

FTIR and XRD analyses of highly weathered Ultisols and Oxisols in Peninsular Malaysia

ABSTRACT

For this study, four soil series with two depth levels (0-15cm, 15-30cm) were collected namely: Bungor, Kuala Brang, Segamat and Kuantan Series. The former two represent Ultisols, while the latter two represent Oxisols in Malaysia. All the samples were subjected to Fourier transmission infrared (FTIR) and X-ray diffraction analysis to determine the functional groups and mineralogical composition. All the soils were found to be acidic in nature (pH 3-5) with Al toxicity, which is an indication of low fertility. From the FTIR analysis, hydroxyl (OH⁻) functional group showed the presence of kaolinite [Al₂Si₂O₅ (OH)₄], halloysite and gibbsite [Al(OH)₃] in both Ultisols and Oxisols. In addition, the carboxylate (C=O) stretching band (Si-O) silicate impurities confirmed the dominance of kaolinite in both soil types. The XRD analysis showed the presence of kaolinite as the major constituent in both Ultisols and Oxisols under study. Besides that, gibbsite, quartz and mica were common in the Ultisols, while mica, goethite and hematite were in trace amount in the Oxisols. Cation exchange capacity which ranged from 7.5 to 12 cmol_ckg⁻¹ were low for all the soils, while exchangeable Al were above the threshold value for the growth of Al sensitive crops. This may indicate the potential of Al toxicity in the soils. Base saturation was in the range of 1.3 to 10.9%, which was very low. All soils were deficient in available P (<9.96 mg kg⁻¹). Meanwhile, free iron (Fe₂O₃) contents were the lowest in Bungor (43 g kg⁻¹) and the highest in Kuantan with the value of 419 g kg⁻¹, indicative of hematite dominance shown supported by XRD analysis. Analysis of variance showed significant differences among exchangeable base cations, carbon, nitrogen and Fe oxides in the topsoil at p<0.05. The soils were acidic and too low in macronutrients (Ca²⁺, Mg²⁺ and K⁺) to sustain agricultural production. Thus, applying appropriate amendments and/or fertilizers containing necessary nutrients is required to enhance soil fertility for crop production.

Keyword: FTIR spectroscopy; XRD analysis; Acidic soil; Low CEC; Fe and/or Al availability