Dielectric Constant and Emissivityof Soil Samplesof Jalgaon District at Microwave Frequency

Chhaya B. Patil[1], P.R. Chaudhari[2]

[1]*Ph.D Student, Microwave Research Laboratory,Z. B. Patil College, Dhule-424002, INDIA*

[2]*Associate Professor, Microwave Research Laboratory, Z. B. Patil College, Dhule-424002, INDIA*

email:- chhaya26nov@rediffmail.com,prc_61@rediffmail.com

contact no. 9604563516, 9422757654

Abstract:*The measurement of dielectric constant and emissivity with moisture content for five soil samples at 9.6GHz microwave frequency by using waveguide cell method. The soil samples are pure black soil, medium black soil, loamy soil, forest soil and sandy soil. The values of emissivity of soil samples are measured by using respective dielectric constant. The measurement of emissivity with moisture content forhorizontal polarization. The result shows that the emissivity of soildepends on microwave frequency in x-band region and angle of incidence.*

Keywords:*Dielectric constant, emissivity, soils Samples, microwave frequency, Moisture Content.*

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1. INTRODUCTION

The whole electromagnetic spectrum is divided into the radio spectrum extending from DC to 300 GHz and the optical spectrum extending from 300 GHz to infinity. The electromagnetic waves ranging from about 300 MHz to 300 GHz are referred as microwaves. The study of earth's surface is important for remote sensing applications. The electrical properties like dielectric constant and emissivity of the objects on the earth surface like soil samples are fundamental significance in microwave remote sensing. In microwave frequency region, it is observed that dielectric constant increases with increase in moisture content slowly up to transition moisture then it increases rapidly with increase in moisture content. Also found that emissivity decreases with increase in moisture content[1].This property of emission of electromagnetic energy is called emissivity.Emissivity is the important parameter, which provides information about soil. Because of absorption of minute amount of moisture from atmosphere, the dielectric constant and emissivity become frequency dependent. In this paper dielectric constant and emissivity are measured for five soil samples at 9.6GHz microwave frequency in X- band region.The emissivity of soil also varies with different moisture content. Knowledge of emissivity of soil is useful for the efficient use of soil [2].

2. RELATED WORK

2.1. Measurement of Dielectric Constant

The dielectric constant of pure black soil, medium black soil, loamy soil, forest soil and sandy soilsamples have been measured at9.6 GHz microwave frequencyin X- band region. The X-band microwave test bench shown in Fig.1 was used to measure dielectric constant of soil samples. Soil samples were shaped according to the dimensions of rectangular waveguide i.e. with 2.286 cm x 1.016 cm. The waveguide cell method was used to measure dielectric constant. The dielectric constant first increases slowly with moisture content up to a certain point and then increases rapidly with moisture content[3].

Fig. 1 X-band microwave test bench

The equation of dielectric constant is,

$$\varepsilon' = \frac{\left[(a/\pi)^2 (x/l_\varepsilon)^2\right] + 1}{(2a/\lambda_g)^2 + 1} \qquad \dots (1)$$

Where x is found by following equation,

$$\tan x / x = \frac{\tan\left[\beta\left(l_\varepsilon + D_R - D\right)\right]}{\beta l_\varepsilon} \qquad \dots (2)$$

Where, $\beta = (2\pi/\lambda_g)$ ε' = dielectric constant, β = phase shift,

a = width of wavelength, l_ε =sample length, λg = guide wavelength,

(D_R–D) = shift in minima, D_R =minima for without sample, D = minima for with sample.

2.2.Estimation of Emissivity

The values of emissivity of forest soil samples are estimated for angle of incidence from 0^0 to 90^0. These values are estimated for verticalpolarization by using already measured dielectric constant at three microwave frequencies [4].

The equation of emissivity $e_p(\theta)$ is

$$\mathbf{e_p(\theta) = 1 - r_p(\theta) = 1 - |R_p(\theta)|} \quad ...(3)$$

Where, $R_p(\theta)$is the Fresnel reflectioncoefficient

For vertical polarization,

$$\mathbf{e_p(\theta) = 1 - \frac{\varepsilon' \cos\theta - (\varepsilon' - \sin^2\theta)^{1/2}}{\varepsilon' \cos\theta + (\varepsilon' - \sin^2\theta)^{1/2}}} \quad ... (4)$$

Where θ is the angle of incidence and ε' is the dielectric constant.

