Portable X-Ray Fluorescence for Autonomous In Situ Characterization of Chloride in Oil and Gas Waste

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Soil salinization resulting from anthropogenic activities affects soil health and productivity. Methods that can provide rapid, inexpensive, and accurate salinity characterization over vast areas of soil and waste materials will help in managing their impacts. Methods have a wide analyte concentration range, and that are also robust against changes in environmental parameters (e.g. moisture content) have greatest potential to be used autonomously on robotic systems. The objective of this work was to evaluate the accuracy and precision of portable X-ray Fluorescence (pXRF) Cl^- measurements of highly saline waste material (WMs) from oil and gas production sites. We compared pXRF Cl^- measurements of three unconsolidated WMs to a standard laboratory method for determining soil salinity and identified the WM properties that most affect the precision and accuracy of the pXRF Cl^- measurement. Despite covering a range of several orders of magnitude in chloride concentration, calibrated pXRF measurements varied by no more than 14% compared to standard laboratory Cl^- measurements for dry homogenous samples. Measurements taken of WMs that were not homogenized decreased pXRF accuracy by 75% while moisture content decreased accuracy by 15%. Field measurements made at different areas inside an oil and gas WM reserve pit were accurate within 60% of the standard laboratory Cl^- measurements, despite the samples having a wide range of moisture content and particle size distributions. This study indicates that pXRF can be used to rapidly characterize soil salinity in situ with acceptable accuracy and precision for screening purposes, opening the door for automated robotic measurements of chloride over large areas.