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Review And Analysis of Microwave Remote Sensing Behaviour of Soil In India

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Abstract- In this paper an attempt has been made to review as well as analyze the microwave remote sensing behaviour of soil in India Soil and dielectric constant Knowledge of dielectric constant of soil at microwave frequencies is valuable in microwave remote sensing. It determines the response of the soil to an incident electromagnetic wave. This response is composed of two parts, which determined the wave velocity and energy losses respectively. In a non homogeneous medium such as soil the dielectric properties have a strong impact an its microwave emission. However, the relationship between soil dielectric constant and the soil physical properties is not straight forward. Soil plays a key role in various hydrological and meteorological applications. In microwave remote sensing, for the study of soil, the dielectric constant is the most important parameter. In active microwave remote sensing the sensors measure the back scatter coefficient of the soil and in passive microwave remote sensing the sensors are sensitive to the emissivity parameter of the soil. The backscatter coefficient and emissivity depend on the dielectric constant of the soil. The moisture content in the soil has effect an on the dielectric constant of the soil. The value of dielectric constant depends upon the percentage of moisture content in the soil. Soils are composed of solids, liquids and gases mixed together in variable proportions. Study of physical properties, chemical properties, dielectric properties of soil with varied organic and inorganic matter is useful in agriculture to predict quality and fertility of soil. Also it is useful for the researchers working in the field of microwave remote sensing. When microwaves are directed towards a material, energy gets reflected or transmitted through the surface or absorbed by it. The proportions of energy, which fall into these three category, have been defined in terms of material proportions. Permittivity and permeability are the key parameters describing the interactions of materials with electromagnetic field (1973). Really soil texture has remarkable effect in the dielectric properties. Soil characterization of a region is an important aspect in relation to sustainable agricultural productions.
Keywords- microwave, soil, moisture content, dielectric, soil texture.

1. INTRODUCTION

In India, there are pioneer researchers who are leading the MRS behaviour of soil. Soil is one of our most important natural resources. It is at the heart of terrestrial ecology , and an understanding of the soil system is key to the success and environmental harmony of any human use of the land. Soil texture describes the size of the soil particles. Soil colours have little effect on the behaviour and use of soil. The dielectric constants of soils varies in different places. Soil has electric properties viz, electrical conductivity , dielectric properties , permittivity and loss factor, polarization of dielectrics, power density and penetration depth **[1]**. Microwave remote sensing of natural earth material such as soil and water has a very close dependence on their electrical parameters. The most important parameter is the dielectric constant. The knowledge of DC helps in the study of soils using microwave sensors. It has been observed that dielectric constant of soil is independent of frequency. Remote sensing is defined as the process or technique of obtaining information about on object, area, or phenomenon through the analysis of data acquired by a device without being in contact with the object, area, or phenomena being studied. It consists of the interpretation of measurements of electromagnetic energy reflected from or emitted by a target from a vantage point that is distant from the target. It is a methodology employed to study from a distance the physical and chemical characteristics of objects. Human sight, smell and hearing are examples of rudimentary forms of remote sensing. Elements of photographic interpretation is considered a part of remote sensing however , it is generally limited to study of images recorded on photographic emulsions. Soils are formed as a result of weathering of rocks and minerals . To define soil is not an easy task in view of the heterogeneity and complexity of the soil system. Soil is a dynamic natural body developed as a result of pedogenic processes during and after weathering of rocks , consisting of mineral and organic constituents, possessing definite chemical, physical, mineralogical and biological properties

having a variable depth over the surface of the earth and providing a medium for plant growth for land plants.

