

## Summary

In recent years, the demand for soil data has increased across various fields, prompting the exploration of more efficient and cost-effective methods for soil analysis. Traditional physiochemical laboratory analyses and soil surveys, while informative, are often time-consuming and expensive. Recognizing this, researchers have turned to innovative techniques, one of which is Portable X-ray Fluorescence (PXRF) spectrometry. Widely employed in both field and laboratory settings, PXRF has gained popularity for its effectiveness in predicting soil qualities. Numerous studies have demonstrated strong correlations between PXRF readings and information obtained through traditional methods, showcasing the reliability and precision of PXRF equipment. As a result, PXRF analyses are increasingly becoming the method of choice for experts in various fields, including ecology, toxicology, soil science, and geochemistry.

However, despite its advantages, researchers are actively working to understand the overall accuracy of PXRF and identify potential sources of error. Notably, there is currently no universally accepted protocol for PXRF sample pretreatment in soil sample analyses. This research endeavors to fill this gap by investigating the impact of different sample pretreatment methods, such as air drying, homogenization, and fine grinding, on PXRF results in comparison to untreated soil samples.

The justification for this study lies in the time-intensive nature of traditional laboratory measurements, which may lead to inaccuracies due to sample contamination and human errors. PXRF spectrometry emerges as a promising alternative, offering increased accuracy, efficiency, and cost-effectiveness. The specific objective of the study is to determine how various soil sample measurement techniques affect PXRF results, with broader goals of comparing different measurement techniques and identifying the most accurate approach.

To guide the investigation, several research questions are posed. These include inquiries into the impact of temperature during measurement, the effects of grinding as a soil sample pretreatment technique, the influence of the time duration between field sample collection and laboratory measurement, and the correlation between soil sample moisture content and measurement results.

Transitioning to the literature review, the historical development of soil science in the 1800s is outlined, emphasizing its multifaceted nature, including soil physics, chemistry, biology, and survey. The subdiscipline of pedology, defined as the study of soil in the field, is explored with its central focus on the soil profile. Soil classification systems, such as Soil Taxonomy and the World Reference Base, are introduced, highlighting their role in organizing knowledge about soils on a global scale.

Moving further, the significance of the soil profile is underscored, depicting it as a vertical cross-section revealing distinct soil layers influenced by various factors over time. A trench between two and six meters deep unveils these layers, providing insights into the formation processes driven by parent rock type, vegetation, terrain, and climate. Understanding soil profiles is deemed crucial for comprehending landscapes and the intricate relationships between rocks and soils forming the profile.

The study utilized the Gödöllő University Forest as its field site, focusing on soil profiles characterized by the WRB/FAO classification system. The profiles consisted of six horizons: O, A, AB, Bt, BC, and Ck. A detailed description of the soil profile, including depth ranges, pH levels, organic matter content, and other properties. Field methods involved sample collection from a soil profile pit in the university forest, conducted in December 2023 at -2°C temperature. The samples were collected vertically from bottom to top, encompassing all horizons, and were subsequently scanned with Portable X-ray Fluorescence (PXRF) in situ. The PXRF measurements were performed using the portable X-ray fluorescence spectrometer.

In the laboratory, the collected samples underwent PXRF scanning under three different conditions: 1) as received from the field (wet sample), 2) air-dried sample, and 3) ground sample (pre-treated) passing through a 2 mm sieve, achieved through grinding with a mortar and pestle. This comprehensive approach aimed to investigate the effects of various sample pretreatment methods on PXRF results.

The data analysis phase involved obtaining descriptive statistical parameters, including mean, standard deviation, median, minimum, maximum, and range for each variable. Microsoft Excel 2007 was utilized for this purpose, employing its data analysis add-in. Additionally, a boxplot was generated to visually represent the concentration of each element in different horizons. The combination of in situ PXRF measurements, laboratory analysis under different conditions, and detailed statistical analysis contributed to a comprehensive understanding of the soil characteristics and the impact of sample pretreatment methods on PXRF results.

In the analysis of different soil elements using Portable X-ray Fluorescence (PXRF) spectrometry, the study focused on magnesium, aluminum, calcium, sulfur, manganese, iron, rubidium, and titanium. The results revealed interesting patterns and limitations of PXRF in detecting certain elements under various conditions.

The analysis of magnesium showed that PXRF had limitations in detecting magnesium concentrations in certain horizons, particularly in the O, A, AB, and Bt horizons. The BC and Ck horizons exhibited measurable magnesium levels. The post-treatment samples showed variations in magnesium concentrations across all horizons, indicating the impact of sample treatment methods. The study highlighted the difficulty of PXRF in reliably detecting magnesium, especially in the absence of a vacuum or He atmosphere.

The analysis of aluminum concentrations demonstrated variations between different horizons and treatment conditions. Pre-treated samples showed consistent aluminum concentrations in most horizons, except for A and Ck. Wet samples displayed nearly constant aluminum concentrations, while dry samples showed variations in the O and AB horizons. Post-treatment samples revealed changes in aluminum concentrations, particularly in the Ck horizon. The study suggested limitations in PXRF's ability to accurately measure aluminum, emphasizing potential losses in the AB horizon.

Calcium concentrations exhibited varying levels across different horizons and treatment conditions. Pre-treated samples showed small concentrations in O, A, AB, and Bt horizons, with a significant increase in the Ck horizon. Wet samples displayed a consistent pattern, while dry samples showed fluctuations in the O horizon. Post-treatment samples revealed a noticeable increase in calcium concentrations in the Ck horizon. The study indicated PXRF's ability to

measure calcium, correlating with soil science principles regarding the sources of calcium in the soil.

Sulphur analysis revealed limitations in PXRF's ability to detect sulphur, with no values observed in certain horizons, particularly in the post-treatment Ck horizon. Wet samples showed sulphur values in all horizons, while dry samples exhibited variations. The study emphasized the challenge PXRF faces in identifying light major elements like sulphur.

Manganese concentrations showed consistent levels across pre-treatment, wet, dry, and post-treatment samples, indicating PXRF's capability to measure manganese accurately. The findings aligned with previous research affirming PXRF's effectiveness in manganese analysis.

Iron concentrations demonstrated stability across wet, dry, post-treatment, and pre-treatment samples, with slight changes in the BC horizon in the dry state. The study supported PXRF's ability to measure iron levels, consistent with previous research findings.

Rubidium analysis showed minimal changes in concentrations across wet, dry, post-treatment, and pre-treatment samples, indicating PXRF's ability to measure rubidium levels reliably. The study supported existing literature affirming PXRF's efficacy in rubidium analysis.

Titanium concentrations displayed stability in the wet, dry, post-treatment, and pre-treatment states, with slight changes in the BC and Ck horizons. The study confirmed PXRF's capability to measure titanium concentrations effectively.

In summary, the study provided valuable insights into the performance of PXRF in analyzing various soil elements under different conditions. While PXRF demonstrated effectiveness in some elements like manganese, iron, rubidium, and titanium, limitations were observed in detecting elements such as magnesium, aluminum, sulfur, and calcium under certain circumstances. These findings contribute to the understanding of PXRF's applicability in soil analysis and underscore the importance of considering specific soil and environmental factors in interpreting results.