ANALYSIS AND INTERPRETATION OF MICROWAVE DIELECTRIC BEHAVIOUR OF VEGETABLE-BASED SOIL

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ABSTRACT

Soil plays a very important role in vegetable production. Soil has physical, chemical, geographical as well as electrical properties. Chemical properties have very significant role in agriculture. In this paper our main focus is to estimate the chemical properties. The Chemical properties act as a bridge regarding vegetable production. Chemical properties of soil comprise pH, organic carbon and nutrients. Physical and chemical properties are different to different region. It has been observed that dielectric constant increases with increasing the moisture content.

Keywords: Agriculture, Chemical properties, Electrical properties,Geographical, Nutrients, Organic carbon, Vegetable.

Introduction: Dielectric properties of the material depend on the activity of permanent electrical dipoles. The microwave soil dielectric measurement uses absorption of microwaves corresponding to rotational energy of molecules when electromagnetic field is applied to the dielectric material, energy is dissipated in this material, as a result of dielectric relaxation process. The interaction of electromagnetic field depends upon the complex dielectric permittivity relative to the free space. The dielectric properties of soil are function of its naturally available chemical constituents such as carbon, sodium, potassium, iron and physical properties such as sand, silt, clay. Soil moisture plays an important role in the functioning of ecosystems. Remote sensing techniques offer an alternative means of fulfilling this gap for rapid measurement of the moisture status near the soil surface over extended areas. The technique can also be used to measure soil moisture quantitatively on bare and short vegetated surfaces. Basic to the soil moisture information is the knowledge of its permittivity (Dielectric Constant).Dielectric Constant of dry soil is independent of temperature and frequency. The imaginary part ε'' is < 0.05. The dielectric constants are dependent on moisture content. Dielectric constant decreases with decreasing the moisture content in the soil. Due to this Dielectric constant of sand decreases with increasing percentage of sand in soil. The Dielectric constant increases with increasing the moisture content in the soil. Due to this Dielectric behaviour of silt increases with increasing the percentage of silt.

Theoretical Consideration: Experimental techniques for determining dielectric properties of soils

In present decade, the dielectric property of material has gain significance in many industrial applications because these properties provide very useful information to enhance design, processing, cost and quality of product. Golhar N.P., (2020) explained that the dielectric properties of soil have been shown very close relationship with the frequency of measurement. There is not a single technique available that will work for the entire frequency of measurement. There is not a single technique available that will work for the entire frequency range, so several techniques are used. Each technique has unique significance. While selecting a perfect measurement technique for our research work there are so many factors that have to be taken into consideration like measuring frequency, measurement temperature, sample size, testing material and its nature, cost and loses associated with the materials. Behaviour of material is dynamic because dielectric properties depend on frequency and temperature.

Venkatesh M.S. and Raghavan G.S.V., (2004) illustrated that the measurement techniques for measurement of dielectric properties can be broadly divided into two categories:

1. Resonant method
2. Non resonant method

Resonant method can characterize the material at single or with some discrete frequency points. In this method a dielectric material used as a resonant element. This method is suitable for lower and moderate loss samples.

A non-resonant method can measure over the broad range of frequencies. It can categorize the material by determining the reflection and transmission coefficient. That is caused by changes in characteristic impedance and wave velocity. The sum of reflection coefficient and transmission coefficient is always equal to 1.

Dielectric properties of soil:

Dielectric properties is an important characteristics of material ; it depend on the activity of permanent dipole, ionic conduction and degree of dipole alignment when the time varying electric field is applied. Dielectric constant shows the ability of the material to store electrical energy. The soil characterization of region play important role in sustainable farming. There is lots of parameters that affect the farming production. It has been observed that sand, silt, clay, electrical conductivity, bulk density, porosity, pH, macronutrients, moisture content, affected the dielectric constant of soil. Although it has been seen experimentally in my research work.

Analysis of effect of moisture content on dielectric properties of soil:

The table below represent the real and imaginary part of dielectric constant at different moisture level (0%, 10%, 20%, 30%, 40%). Moisture content of soil is an important parameter that influences the properties of soil.

Table: 1 Dielectric constant and dielectric loss at moisture level (0%, 10%, 20%, 30%, 40%).

