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## Using the Dual Energy Gamma-Ray Transmission Technique to Measure Soil Bulk Density and Water Content of Central Southwestern Nigerian Soils

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### ABSTRACT

In this work, a radiological technique which simultaneously measures soil bulk density and water contents accurately and quickly in a non-destructive manner at different depths of the soil profile of the major soil series of Central Southwestern Nigeria is developed. Undisturbed samples from Iwo, Ondo, Egbeda, Itaganmodi, Okemessi, Mamu, Origo and Jago soil series of Southwestern Nigeria were collected on monthly intervals from June 2006 to May 2007. Using gamma-ray energy pairs of 122 and 1112 keV; and 344 and 1408 keV obtained from europium-152 (<sup>152</sup>Eu) radionuclide, the attenuation coefficients for soil and water,  $\mu_s$ ,  $\mu_w$  and consequently  $\rho_s$  and  $\theta_v$  at varying soil depths of these series were calculated. Comparative gravimetric measurements of these soil parameters were carried out. Using the XCOM computer algorithm with the soil elemental concentrations obtained using the Energy Dispersive X-Ray Fluorescence analysis (EDXRF) technique, theoretical estimates of  $\mu_s$  for the various soil series were obtained and compared with the experimental values. The result of the developed dual energy gamma-ray transmission technique was compared with the gravimetric measurement method and Pearson correlation coefficient (0.987,  $p < 0.001$ ) was obtained for  $\rho_s$  and (0.996,  $p < 0.001$ ) for  $\theta_v$ . The results of the measurements showed that  $\theta_v$  minima with values 0.1931, 0.1987, 0.2377, 0.2111, 0.1738, 0.1701, 0.2334, 0.2341 and minima  $\rho_s$  values of 1.21 g/cm<sup>3</sup>, 1.20 g/cm<sup>3</sup>, 1.02 g/cm<sup>3</sup>, 1.38 g/cm<sup>3</sup>, 1.12 g/cm<sup>3</sup>, 1.14 g/cm<sup>3</sup>, 0.64 g/cm<sup>3</sup>, 1.33 g/cm<sup>3</sup> were obtained respectively for the soil series stated above in January. The maxima  $\theta_v$  with values 0.3621, 0.4212, 0.3962, 0.3794, 0.3049, 0.2811, 0.4415, 0.4416 and maxima  $\rho_s$  values of 1.52 g/cm<sup>3</sup>, 1.67 g/cm<sup>3</sup>, 1.74 g/cm<sup>3</sup>, 1.69 g/cm<sup>3</sup>, 1.70 g/cm<sup>3</sup>, 1.68 g/cm<sup>3</sup>, 1.08 g/cm<sup>3</sup>, 1.54 g/cm<sup>3</sup> occurred for these soil series respectively in July except for Mamu soil series which occurred in May. These correlated very well with the occurrence of the Dry and Rainy seasons in the study area. The results of the EDXRF analysis showed that maxima Iron, Fe concentrations of 5.0890 ppm at the depth of 90 - 120 cm into the soil profile, was obtained for Iwo series, 4.4691 ppm at 50 - 70 cm for Ondo, 6.3438 ppm at 15 - 30 cm for Egbeda, 6.6845 ppm at 30 - 50 cm for Itaganmodi, 5.0252 ppm at 90 - 120 cm for Okemessi, 3.4996 ppm at 30 - 50 cm for Mamu, 5.1191 ppm at 50 - 70 cm for Jago and 4.7193 ppm at 90 - 120 cm for Origo. Maxima Potassium, K concentrations of 2.9613 ppm at the depth of 50 - 70 cm, was obtained for Iwo soil series, 2.3315 ppm at 0 - 15 cm for Egbeda, 2.2763 ppm at 70 - 90 cm for Okemessi and 3.3636 ppm at 50 - 70 cm for Mamu. Maxima Ti concentrations of 1.4822 ppm at 0 - 15 cm was obtained for Ondo soil series, 2.5159 ppm at 15 - 30 cm for Egbeda, 1.8690 ppm at 90 - 120 cm for Itaganmodi, 2.2975 ppm at 15-30 cm for Okemessi, 1.6453 ppm at 0 - 15 cm for Jago and 1.0513 ppm at 30 - 50 cm for Origo.

### KEYWORDS

Dual Energy; Gamma-Ray; Bulk Density; Water Content; Radiological; Attenuation Coefficient

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