In India generally there are size type of major soil i.e. alluvial, red & yellow, black, laterite, arid, forest & mountainous. A map of major soil type is given further, soil is the unconsolidated material on the immediate surface of the earth that serves as a natural medium for the growth of land plants. The pH of a soil refers to how acidic or alkaline the soil is. Thirteen elements, called nutrients , are essential for plant growth**[2]**. A dielectric is a material in which all the electrons are tightly bound to the nuclei of the atoms so that there are no or very few free electrons to carry currents. In others words , the electrical conductivity of a dielectric is very low , because the conductivity for an ideal dielectric is zero. The insulating material is called the dielectric. Dielectric constant is also called relative permittivity. The relative permittivity or dielectric, constant may be defined as the ratio of the electric field in free space to that in dielectric and is represented by the symbol $\in_r$ and numerically it is given by,

$$\in_r = \frac{\in}{\in_o} \qquad (1)$$

In this way, dielectric constant may be defined as the ratio of the absolute permittivity of the dielectric to that of free space. Dielectric materials behave differently in the presence of an electromagnetic field. When microwaves are directed towards a material, energy gets reflected or transmitted through the surface or absorbed by it, In this research paper dielectric constants of different regions have been described, at different frequencies.

2. THEORETICAL CONSIDERATION.

Microwave remote sensing of natural earth material such as soil and water has a very close dependence on that electrical parameters .The most important parameters in the dielectric constant the choice of methods of measurement depends on many factors such as the physical properties including shape and size of the sample , temperature, humidity and the field of measurement . There are different methods of measurement of dielectric constant of soil at microwave frequencies. They are as follows **[3]**:-

- Transmission Method
- Cavity Method
- Free space Method
- Waveguide cell Method
- Infinite sample Method.

Almost all researchers have concluded that the dielectric constant of soil is strongly dependent on moisture content. Further, Sami's has reported the effect of chemical and mineral composition of dust on dielectric constant **[4],** Srivastava S.K. and Mishra G.P. studied characteristics of soils Chhattisgarh at X band frequency and shown the dependence of dielectric constant of soil on its texture of soils **[5].** Calla O.P.N. et. al. have studied the variability of dielectric constant of dry soil with its physical constituents at microwave frequencies**[6].** Chaudhari H.C. and Shinde V.J. have reported that the dielectric properties of dry soil at microwave frequency in X -band are function of its chemical constituents and physical properties. further Sengwa R.J. and Soni A. have reported the variation of dielectric constant with density of dry minerals of soil at 10.1, GH_z

The complex dielectric constant can be calculated using the relation**[7]:**

$$\in^* = \in' - j \in'' \qquad (2)$$

Where,

$$\in^* = \frac{1}{1+\left[\frac{\lambda_c}{\lambda_g}\right]^2} + \frac{1}{1+\left[\frac{\lambda_g}{\lambda_c}\right]^2}\left[\frac{r - j\tan[k(D-D_R)]}{1 - jr.\tan[k(D-D_R)]}\right]^2 \quad (3)$$

Separating the real and imaginary part of dielectric constant from eq (2), the equation for dielectric constant $\in'$ is given by,

$$\in' = \frac{1}{1+\left[\frac{\lambda_c}{\lambda_g}\right]^2} + \frac{\left[\frac{\lambda_c}{\lambda_g}\right]^2}{1+\left[\frac{\lambda_c}{\lambda_g}\right]^2}\left[\frac{(r^2-E^2)(1-r^2E^2)+(2rE)^2}{(1-r^2E^2)+(2rE)^2}\right] \quad (4)$$

And dielectric loss ϵ'' is given by

$$\epsilon'' = \frac{\left[\frac{\lambda_c}{\lambda_g}\right]^2}{1+\left[\frac{\lambda_c}{\lambda_g}\right]^2}\left[\frac{2rE\{(1-r^2E^2)-(r^2-E^2)\}}{(1-r^2E^2)^2+(2rE)^2}\right] \qquad (5)$$