On the basis of dielectric constant and dielectric loss, tangent loss can be calculated which is tabulated below

$$\text{Tangent loss: } \tan\delta = \frac{\epsilon''}{\epsilon'}$$

S.NO.	Sample	Real part of dielectric constant Ɛ′					Imaginary part of dielectric constant Ɛ''				
		Dry soil (0%)	10%	20%	30%	40%	Dry soil (0%)	10%	20%	30%	40%
1.	S_1/Mangla, Bilaspur	3.13	6.92	11.19	16.89	26.29	0.23	0.28	0.40	1.19	1.47
2.	S_2/ Mahasamund, Raipur	3.03	6.59	11.02	16.66	26.27	0.11	0.19	0.33	1.19	1.17
3.	S_3/ Rajnandgaon, Durg	3.15	6.77	11.13	16.79	26.48	0.16	0.25	0.38	1.57	1.27
4.	S_4/ Ambikapur, Surguja	3.19	6.86	11.18	16.83	26.51	0.20	0.26	0.37	1.83	1.38
5.	S_5/ Jagdalpur, Baster	3.11	6.61	11.11	16.71	26.34	0.14	0.23	0.36	1.36	1.19

Table: 2 Calculated value of tangent loss for different moisture level (0%, 10%, 20%, 30%, 40%).

S.NO.	Sample	Tangent loss				
		Dry soil (0%)	10%	20%	30%	40%
1.	S_1/Mangla, Bilaspur	0.073	0.040	0.035	0.070	0.055
2.	S_2/ Mahasamund, Raipur	0.036	0.028	0.029	0.071	0.044
3.	S_3/ Rajnandgaon,Durg	0.050	0.036	0.033	0.093	0.047
4.	S_4/ Ambikapur, Surguja	0.062	0.037	0.033	0.108	0.052
5.	S_5/ Jagdalpur, Baster	0.045	0.034	0.032	0.081	0.045

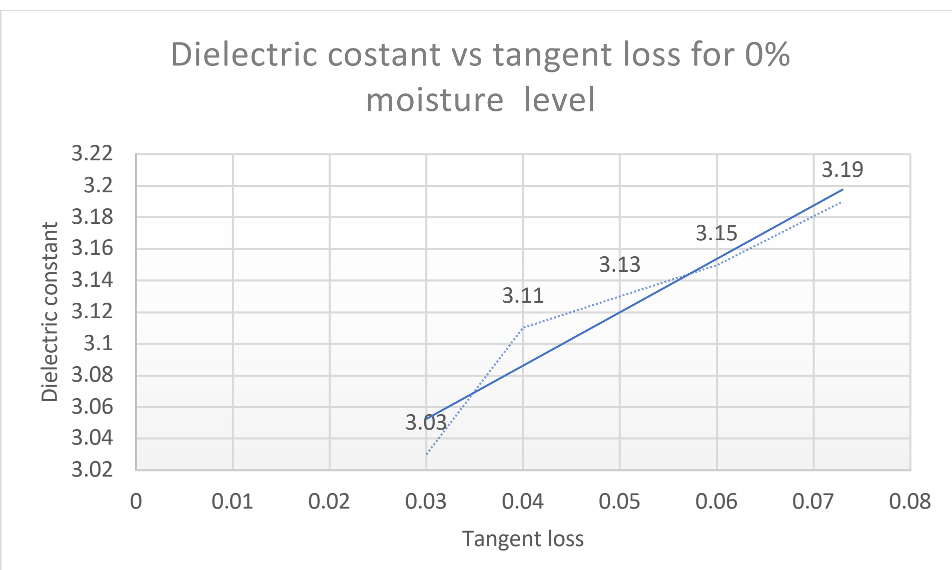

Fig.1 Variation of dielectric constant ∈ ′ with tangent loss for dry soil (0%) of different samples.