2.3 Samples Collected from Villages.

SAMPLES	SOIL SAMPLES NAME	VILLAGE NAME
PB	PURE BLACK SOIL	MARVAD (TAL AMALNER,DIST.JALGAON)
MB	MEDIUM BLACK SOIL	CHAHARDI (TAL CHOPDA, DIST.JALGAON)
LS	LOAMY SOIL	NIMBHORA(TAL BHADGAON, DIST.JALGAON)
FS	FOREST SOIL	GADHRYA PAL(TAL YAWAL ,DIST.JALGAON)
SS	SANDY SOIL	NIMBHORA (TAL BHADGAON, DIST.JALGAON)

3. EXPERIMENTAL RESULTS AND DISCUSSION

3.1 Variation of dielectric constant with moisture content.

Fig. 2 shows variation of dielectric constant with respect to moisture content for all soil samples under study.

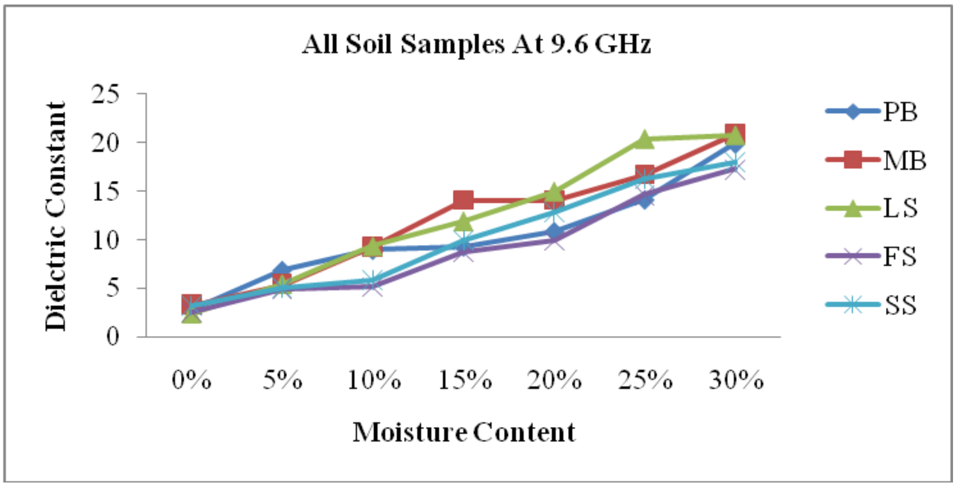
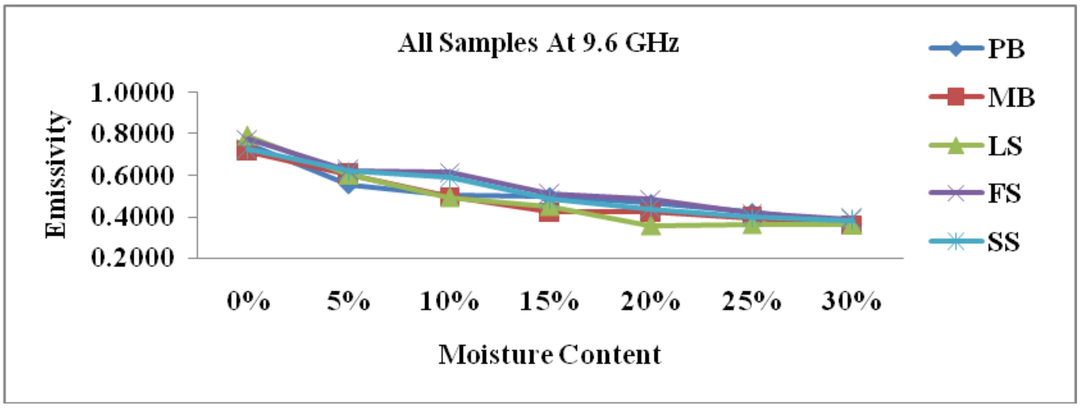


Fig. 2 Variation of DC with MC

From this graph, observed that for all soil samples dielectric constant increases with increases in moisture content

3.2 Variation of Emissivity with various moisture content Horizontal Polarization at 9.6GHz Frequency.

The studies of emission characteristics of dry and wet soils have been carried by Calla and Sharma [5] and Calla et al. [6]. They studied the emissivity of dry and wet soils from different regions of India at different frequencies and different angles of incidence.Fig. 3 shows the variation of emissivity (horizontal polarization) for five soil samples with moisture content at 9.6GHz frequency. It is observed that there is a decrease in emissivity with increase in moisture content for all soil samples.



Emissivity verses Moisture Content

In fig 3observed that for all soil samples, at 9.6GHz frequency,

4. CONCLUSSIONS

From the results and discussion we haveconcluded the following points.

- At a given frequency the trend ofvariationof emissivity with moisture content for all soils samplesunder study, is almostthe same.
- Thevalue of emissivity at 9.6GHzfrequency initially decreases rapidly with moisture content and then afterit starts decreasing slowly.
- For all soil samples at 9.6 GHz frequency, the value of dielectric constant increases with increase in moisture content.

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