Where,

λ_c, is cut off wavelength

λ_g, is guide wavelength

K, is wave vector

r, voltage standing wave ration (VSWR). The gravimetric soil moisture content in percentage W_c (%) is calculated using wet (W_1) and dry (W_2) soil masses using the relation **[8],**

$$Wc\ (\%) = \frac{W_1 - W_2}{W_2} \times 100 \quad (6)$$

From the knowledge of dielectric constant and dielectric loss, the ac electrical conductivity and relation we are obtained by using the relation

$$\sigma = \omega\epsilon_0 \in'' \qquad (7)$$

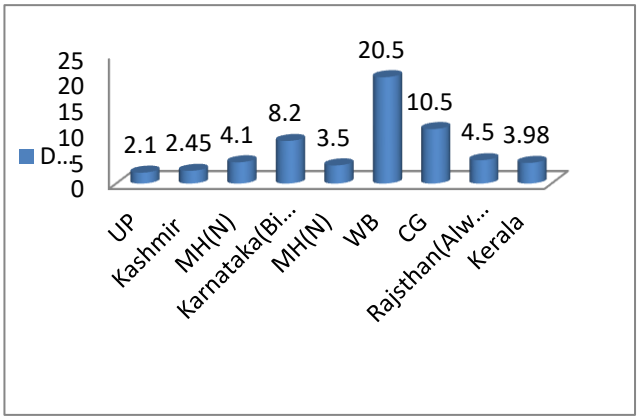
And

$$\tau = \frac{\epsilon''}{\omega\epsilon'} \qquad (8)$$

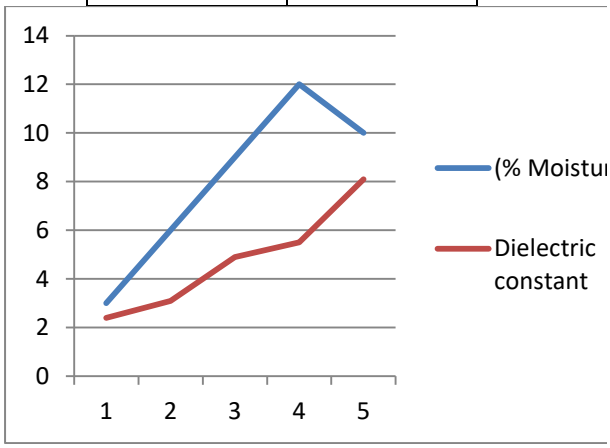
Where, ω is angular frequency (f = *9.44 GHz*), ϵ_0, permittivity of free space ($8.85 \times 10\ Fm^{-1}$)

	GH_z	DC
UP	8-9 (9.0)	2.1
Kashmir	8-9(8.61)	2.45
MH(N)	(4-5)	4.1
	8-12	8.2

Karnataka(Bidar Rys)		
MH(N)	10 GH_z	3.5
WB	11.9 GH_z	20.5
CG	8-12 GH_z	10.5
Rajsthan(Alwar)	8.12 GH_z	4.5
Kerala	1.88GH_z	3.98



(% Moisture)	Dielectric constant
3	2.4
6	3.1
9	4.9
12	5.5
10	8.1



3. RESULT AND DISCUSSION

Dielectric constant of soil is dependent on the texture of soil, the existence of bound water in soil, water mixtures significantly effects the electrical properties of mixtures, Dielectric constants are not only sensitive to water content, but are also to texture of soil. The dielectric constant of soil varies with the status of nutrients. The dielectric constant of soil is independent of frequency. More accurate values of the dielectric constant will help proper designing of the sensor for microwave remote sensing. Moisture in soil significantly affects the dielectric properties of soil. A dielectric property of soil determines the properties like emissivity, scattering coefficient etc. In the graph the dielectric constant of different parts of region is depicted and this data helps to researchers. The dielectric constant varies 2.45 to 20.5. It has been observed that dielectric constant of Haridwar, Coimbatore, Indore and Bangalore 3.2 3.54, 3.15, 2.75 respectively. It can be found that from the analysis of data of dielectric constant study of agricultural crops helps to formers.

4. CONCLUSION

The dielectric constants of soils are strongly dependent on soil moisture and soil texture.This research of such studies may not be only important for the understanding of the fundamental moisture of the response of the particulate soil to the high frequency electromagnetic fields but also of applied nature , useful to compare the pure space of soil.

This study may be useful to predict the soil fertility and soil health . These result may be useful the researchers working the field of agriculture and microwave remote sensing. Hence research in this area will enrich our knowledge of soil science and will prove beneficial to the agriculturists.

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