IMPACT ANALYSIS OF VARIATION IN SOIL TEXTURE FOR OF DIELECTRIC BEHAVIOUR

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ABSTRACT

The goal of the current study is to examine how variations in soil texture affect estimates of dielectric behaviour. According to one definition, soil is a heterogeneous mixture of silicate particles, humus, insoluble salts, and metal oxides that represents the solid, liquid, and gaseous phase. Even in the tropical circumstances found in India, the organic matter content and structural improvement of soil can be developed and maintained with the regular and thoughtful application of manures. The results of the study show that the texture of soil affects its dielectric constant. The soil's dielectric constant is highly influenced by the soil's texture and moisture content. The soil's moisture content has a big impact on how dielectric it is. By studying soil characteristics such as texture, moisture content, and dielectric constant, researchers and practitioners can make informed decisions to optimize agricultural practices. This knowledge is particularly valuable in the context of microwave remote sensing, where accurate information about soil properties can enhance the effectiveness of remote sensing techniques for agricultural monitoring and management. Ultimately, the study of soil's dielectric behavior can contribute to improving productivity in agriculture.

Key words: Soil texture, heterogeneous, humus, organic matter, soil, remote sensing, phase.

Introduction:

Textural analysis and electrical conductivity is very essential for any researcher in the relation to soil behaviour [1]. Besides the moisture content is also very important. Soil texture consists of particle size distribution, limitation of Stocke's law, soil structure and and aggregation, soil colour, soil consistency, soil plasticity, soil compaction, soil crusting, hydration, swelling, specific surface, soil tilth and tillage, soil conditioners, soil water energetics, total soil water potential, differential water capacity, hysteresis, hydraulic conductivity, permeability, fluidity, Reynolds number, soil water diffusibility, infiltration, redistribution of soil moisture, soil water balance, evaporation, groundwater drainage, solute transport, diffusion, hydrodynamic dispersion, soil aeration, characterization of soil aeration status [2-3], dynamics of soil aeration, soil aeration management, soil aeration in relation to plant growth, soil temperature in relation to plant growth, thermal properties of soil, heat transfer through soil, soil temperature management. Soil rheology is a also very important in which stress, strain, Hooke's law, Poisson ratio, modulus of rigidity, bulk modulus plays important role in soil [4]. It is well known that texture of soil refers to relative proportion of different size groups of individual soil grains in a mass of soil. Specifically it refers to the proportion of clay, silt and sand below 2 mm diameter. The table 1 of soil texture is given below:

Table 1: Particle size Classification system of the U.S. Department of Agriculture and the International Soil Science society

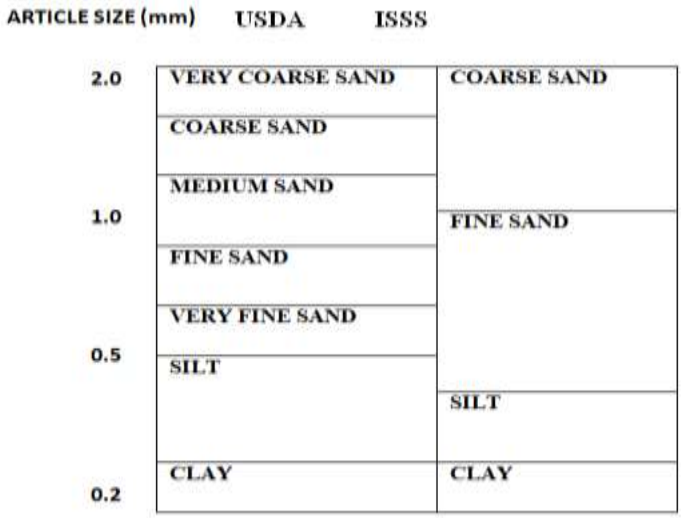

Table 2: According to International Soil Science society (ISSS)

S.No	Name of Soil Separate	Particle Diameter (mm)
1	Coarse Sand	2-0.2
2	Fine sand	0.2-0.02
3	Silt	0.02-0.002
4	Clay	<0.002

Table 3: According to U.S. Department of Agriculture (USDA)

S.No	Name of Soil Separate	Particle Diameter (mm)
1	Very Coarse	2.0-1.0
2	Coarse	1.0-0.5
3	Medium	0.5-0.25
4	Fine	0.25-0.10
5	Very Fine	0.10-0.05
6	Silt	0.05-0.002
7	Clay	<0.002

