

# FROM MINING WASTE TO RESOURCE: A TRANSDISCIPLINARY PATHWAY TO A SMART AND SUSTAINABLE ECONOMY

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## ABSTRACT

The increasing scarcity of raw materials (RMs), resource depletion, rising metal prices, and environmental pressures have made RM recovery from waste a global priority. Mining waste, produced in vast quantities worldwide, represents both an environmental challenge and a potential resource. Unlocking this potential requires accurate data on waste location and residual exploitable minerals, coupled with innovative recovery strategies. Since 2014, our research group has conducted extensive mining waste sampling campaigns across Europe, Africa, India, and Latin America, within the framework of numerous national, European, and international projects. Over a decade of research and strong collaborations with universities, research centers, public institutions, and private enterprises have enabled the development of a transdisciplinary approach that integrates advanced spectral, chemical, and mineralogical characterization, satellite and drone mapping, and innovative phytoextraction assisted by mycorrhizal fungi and bio-hydrometallurgical processes. This integrated methodology will be further applied to study areas in Argentina and Europe, where ongoing research aims to transform mining waste into a valuable resource and foster smart economy pathways for a sustainable future. Future activities will include the creation of a geodatabase, the use of next-generation satellite and UAV technologies, and the application of phytoremediation assisted by mycorrhizal fungi and bio-hydrometallurgical processes, strengthening the role of mining waste recovery as a cornerstone of the circular economy.

Key words: Mining waste, Transdisciplinary approach, Hyperspectral remote sensing, Phytoextraction