KEYNOTE SPEECH

Significance of Soil Moisture Content and its Measurement Techniques

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Soil moisture is an inevitable part of the soil and has a significant influence on the engineering, agronomic, geological, ecological, biological, and hydrological behavior of the soil mass. A small change in the soil moisture content alters the behavior or mechanical properties of the soil mass, viz., consistency, compatibility, cracking, swelling, shrinkage, and density. The soil moisture content can be considered as a multi-disciplinary parameter as it has been used as a critical parameter in civil, agricultural, and environmental engineering disciplines. In geotechnical engineering, construction of embankments, pavements, earthen dam, retaining walls, foundations, evaluation of contaminant transport within the unsaturated zone, and slope stability determination, spatial and temporal soil moisture content variation has vital importance. Furthermore, it has a significant role to play as far as plant growth, organization of the natural ecosystems, and biodiversity are concerned. In the agriculture sector, adequate and timely moisture for irrigation, depending upon the soil-moisture-plant environment, is essential for crop production. Considering the facts mentioned above, the determination of the soil moisture content becomes quite crucial. In this context, earlier researchers have developed several techniques (viz., gravimetric, neutron scattering, soil resistivity, dielectric techniques like time domain reflectometry, frequency domain reflectometry and capacitance, etc.) for measuring this parameter. A critical synthesis of the existing literature indicates that these techniques are quite intricate and expensive (due to elaborate circuitry and paraphernalia) and hence are beyond many. Also, ascertaining the applicability of these techniques to the soils of entirely different characteristics and the 'types of moisture, which they can measure (viz., hygroscopic moisture, free/gravity moisture, bound/ capillary moisture, etc.) is still a point of debate (Susha Lekshmi et al., 2014).

Twenty-eight soils (four standard sands, marine clay, and commercially available white clay, bentonite, and soils from the agricultural fields collected from various parts of India) were selected for this study. These soils were characterized for their physical, chemical, and mineralogical properties to ascertain that they are entirely different. Subsequently, to establish electrical properties of these soils (in their other compaction states), two setups, which employ plate and point electrodes, were developed, and COMSOL Multiphysics® software was used to simulate the zone of influence of the electric field generated by these electrodes in the media contained in them. Subsequently, the point-electrodes' optimized configuration has been employed for measuring the electrical properties of various media, and the results were compared vis-à-vis those obtained from the impedance analyzer (Susha Lekshmi et al., 2016).

Moreover, a critical synthesis of the literature done by Susha Lekshmi et al. (2014) highlights that dielectric based electromagnetic techniques (viz., Time Domain Reflectometry, TDR and capacitance techniques, CT)

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have gained much more popularity, mainly due to revolutionary developments in the field of electronics and data communication systems for instantaneous and non-invasive measurements. Hence, detailed investigations on the relative performance of TDR and CT based probes were also taken up. It has been observed that the dielectric constants obtained from these measurements are not unique. Furthermore, as these techniques employ Topp's equation (a relationship between the dielectric constant, *Ka*, and volumetric moisture content, θ, of the soil mass), its validity was crosschecked, and the *Ka* was related to the dielectric constants obtained from the TDR and CT techniques, and the TP (Time Propagation) mixing model. It is believed that this relationship can be used by the researchers and the field engineers for accurate determination of the volumetric moisture content of the soil mass (Susha Lekshmi et al., 2018).

In addition, to address various geoenvironmental issues that have become a bugbear for the modern-day civilization, and realizing the fact that *Ka* of the soil mass manifests in it the magnetic characteristics of the soil in its dry state, the soils were also tested for their magnetic characteristics by employing a magnetometer. Based on the study, a hypothesis to obtain volumetric moisture content of the soil mass based on the area of the soil's magnetic properties and dielectric constant of its compacted mass obtained from an impedance analyzer has also been proposed. However, the generalization of this relationship and demonstrating its utility and efficiency for soils from different parts of the world remains a challenge (Susha Lekshmi et al., 2018).

Though, most of the issues in moisture sensing have been addressed through this study, efforts should be made to validate the proposed hypotheses by conducting extensive tests on the soils (in their contaminated and uncontaminated states) of different characteristics, collected from different parts of the world, both under in-situ and ex-situ conditions. There is a need to develop a soil moisture sensor that would be reliable, safe, accurate, instantaneous, easy to operate and maintain, not dependent on the soil type and contaminants, and finally it should be economically viable for mass applications.

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