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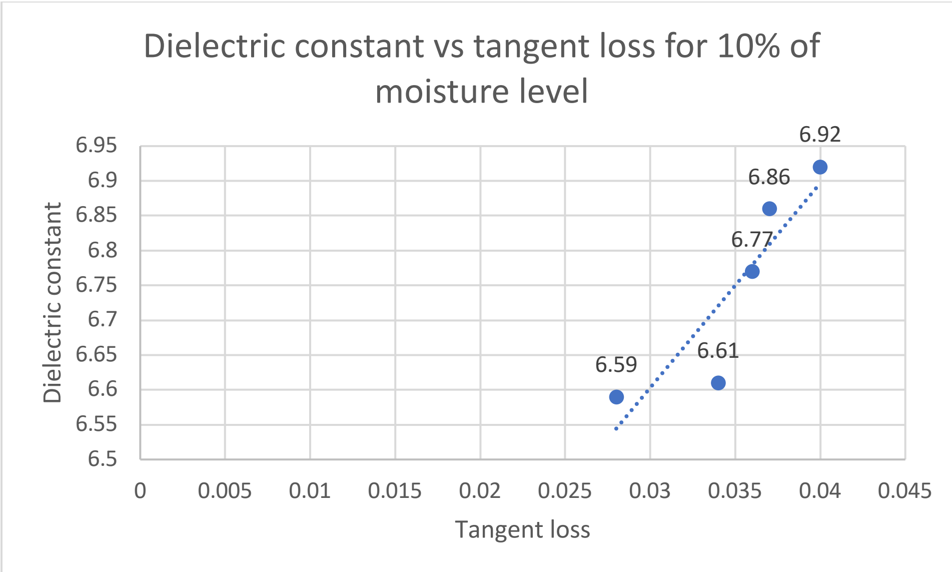

Fig.2 Variation of dielectric constant ∈ ′ with tangent loss for (10%) moisture level of different samples.

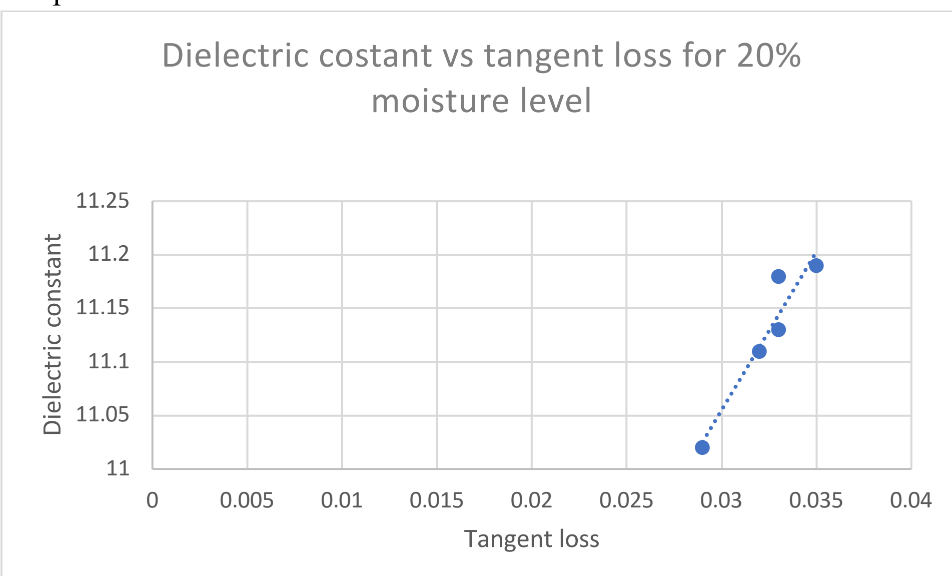

Fig.3 Variation of dielectric constant ∈ ′ with tangent loss for (20%) moisture level of different samples.

