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Anti-oxidative response of *Cistus salviifolius* L. grown in gossan mine wastes amended with ash and organic residues

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Mine waste heaps can be considered extreme environments, due to their high concentrations of potentially hazardous elements (PHE). When PHE are combined with adverse physical characteristics and low contents of organic matter and nutrients, the development of the majority of plant species is impaired and the biodiversity of the area is severely reduced. The abandoned São Domingos mining area represents such an environment. It is located in the Iberian Pyrite Belt (South of the Iberian Peninsula) and has one of the largest concentrations of polymetallic massive sulfide deposits in Europe.

Some autochthonous plant species are well adapted to extreme environments and are able to grow naturally in degraded areas, contributing to minimize the negative chemical impacts and improve the landscape quality. However, the environmental rehabilitation processes associated to the development of these plants (phytostabilization) are very slow and the combined use of materials/wastes that improve some physico-chemical characteristics of the matrix is necessary. This work studied the physiological response of *C. salviifolius*, an autochthonous species, tolerant to growth in harsh environments, when grown in gossan mine wastes from the mine of São Domingos amended with organic/inorganic wastes. The amendments used were (g/kg of gossan): biomass ash (BA, 2.5), a mixture of organic residues (OR, 120) and a mixture of both (BA+OR).

The amendments that comprised organic wastes (OR and BA+OR) gave rise to the best vegetative development, without visible signs of toxicity and with the lowest concentrations of hydrogen peroxide (H₂O₂). Plants grown in the presence of organic wastes also had better levels of cell redox status and a large pool of antioxidants. Although both roots and shoots of these plants had low levels of H₂O₂, in roots, both glutathione and ascorbate had high levels of oxidation.

A successful environmental rehabilitation has to take into account both the amendments applied and also the growth and the ability of the plant cover to adapt to the adverse environmental conditions imposed upon it. *Cistus salviifolius* was able to grow better and withstand the high PHE levels of the gossan material when organic matter was used as amendment. In those conditions, the plants had a more functional anti-oxidative system that enabled them to cope with oxidative stress. A better plant cover was achieved and chemical properties of the mine wastes were

improved, such as lower concentrations of PHE in the available fraction, higher fertility and water-holding capacity.