Table 4: According to British Standard Institution (BSI)

S.No	Name of Soil Separate	Particle Diameter (mm)
1	**Very Coarse**	2.0-0.6
2	**Coarse**	0.6-0.2
3	Medium	0.2-0.06
4	Fine	0.06-0.02
5	Very Fine	0.02-0.006
6	Silt	0.006-0.002
7	Clay	<0.002mm

The textural grades are listed in order of coarsest to finest and include sand, loamy sand, sandy loam, loam, clay, silty clay, and clay [5-7]. Clay soil stands out because it can store a lot of water and is very plastic, sticky, and expanding, whereas sandy soils are obvious because the particles are absent. The word "soil structure" refers to the organisation or arrangement of soil particles. Soil continues to be a composite body. It speaks about the overall general arrangement or combination of primary soil particles in secondary groupings known as aggregates or peds. Various forms of soil structures are described as,

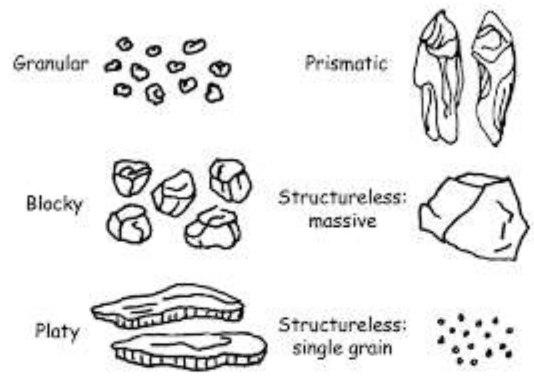

Fig. 1: Soil Structure

The present paper focuses on the impact analysis of variation in soil texture for the estimation of dielectric behavior [8-9]. Soil is a complex mixture of various components such as silicate particles, humus, and various types of salts and oxides of metals, which constitute the solid-liquid-gaseous phase. Soil's organic matter level and structural improvement can be enhanced and maintained by the judicious application of manures, especially under tropical conditions prevalent in India.

The study found that the dielectric constant of soil is closely related to soil texture, with different soil textures exhibiting varying dielectric behavior. Moisture content in soil also significantly affects its dielectric properties. This study of soil is useful in microwave remote sensing and agriculture, as it can help to increase productivity by identifying soil characteristics that are conducive to plant growth.

Overall, this research highlights the importance of understanding the relationship between soil texture, moisture content, and dielectric behavior for improving agricultural practices and remote sensing applications. By carefully managing soil texture and moisture, farmers can improve crop yields and ensure sustainable agriculture practices. Increasing soil temperature increases rate of water absorption by plants along with uptake of soil nutrients. Temperature range of 15°C -40°C is the best for growth of plant, above and below which growth rate is severely restricted. However, it has to be borne in mind that growth of crop plants is dependent on several factors viz. species and varieties of crops, age of the plant, stage of development etc.

Soil temperature directly affects plant functions viz. photosynthesis, respiration, transpiration, absorption of water and nutrients etc. Effect of temperature on photosynthesis is complex and varies with carbon dioxide content of the atmosphere, plant species, duration and intensity of light. If light is limiting, temperature has little effect on photosynthesis, whereas, on the contrary photosynthesis increases with an increase in temperature though carbon dioxide may be limiting. Respiration and transpiration rate increases with increase in temperature. Temperature also affects plant growth indirectly by its effect on microbial population in the soil. Optimum temperature requirement for most beneficial soil microorganisms is between 10°C -30°C below and above which their activity is restricted. Soil temperature also has profound effect on soil air change as composition of soil air is related to activity of microorganisms. When microbial activity is more, partial pressure of carbon dioxide in soil will increase due to increase in decomposition of soil organic matter and there will be decrease in partial pressure of oxygen that in turn affects the rate of respiration, water and/or nutrient absorption by plant roots [10].

Textual class of a soil maybe determined by two methods such as

1. Feel method
2. Laboratory method

In older method of grading the particles used to be separated into the following categories such as stones, coarse sand, fine sand, silt, fine silt and clay (table 6). More recently the following ranges have been adopted for international use.

