Using Vegetation as a Tool for Environmental Monitoring in Legacy Mines

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Remote sensing has proven invaluable to geosciences, supporting applications from mineral exploration to environmental monitoring. In densely vegetated terrain, canopy reflectance often masks the spectral signal of underlying soils and rocks. The vegetation’s spectral response can act as an indirect proxy for soil quality, allowing plants to indicate information and thus serve as a preliminary tool for environmental monitoring. Legacy mine sites that were never adequately rehabilitated often pose serious environmental problems due to the weathering of the waste dumps, discharging toxic elements like heavy metals into surrounding soils and waters.

This study investigates how contaminated soils alter the growing plant’s health and how those stress-induced changes are reflected in vegetation spectral signatures relative to uncontaminated, healthy plants. These changes (anomalies) are detected using vegetation indices through a handheld hyperspectral sensor. The pilot study focuses on a legacy tailings site where geochemical analyses reveal elevated arsenic concentrations in both soil and water. In the study, laboratory pot tests are conducted with four soil treatments: naturally contaminated tailings-derived and uncontaminated soil from the pilot site, clean and artificially contaminated soil matching the pilot site’s heavy-metal load. Seedlings are grown in each substrate until their leaves reach a consistent, analyzable size, at which point hyperspectral measurements begin. Throughout the experiment, macroscopic indicators such as leaf length and visible color changes are recorded to complement the results. Field- and lab-derived vegetation spectra are analysed to expose differences between contaminated and reference sites. Important conclusions regarding vegetation indices are derived from the laboratory tests. The next step is to apply these indices to satellite imagery, generating arsenic contamination maps for AMD-affected pilot sites, which will be validated with in-situ geochemical data. The results should deliver a non-invasive, transferable framework providing insights for generating maps of arsenic-contaminated zones in vegetated mining-affected landscapes.