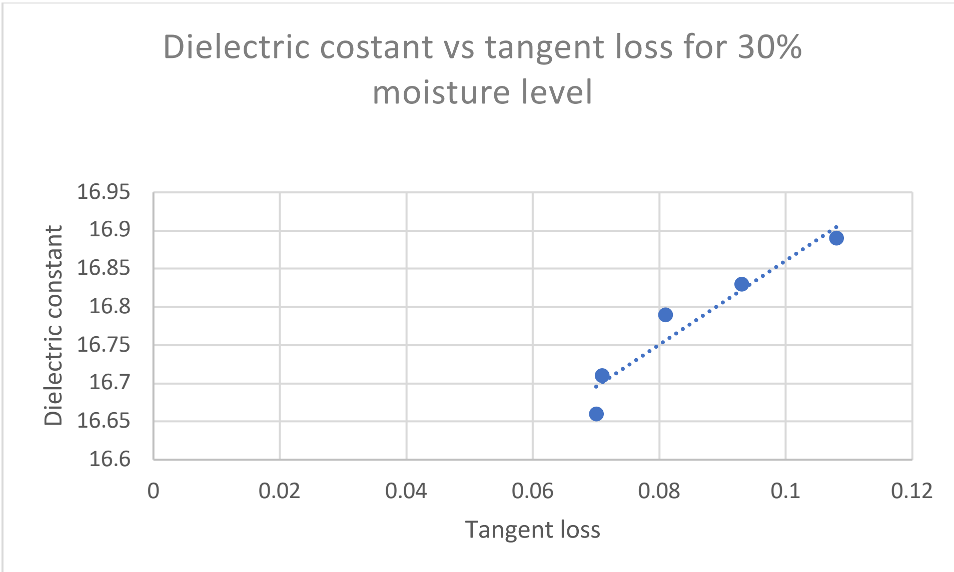

Fig 4 Variation of dielectric constant ∈ ′ with tangent loss for (30%) moisture level of different samples.

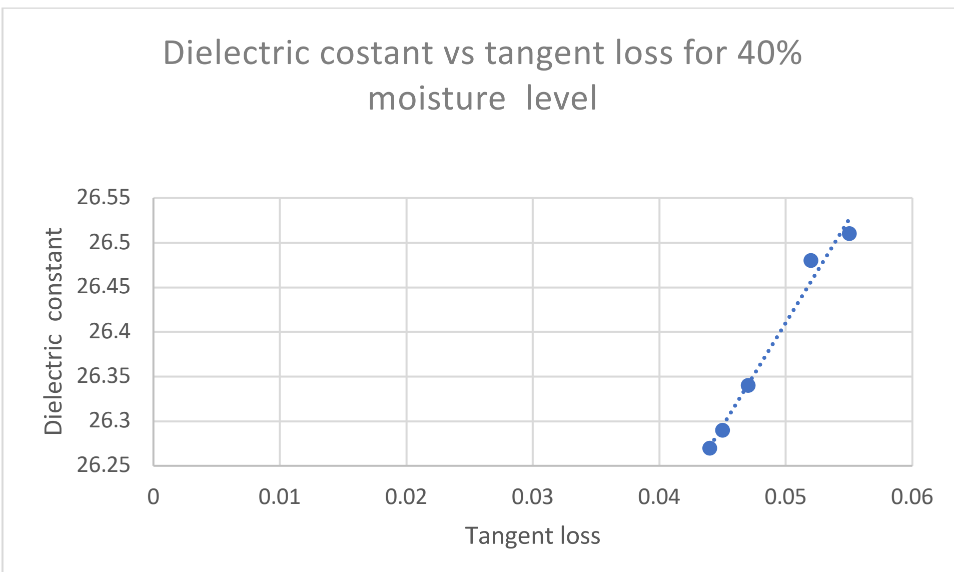

Fig. 5 Variation of dielectric constant ∈ ′ with tangent loss for (40%) moisture level of different samples.

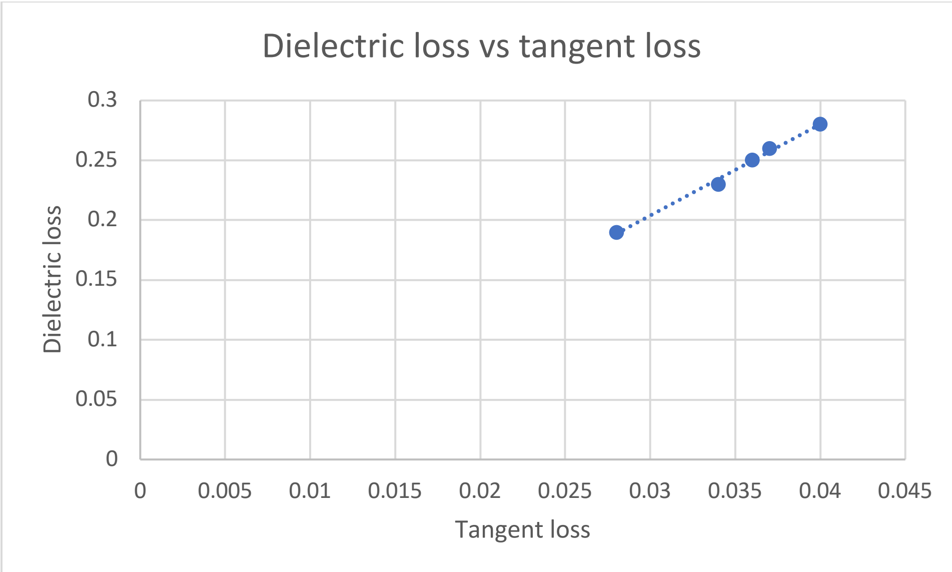

Fig. 6 Variation of dielectric loss ∈ ′′ with tangent loss for dry soil of different samples.