Table 6: diameter limits of different material

Fraction	Diameter limits
Stones	>2.0mm
Coarse Sand	2.0-0.2mm
Fine Sand	0.2-0.02mm
Silt	0.02-0.002mm
Clay	<0.002mm

Theoretical Consideration:

In fact, understanding soil's microwave dielectric behaviour depends greatly on the texture of the soil. A thin layer of the Earth's crust that acts as a natural growing medium for plants is generally referred to as soil. It is made up of loose mineral fragments that have been subjected to a variety of influences over a long period of time, including source material, climate, creatures, and terrain [11].

Soil's dielectric constant changes depending on the frequency used. Dielectric dispersion results from the application of an adequate frequency alternating electric field. The distinctive orientation motions of the soil's dipoles, which cause changes in the dielectric constant and the appearance of dielectric loss, are the cause of this dispersion.

The forces preventing dipole orientation become dominant at sufficiently high frequencies where the electric field's direction changes quickly, making it impossible for the dipoles to track the changes. As a result, the dielectric constant is less affected by the permanent dipoles' orientation. Energy is extracted from the electric source and lost as heat when a phase lag between the electric field and dipole orientation develops within a given frequency range.
Understanding these principles of dielectric behavior is vital for analyzing soil properties using microwave remote sensing techniques. By studying the frequency-dependent dielectric properties of soil, researchers and agricultural practitioners can gain valuable insights into soil moisture content, texture, and other relevant characteristics, enabling them to make informed decisions to optimize agricultural practices and increase productivity (Fig. 1).

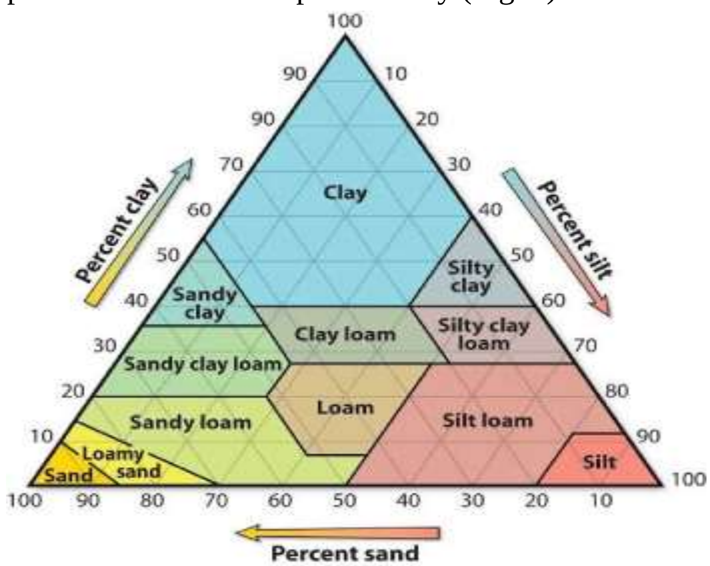

Fig.1 : Soil Triangle

The phenomena is described by equation

$$\epsilon = \epsilon' - j\,\epsilon''$$

Here ϵ' is dielectric constant ϵ'' is dielectric loss and $\tan\delta = \frac{\epsilon''}{\epsilon'}$ is the loss tangent and δ is loss angle.

Dielectric constant of water is described by the modified Debye's equation

$$\epsilon = \epsilon_\infty + (\epsilon_s - \epsilon_\infty)(1 + j\omega\tau)$$

This in component form reduces to

$$\epsilon' = \epsilon_\infty + (\epsilon_s - \epsilon_\infty)/(1 + \omega^2\tau^2)$$

$$\epsilon'' = (\epsilon s - \epsilon_\infty)\,\omega\tau/(1 + \omega^2\tau^2)$$

where ϵ_s is the static dielectric constant

ϵ_∞ is high frequency limit of dielectric constant

ω is the applied angular frequency $(2\pi f)$ τ is relaxation time

It is emphasised in the discussion that a number of factors, including soil texture and the presence of bound water, affect soil's dielectric constant. Understanding the behaviour of soil water molecules is essential for comprehending dielectric characteristics.

When an electric field is applied, water molecules in the soil align themselves with the field due to their permanent dipole moment. This orientation response is characterized by an exponential function, and the time constant (relaxation time) τ determines the speed of this response. The relaxation time is influenced by the interactions between water molecules and their environment, as well as the temperature.

It is noted that the presence of non-electric forces can impede the response of water molecules to the applied electric field, effectively increasing the relaxation time. Bound water molecules in soil tend to have longer relaxation times compared to free water molecules.

