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Study of Dielectric Behavior of Solids and Soils

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ABSTRACT

The dielectric properties such as dielectric permittivity, dielectric loss and dielectric tangent loss studied using microwave transmission method at room temperature. Thedielectric propertiesof different solids and soil samples such as fused quartz, cream granite, green granite, brown grantee and black granite etc and black soil, red soil and white soil are studied.The value of dielectric permittivity of solids is in the range of 3.29 mm to 4.38mm. The dielectric permittivity of red soil is 3.72 and black soil 3.81 forms.This value of dielectric permittivity of black soil is larger than red soil because black soil has less porosity than red soil.

Key words: Microwave transmission method, Solids, Soils, dielectric properties.

Introduction:

The effect of rock/solid/ water interaction on the dielectric behavior of solids has been studied by Knight and Nur [1] and Knight and Endres [2]. In these studies the real part of the dielectric constant of solid sample was measured at the level of water saturation and was varied the volume fraction of the pore space filled with water, the remainder being filled with air. The frequency of the measurements was 1 to 4 MHz. In all cases, there is dramatic increase in the dielectric constant of the rock stone with the addition of small amount of water in the region 0<sw<sw0; where sw0 has been defined as the critical saturation point such as increase at low saturation was attributed to interactions between the solid rock and a surface layer of water 1 nm in thickness wetting the solid surface.Using the complex refractive index method and three component effective medium theories of Feng and Sen [3], it was shown by knight and Endres [2] that the dielectric constant of sandstone of various level of water saturation can be predicted. However, if the three components are defined as the dry rock, the water, and the air, the predicted dielectric constant is measured. In this study, we now address the problem of soil/rock/water interaction in an experimental way on microwave x-band setup. [4,5].

Experimental:

The dielectric permittivity of solids has been measured for 35mm wavelengths at room temperature. The solid samples were collected from different locations of Maharashtra and Karnatak state. These samples were collected from different areas to determine its dielectric properties and to study the solid water interaction by dielectric measurement. Amongst the solids the soil samples were collected from non-irrigated farming lands in hot summer with negligible water content, called as dry soil. These soil samples are the mixture of sand, silt and clay with very high percentage of clay. The solid sample under measurement of known length was placed in the empty solid dielectric cell, and pressed by a laboratory developed mechanical system to remove the air and discontinuities in the sample. The solid cell with sample was connected to the opposite end of the source of microwave bench set up. The signal generated from the microwave source was allowed to incident on the soil sample. The soil sample reflects part of the incident signal through the solid from its front surface. The values of power at different points of standing waves have been measured as a function of probe position. About (80 -100) points were recorded for a single standing wave pattern. The least squares fit has been used to determine the values of , c, and for the sample.These solid samples are selected for study of solid water interaction which is determined in terms of dielectric permittivity which is useful in ground penetration radar and similar such studies will provide useful mean for determination whether water or some other chemical or fluid species is absorbed to the solid surface, which is useful in oil industry to distinguish between water-wet and oil-wet formation. The quartz and soil samples are collected from the agricultural lands and these are the subsurface samples. The granite solid samples are collected from the commercial shops, and they are cut in a particular shape of the solid cell. Three samples of particular granite are taken for the experimental study. These samples have been collected to study its dielectric permittivity, dielectric loss and their interaction with the water and the resultant effect was considered in terms of dielectric permittivity.

Result and discussion:

The dielectric permittivity and dielectric loss of all solid samples are calculated by using following relations (1) and (2).

$$\varepsilon' = \lambda_0^2 \left[\frac{1}{\lambda_c^2} + \frac{\beta^2 - \alpha^2}{4\pi^2} \right] \qquad (1)$$

$$\varepsilon'' = \frac{\lambda_0^2 \alpha\beta}{2\pi^2} \qquad (2)$$

Where free space wavelength, c cutoff wavelength, and are the attenuation and phase constants respectively and can be obtain experimentally [6]. The values of dielectric permittivity, dielectric loss and loss tangent of solids are listed Table 1. Form Table 1 it shows that dielectric permittivity and dielectric loss of fused quartz is less than all granite samples because the quartz material have high porosity than granite. The value ofdielectric loss of all solid samples is also different it less than unity in the range of 0.13 to 0.42 many investigators have shown that dielectric loss less than one at this wavelength[7,8]. The loss tangent which is the ratio of dielectric loss to dielectric permittivity is also reported for these solid samples and it is given in the same table. The errors in permittivity lie in the range of (+ or -) 0.01 to 0.05 and the errors in dielectric loss are zero and these are given in Table 1. The dielectric permittivity, dielectric loss and loss tangent value of soil samples are presented in Table 2. Table 2 shows that dielectric permittivity of black soil is high as compared to red soil due to more sand contains in red soil.

Table 1: Dielectric properties of solids at 35mm wavelength

Sr. No	Name of solid sample	Dielectric Permittivity (ε′)	Dielectric Loss (ε″)	Error in Permittivity (±Δε′)x10⁻³	Error in loss (±Δε″)	Loss tangent (Tan δ)
1	Fused quartz	3.29	0.15	2.54		
2	CreamGranite	4.35	0.17	2.73	0	0.045
3	GreenGranite	4.29	0.42	5.49	0	0.039
4	BrownGranite	4.38	0.26	2.29	0	0.097
5	BlackGranite	4.35	0.15	2.65	0	0.059
6	Dark Brown Granite	4.34	0.13	1.75	0	0.034
					0	0.029

Table 2: Dielectric properties of soil at 35mm wavelength

Sr. No	Name of solid sample	Dielectric Permittivity (ε′)	Dielectric Loss (ε″)	Error in Permittivity (±Δε′)x10⁻³	Error in loss (±Δε″)	Loss tangent (Tan δ)
1	Soil black	3.81	0.17	1.98	0	0.044
2	Soil white	3.77	0.24	1.98	0	0.06
3	Soil red	3.72	0.14	1.98	0	0.045

The sanding wave pattern of cream granite solid sample for different pc is depicted in Fig 1. From fig 1 it is noticed that the sanding wave pattern of 18 pc is out of phase as compared to 6,12 pc. Increases in pc decreases the power, the similar result are reported [9, 10].

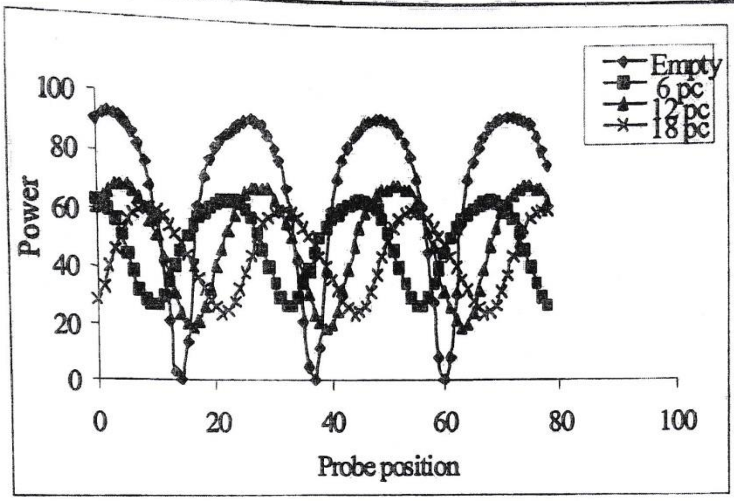

Fig.1: Standing wave pattern of Cream granite at 35 mm.

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