RED MUD SOIL CONTAMINATION NEAR AN URBAN SETTLEMENT ANALYZED BY AIRBORNE HYPERSPECTRAL REMOTE SENSING

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Aluminium is one of the world's most abundant and useful metals. The principal source of aluminium is bauxite that contains high concentrations of the oxide alumina (Al_2O_3). Alumina is extracted from the bauxite through a refining process and then converted to aluminium metal through a smelting process. The main solid waste from the aluminium plant is red mud due to its caustic nature and to the hazardous residues (i.e. traces of heavy metals, dioxins, furans, polycyclic aromatics, etc.) poses a major environmental problem. The red mud residue is characterized by very high alkalinity and its major constituents are crystalline hematite (Fe_2O_3), boehmite (γ-AlOOH), quartz (SiO_2), sodalite ($Na_4Al_3Si_3O_{12}Cl$) and gypsum ($CaSO_4 \bullet 2H_2O$), with a minor presence of calcite ($CaCO_3$), whewellite ($CaC_2O_4 \bullet H_2O$) and gibbsite Al $(OH)_3$. The red mud dust risk involves the accumulative contamination of land and dwellings in the community with fine particulate that is highly alkaline and hence needs special precaution, while disposing of red mud waste entail the pollution of surface as well ground water resources, so determining the consequential exposure and health risk (e.g., from respiratory irritation to cancer) to residents and the surrounding ecosystem. Deposition of heavy metals and other pollutants can also potentially affect crop and livestock production and the quality of agricultural products from nearby land. Therefore, the dust management systems have to involve a range of strategies with a significant effort in planning, implementation and monitoring activities to ensure an effective dust control. A common way for surveying the spatial distribution of pollutants (e.g., heavy metals) involves the systematic sampling and laboratory analysis of soil, stream sediment and water samples followed by interpolation of the point results in compiling distribution maps; however, such an approach is time-consuming and costly.

Within this context, hyperspectral airborne remote sensing data can provide an effective, rapid and repeatable tool for mapping and monitoring the spread of red dust providing the location of the polluted areas to be checked.

In this study, since the main objective is to individuate and monitor the red dust extend out of the red mud impoundment area, we first perform laboratory analyses of red mud and soil samples collected in the study area for (a) recognizing the dominant minerals and hazardous residues using X-ray diffraction and fluorescence and (b) calculate the sample Ph values. Second, we identify the optical characteristics of the samples using portable field spectrometer (ASD) to distinguish red mud from other soils and materials. All these field and laboratory measurements were applied to characterize the red mud spectral features and their remote sensing detection requirements. Last, we use hyperspectral airborne data covering the aluminium processing plant (KAP) close to Podgorica city (Montenegro) and surveyed by Multispectral Infrared Visible Imaging Spectrometer (MIVIS) airborne.

The results show that red mud has a distinctive spectral signature with diagnostic features in the Visible and Thermal spectral regions. The joint use of MIVIS reflectance and emissivities data allowed individuating and mapping those sites on which the red dust is spread by the dominant winds, where a check for reclamation or a neutralization intervention is required.

Within this paper it has been demonstrated that the proposed technique is mature to supply local government authorities an efficient, rapid and repeatable red mud dust diffusion mapping procedure providing the location of the polluted areas to be checked.