SOIL WATER CONTENT AND BULK DENSITY VALUES FOR CENTRAL SOUTH WEST NIGERIAN SOILS AS DETERMINED BY DUAL ENERGY GAMMA-RAY TRANSMISSION TECHNIQUE

Related Symposium Topic: Sharing Data and Information

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Extended Abstract

1. Introduction

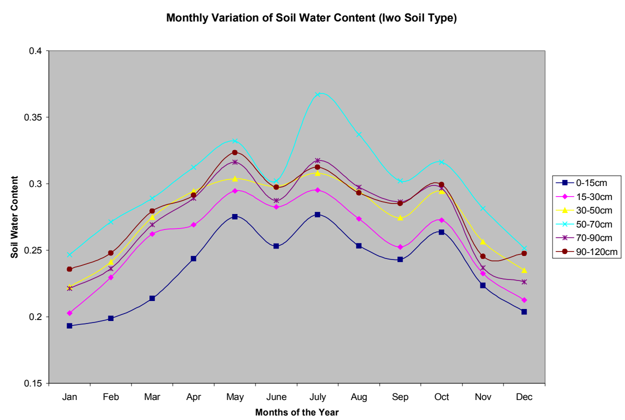
The quantity of ground water or water reservoir in the subsurface and its relation with soil moisture is an important parameter in understanding ground water systems. Plant growth, soil temperature, chemical transport and ground water recharge are all dependent on the state of water in the soil. Maintenance of adequate soil water content through most of the crop-growing period is necessary to support optimum plant growth and yields. Documentation of soil wetness and bulk density at different depths into the soil profile at different periods of the year should go a long way to provide information about soil moisture and more importantly about the exact point at which possible perched aquifers are located. Such information will be of tremendous assistance to designers of sprinklers and drip irrigation systems to develop systems that will pump irrigation water from such ground water reservoirs and also deliver water at rates that will achieve optimal agricultural plant production and quality. Soil bulk density and water content are so dynamic and variable both in space and time and with soil management that specific values can hardly be associated with a soil type; hence it is desirable that these two parameters be frequently observed routinely. The variations in the values of soil water content with depth for different soil types reveal soil types that have high water table and hence soil types from which ground water reservoirs can easily be located close to the surface, thus making possible pumping for irrigation use easier and less expensive than those soils with deep water table. The Central South West Nigeria is drained by a network of seven (7) major river systems all flowing southwards into the Atlantic Ocean. Hitherto, Government owned River basin Authorities (especially the Ogun-Osun and the Benin-Owena) operating in this area divert surface water from these rivers for irrigation purposes thus further depleting available freshwater resource. Exploiting ground water from perched aquifers for irrigation purposes should therefore go a long way in conserving the freshwater resource of this region.