The study also emphasizes the impact of water content, texture, and nutrient status on the dielectric constant of soil. The dielectric constant is sensitive to variations in these factors. Moreover, it is mentioned that the dielectric constant of soil is independent of frequency, indicating that it remains relatively constant over a wide range of frequencies.

Accurate values of the dielectric constant are crucial for designing sensors used in microwave remote sensing. By understanding the dielectric properties of soil, particularly with regard to moisture content, researchers and practitioners can develop more effective strategies for agriculture and improve the productivity of soil (Fig. 2 & 3).

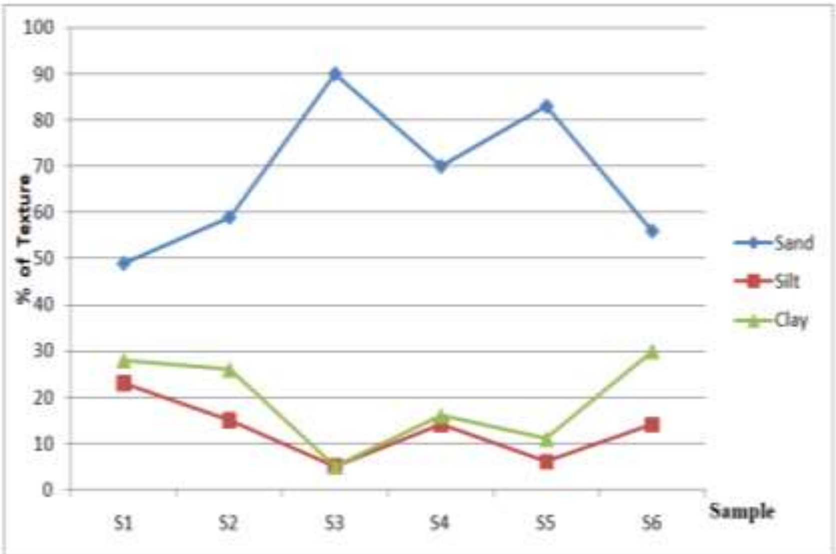

Fig. 2: Textural analysis of Sand, Silt and Clay

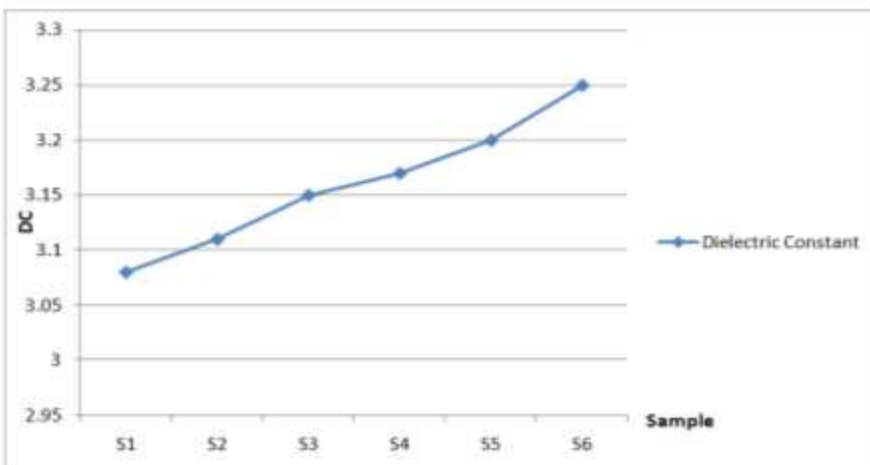

Fig. 3: Dielectric constant of samples

Conclusion:

The characterisation of soil via microwave remote sensing is crucial for agricultural use. Dielectric properties and basic soil characteristics are crucial in agriculture. Fertilisers play a crucial role in agriculture. Agriculture productivity is increased by suggested fertilisers and soil testing. It has been proven beyond a doubt that soil fertility is improved by dielectric characteristics. Textural classes, bulk density, porosity, wilting point, field capacity, transition moisture, hydraulic conductivity, pH, electrical conductivity, organic carbon, calcium carbonate, available nitrogen, available phosphorous, potassium, available iron, available manganese, available zinc, available copper, dielectric constant, dielectric loss, tangent loss, emissivity, scattering, and absorption, which vary with dielectric.

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