted since the end of the last century, and have left on the land a huge amount of mine waste, therefore provoking evident environmental damage including surface and groundwater, soils, vegetation and the food chain, and a potential threat to human health.

The main processes occurring at these sites are: rock disgregation, fragments migration, dust dispersion, oxidation ($E_h > 250\text{mV}$), acidification ($\text{pH} < 7$), hydrolisis and metal leaching, precipitation of oxides and sulphates.

The restoration of these sites, therefore, is a primary objective, in order to reduce/eliminate the risk associated to the contamination sources of past activities, and the consequent environmental and human health hazard. The increasing environmental consciousness of general population compelled Public Administrators to set down effective legislation acts on this subject (e.g. D.L. 152/2006), and more generally on environmental contamination.

In this work we present the results of a survey carried out at several mixed sulphides mine sites in Tuscany, exploited for at least a millennium, and closed in the last century.

Biogeochemical analyses carried out on representative soil profiles (Spolic Technosols) and vegetation in the proximal and distal areas of ore exploitation show heavy metal concentrations (Cd, Cu, Fe, Pb, Zn) overcoming legislation limits on average. Ni, Cr and Mn concentrations, instead, are generally below the reference levels.

The results obtained suggest that the abandoned mine sites represent actual natural laboratories where to experiment new opportunities for restoration of anthropogenically contaminated areas, and to study new pedogenetic trends from these peculiar parent materials. Moreover, plants growing on these substrates are genetically adapted to metal-enriched soils, and therefore may be utilized in *phytoremediation* of contaminated sites. Furthermore, the institution of natural parks in these areas could enhance their educational and scientific value, contributing in the meantime to general population amusement and recreation.

Finally, it is the occasion for soil scientists to submit to the scientific community new classification proposals of this new kind of soils.

Key-words: mine waste, heavy metals, phytoremediation, soil genesis, soil classification