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Importance of Dielectric Constant Study in Agriculture Sector

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Abstract: *The chemical composition and physical characteristics of a material affect its dielectric qualities. Water, air, and both organic and inorganic components are found in soil. Due to variations in climate, habitat, demography, and soil texture, soil types differ from one place to another. For us to receive a good variety of crops to meet our food needs, productive soil is crucial. However, soil contamination has grown to be a serious issue that affects the soil's fertility. An effort has been made to describe the significance of dielectric characteristics in agriculture in this review work. The loss factor is related to a material's capacity to absorb or disperse energy, or to transform electric energy into heat energy, whereas the dielectric constant is related to a material's capacity to store energy in the electric field within the material. It is detailed how different materials' dielectric characteristics change depending on the frequency of the fields they are exposed to, their temperature, and their density. Water has a significant role in agricultural materials; hence its dielectric behavior is covered in this article.*

Keywords: Electrical Conductivity, Moisture Content, density, Apparent Permittivity, Time Domain Reflectometry technique

I. INTRODUCTION

An agricultural economy exists in India. Agriculture is the most significant source of income for the central and state governments. The government of the country has substantial revenue from rising land revenue. Also, the movement of agricultural goods helps generate revenue for the Indian railways, which helps the government in revenue generation. Our needs for food are met by agriculture, which also offers employment opportunities. It is tremendously important to both domestic and international trade. The heart of agriculture is the soil. The main reason for conducting investigations into the dielectric properties of soil is to guarantee the caliber of agricultural output. The progress of agriculture is significantly influenced by soil management. In order to safeguard the environment as well as the country's economy, soil health is crucial.

Theory

The dielectric constant of dry soil varies between 2-3 depending upon the texture whereas the dielectric constant of pure water is around 80 at room temperature and at around 1 GHz. Thus, the dielectric constant will vary between dielectric constant of dry soil and of the saturated soil which is around 30. The chemical components of soil, such as carbon, sodium, potassium, and iron, as well as its physical characteristics, such as sand, silt, and clay, all contribute to its dielectric qualities. Therealpartε'iscalledthedielectricconstantandtheimaginarypart ε'' is called the dielectric loss.[3]A material's capacity to store electromagnetic energy is indicated by its dielectric constant, while a material's loss of the electromagnetic field is shown by its dielectric loss.

Relation of Dielectric Parameters

Increase in temperature in the temperature range considered increases the dielectric constant and loss factor of this material. Further increases in temperature may result in an increase or decrease in ε' and ε'' depending upon the material. In the world of agriculture, understanding soil's dielectric properties is crucial. By increasing the soil's productivity, it enables the farmer to produce a high harvest. Numerous factors, including those listed below, are linked to soil's dielectric behavior.

Moisture content and its relation to Soil Texture

The materials were compressed to their maximum dry density and the relationship between the dielectric constant and moisture content revealed that there is no association between the two variables for sand. With rising moisture content, a rise in dielectric constant was seen for all other materials. The amount of soil moisture affects plant growth. Moisture levels in the soil affect its hydrological behavior and its capacity to fend off erosion.[2]Many applications in the field of agriculture require knowledge of the water content of the soil as a crucial prerequisite. The soil's dielectric constant is influenced by soil moisture and soil structure. The dielectric characteristics of soil are affected by its moisture content.[9] Dry soil has a limited dielectric capacity. The dielectric constant of soils increases as moisture content increases.[4]We can use a variety of strategies to improve the productivity of the soil and the quality of the agricultural output by knowing the percentage of moisture content.

Porosity and Bulk Density

Porosity is the volume of soil that is filled with either water or air. It is inversely related to bulk density, as bulk density increases, porosity decreases. Soil texture is an important determinant of porosity. Porosity of mineral soils is often around 50% for both sandy and clayey soils. The dielectric constant of the soil is influenced by porosity, which is impacted by bulk density. The relationship between bulk density and the dielectric component is favorable.[10] The dielectric permittivity of a material affects how electromagnetic waves interact with it. The real component of the dielectric constant is increased by the number of induced dipoles per unit volume produced when an electric field is applied to a dielectric material. When an oscillating electric field is present, these dipoles align themselves with the field direction. As the bulk density increases, so will the soil dielectric constant. The fertilizers increase the soil's pore space. The dielectric constant increases along with pore space and soil richness.[11,12]Because fertilizers contain a variety of organic chemicals, as fertilizers.

Soil Permittivity

The TDR method is a transmission line technique and determines apparent permittivity from the travel time of an electromagnetic wave that propagates along a transmission line, usually two or more parallel metal rods embedded in soil or sediment. There is a strong relationship between moisture content and permittivity of thesoil. From the analysis of permittivity of the soil we can enhance the productivity of the soil bycontrollingwatercontentinthesoil.[8]

Soilquality

Soil texture can be expressed significantly by its electrical conductivity and dielectric constant. Dielectric constant decreases with increase of sand percentages whereas it increases with the increase in percentage of silt and clay in soil.[5] Mineral components of soil are sand; silt and clay and their relative proportions determine asoil's texture. Properties that are influenced by soil texture are porosity, infiltration, permeability, shrink-swell rate, water holding capacity and susceptibility to erosion. The texture of a soil is a stable parameter that does not change with respect to time. Soils are made up of solids, liquids and gases mixedtogetherinvariableproportions. Theproportionofairandwaterpresentdependsonthestructureofthesoil. Size of particles and structure of the soil decides texture of the soil.[6] Thedielectric properties of a soil depend on the texture of the soil particles viz. sand, silt, or clay.[7,8]

Soil Salinity

Electrical conductivity (EC) is the most common measure of soil salinity and is indicative of the ability of an aqueous solution to carry an electric current. Soil salinity refers to dissolved salts such as sodium chloride, calcium chloride and magnesium chloride, but the dependence on soil salinity is extremelysmall and negligible whereas the imaginary part is controlled by both the soil moisture and salinity.According to some researchers, the real part of the dielectric constant decreases with an increase insalinity, whereasparticularlyatlowfrequenciesthe imaginarypartincreaseswith salinity. Theseresultsdidnotgivetheconcreterelationbetweentherealandimaginarypartsofthedielectricconstantandthesalt content of saline soils.[12,13,15] All soils contain some water-soluble salts, but whenthesesaltsoccurin amounts thatareharmfulforgerminationofseedsandplantgrowth,theyarecalledsaline. Salinity reduces plant growth through osmotic and toxic effects, which decreases root growth,and reduces water movement through the rootwith a decrease in hydraulic conductivity.[12-16]

II. CONCLUSION

Aspects of the soil have an impact on agricultural output. Dielectric characteristics can be used to forecast the soil's fertility, health, and texture. The amount of moisture in the soil has a big impact on how productive it is. In agriculture, factors including bulk density, porosity, permittivity, soil texture, and salinity are crucial. Additionally, soil's dielectric characteristics can help improve soil productivity in agriculture and microwave remote sensing.

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