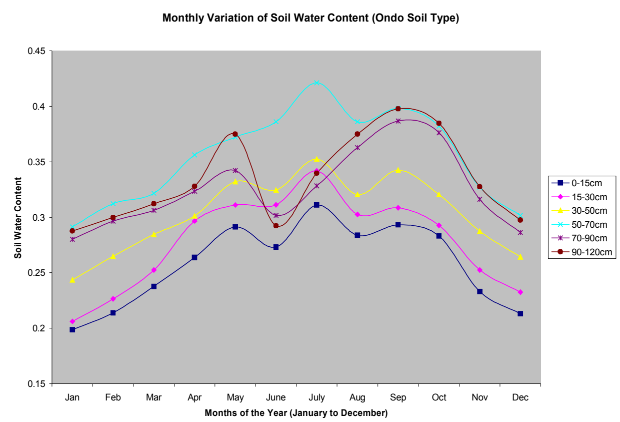
2. Materials and Method

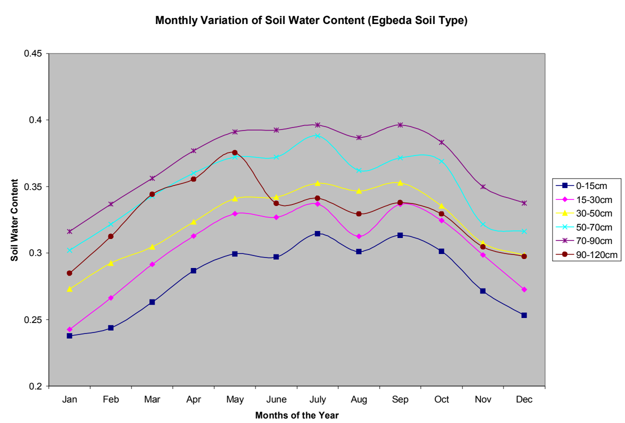
Within the area usually referred to as Central South West Nigeria (lying between longitudes 3^0 15' and 6^0 00' East and latitudes 6^0 35' and 8^0 05' North), test pits whose dimensions are 2m x 1m x 2m were dug at the locations where the eight soil types (Iwo, Ondo, Egbeda, Itagunmodi, Okemessi, Mamu, Origo and Jago) can be found (Smyth and Montgomery, 1962). Using a core sampler, undisturbed soil samples were collected at different depths of 0-15, 15-30, 30-50, 50-70, 70-90, and 90-120cm into the soil profile into similar cylindrical plastic containers, which were covered and tapped all round. Wax was also applied to the container covers to prevent possible loss of water via evaporation. Care was exercised while transporting the collected samples to the laboratory so as to avoid agitating the collected samples. Soil samples were collected at monthly intervals in all the eight locations from June 2005 to May 2007. After collection, the soil samples were taken to the gamma-ray laboratory at CERD, and the gamma-ray spectrometer was arranged in such a way that a narrow beam of gamma-ray emanating from a collimated source (a disc shaped ^{152}Eu radionuclide) passed through the sample and impinged on a well collimated and shielded NaI(Tl) detector. Data was accumulated with the empty container, soil-filled and when filled with distilled water. From the data accumulated, the mass absorption coefficients for water and soil at the varying soil depths were determined using the principles of dual energy methodology and consequently the soil bulk densities and volumetric soil water contents at these varying soil depths were determined. The energy calibration for the detector was carried out using the ^{152}Eu radionuclide as source because the gamma rays obtainable from it covered the entire range of energies over which measurements were made. The spectrum was acquired for 10,800 seconds, and the peaks which correspond to the following energies were used: 1408, 1112, 964, 779, 344 and 122 keV. The energy pairs of 122 and 1112keV; and 344 and 1408 keV were used to determine the volumetric water content, θ_v and soil bulk density, ρ_s at the varying soil depths. The peak areas that were used to determine the numbers of gamma photons N were derived from manually set regions-of-interest (ROI), hence there was no need for a peak width calibration. The activity of the source was corrected for, using the normal decay equation, and the source was located at a distance of 10cm from the scintillator surface along the axis of symmetry of the detector. Gravimetric measurement of soil water content and bulk densities for the same period was carried out (Standard or reference method) and the results were compared; a very good agreement was observed between the two.

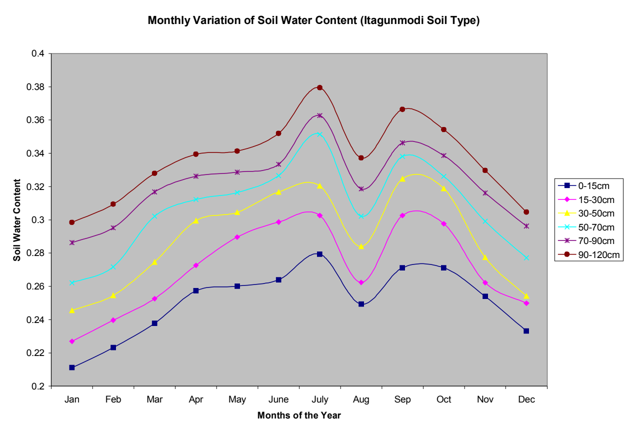
3. Results

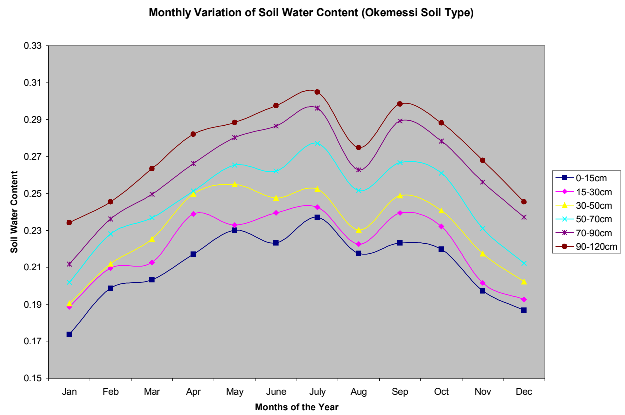
The results for the monthly variations of the volumetric soil water content, θ_v at the varying depths into the soil profile for the different soil types are shown graphical in figures 1 through 8. For all the soil types, the least volumetric soil water content θ_v was obtained at soil depth 0-15cm into the profile, however, the highest θ_v values for the different soil types are revealing. For Iwo soil type, the highest θ_v value ($0.367 cm^3.cm^{-3}$) was obtained at the depth 50-70cm and occurred in July. For the Ondo soil type, the highest θ_v value ($0.4212 cm^3.cm^{-3}$) was again obtained at the depth 50-70cm and occurred in July. Comparative high value ($0.3977 cm^3.cm^{-3}$) was obtained at the depth 90-120cm. The Egbeda soil type had its highest value of $0.3962 cm^3.cm^{-3}$ occurring at the depth 70-90cm in July and September while the Itagunmodi and Okemessi soil types had their highest values of $0.3794 cm^3.cm^{-3}$ and $0.3049 cm^3.cm^{-3}$ respectively in July at 90-120cm depth. The Mamu soil type had its highest θ_v value of $0.2811 cm^3.cm^{-3}$ in May at the 50-70cm depth. Now, the Jago and Origo soil types had very high θ_v values of $0.4415 cm^3.cm^{-3}$ and $0.4416 cm^3.cm^{-3}$ at the 50-70cm and 70-90cm depths respectively in July and beyond these depths no data was obtainable as a result of encounter with water table.