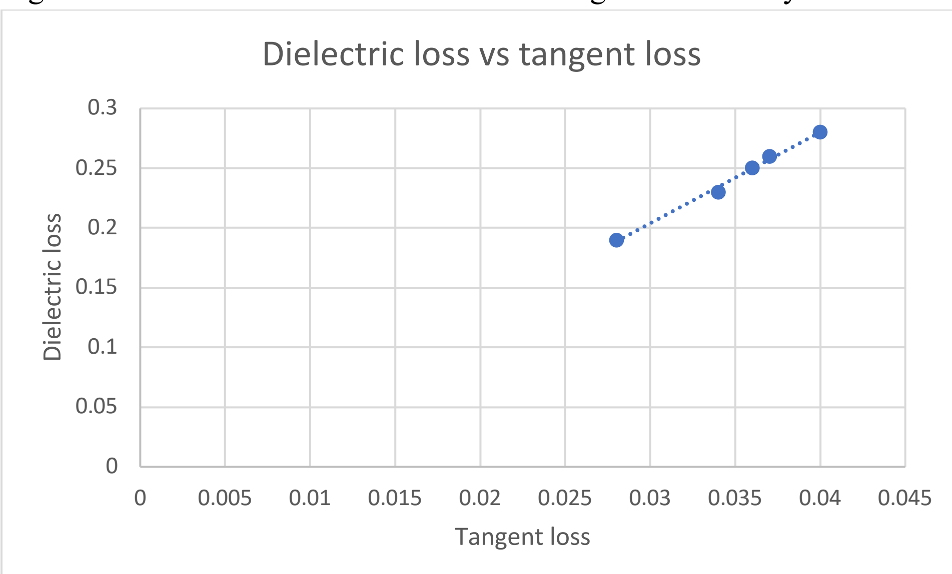

Fig. 7 Variation of dielectric loss ∈ ′′ with tangent loss for 10% moisture level of different samples.

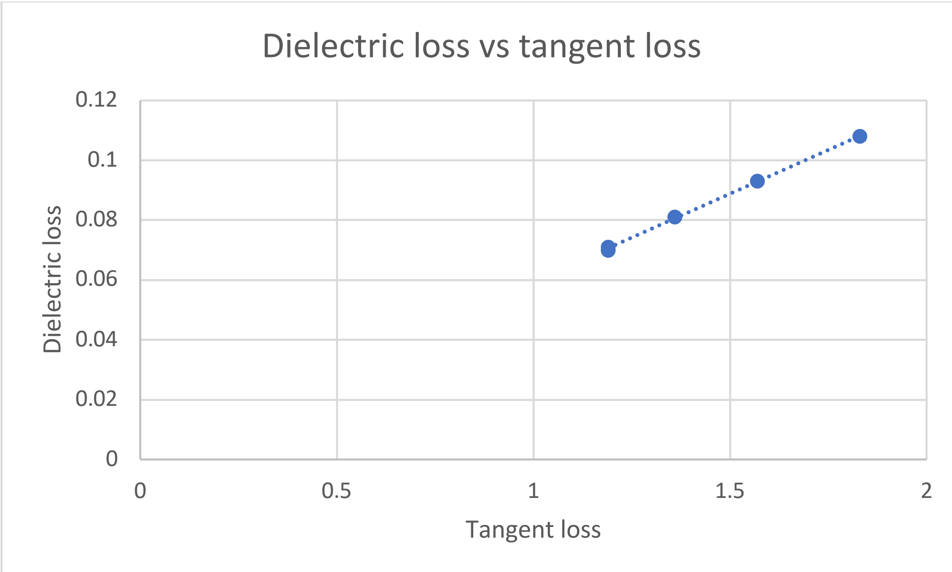

Fig 8 Variation of dielectric loss ∈ ″ with tangent loss for 20% moisture level of different samples.

