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Comprehensive Soil Characterization Using Spectroscopic and Microscopic Techniques

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Abstract: *Various analytical methods have been employed to elucidate the physical and chemical properties of soil.The study employed X-ray diffraction (XRD), Raman spectroscopy, Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy with energy-dispersive spectroscopy (SEM-EDS), and ultraviolet-visible spectroscopy (UV-Vis).Among these, X-ray diffraction (XRD) was chosen for this study because it provides information on the major crystalline minerals (e.g., quartz, feldspar, kaolinite, and montmorillonite), which are the primary factors influencing soil texture, cation exchange capacity, and water retention capacity.FTIR and Raman Spectroscopy revealed organic and clay minerals' molecular structures and functional groups (silicates, -OH, and carbonates).SEM and EDS are used to obtain data on specific spatial and microstructural properties. In addition to this, EDS helped to analyze the elemental composition of soils and many oxides, which are known to be the sources of major soil fertility and structural integrity, including pH, on which soil productivity depends, especiallySiO, AlO, MgO, and CaO. By means of ultraviolet- visible spectroscopy, the connections between the content and quality status of the soils, organic matter, and iron oxides have been determined. The combination of all these complementary analysis methods assisted in the complete description of the I/O properties of the soils. The paper demonstrates the importance of applying both destructive and non-destructive methods (especially those that can be implemented within a short period) to manage soils adaptively.*

Keywords: Soil characterization, Spectroscopic analysis, Microscopic techniques, Mineral composition, Sustainable agriculture

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