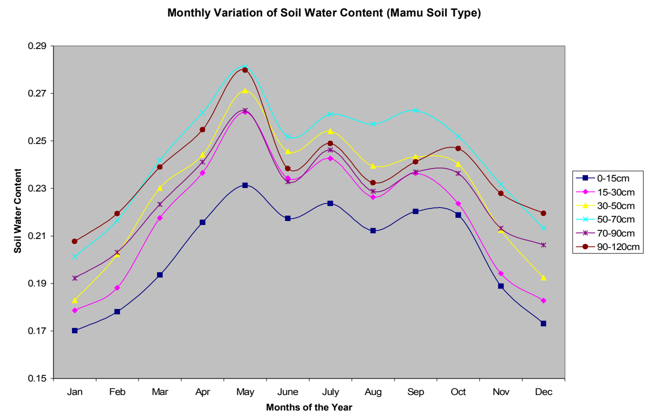


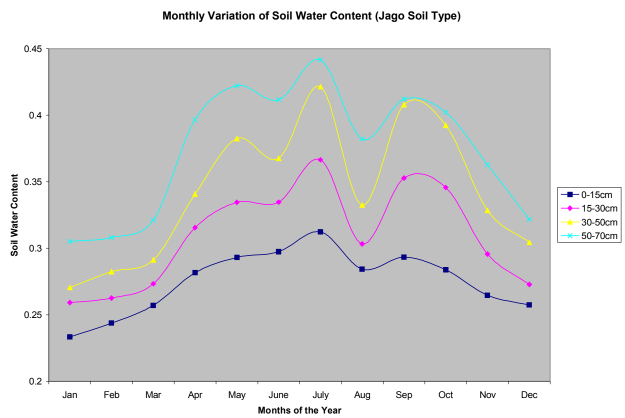


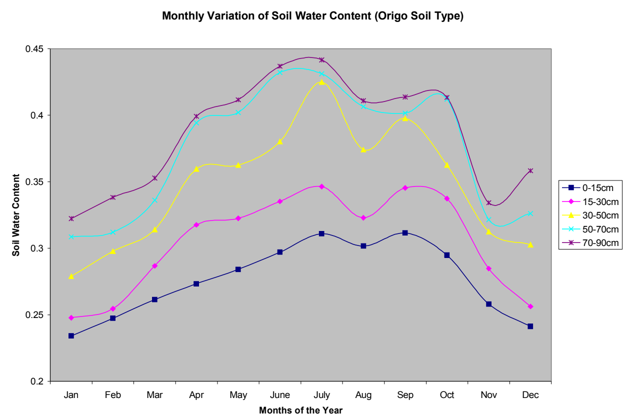












4. Conclusion

These measurements have revealed that useable ground water reservoir exist for the Jago and Origo soil types. Smyth and Montgomery in 1962 described the Jago soil type as soils of various textures in low topographical sites with drainage affected by seasonally high water table; derived from alluvium and local colluvium. The Origo type was described as fine textured soils with impeded drainage; derived from diorite-gneiss. In this work, to a fair extent, the location of perched aquifers in some of the soil types of Southwestern Nigeria have been identified, further work using tomographic image techniques to determine the volume of available water in these aquifers will go a long way in designing irrigation pumping systems for optimal agricultural quality. Finally, from the results of this finding, it may be established that there is a need to allow and respect the free flow of river systems that drain regional boundaries. The Central South West Nigeria is drained by a network of seven (7) major river systems all flowing southwards into the Atlantic Ocean. The values of soil water contents obtained in this region is higher than that obtainable in regions distant from river systems, and to a great extent, this contributes to better agricultural and hence economic value of soils in this region. Thus, when nationals of states and countries where waters flow across communal boundaries respect and allow free flow of these water systems, it leads to improved common economic goals.

References

Smyth, A.J and Montgomery, R.F, (1962). *Soils and Land Use in Central Western Nigeria.* Government Printer Ibadan, Western Nigeria.