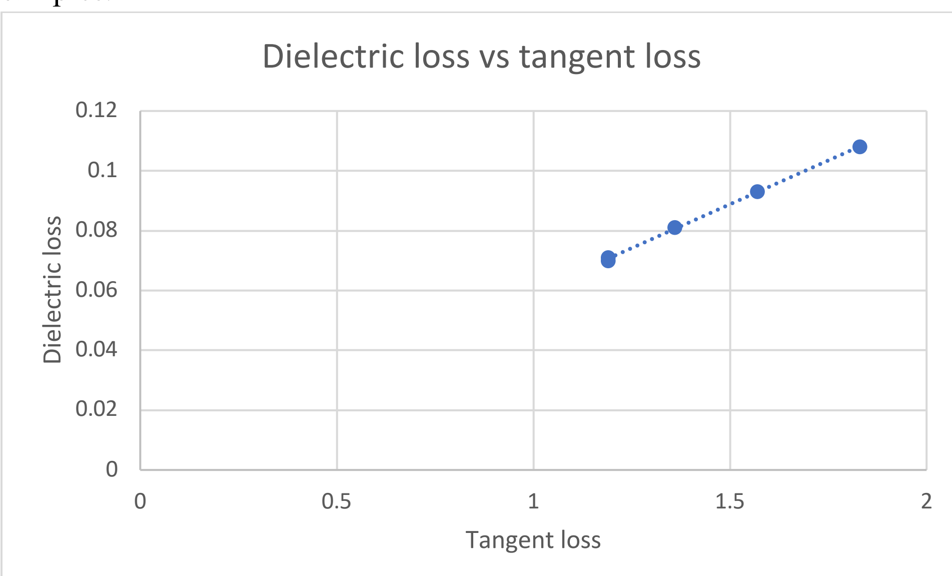

Fig.9 Variation of dielectric loss ∈ ″ with tangent loss for 30% moisture level of different samples.

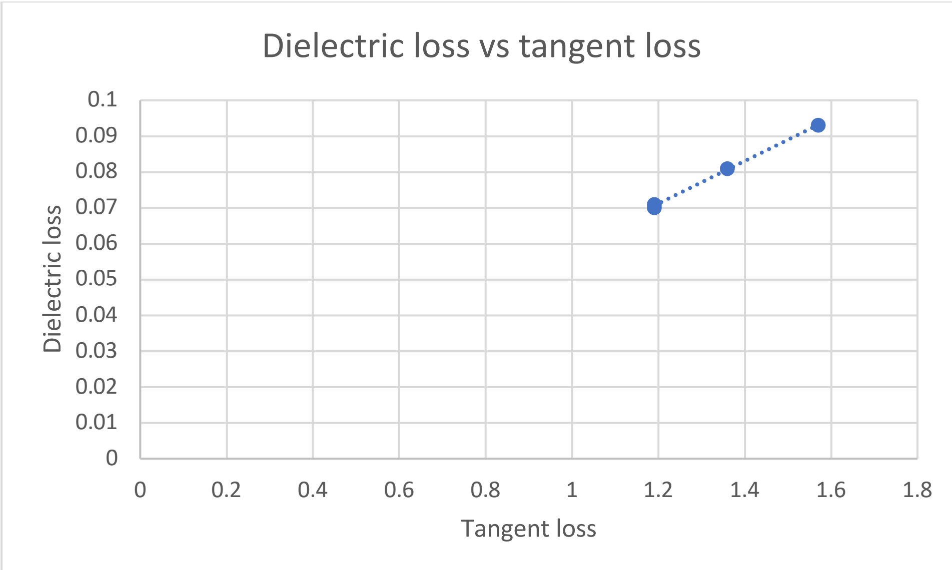

Fig.10Variation of dielectric loss ∈ ″ with tangent loss for 40% moisture level of different samples.

Analysis and interpretation: Graphs are plotted between dielectric constant ∈ ′ and dielectric loss ∈ ″ with tangent loss. Both the graph show linear variation. For each of five samples graphs are plotted that shows the variation of dielectric constant and dielectric loss with different pH value, Electrical conductivity, organic carbon, and different nutrients.There are so many parameters viz Physical and Chemical parameters that affect the microwave dielectric behaviour of vegetable-based soil.

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