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Microwave Dielectric Study of Chemical Fertilizers in Sand Dunes Soil at X-Band

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Abstratct – The study of dielectric properties of soil is very important to understand its various aspects including porosity, water holding capacity, quantum of minerals and fertility etc. The coarse dune soil is generally deficient in various minerals and other nutrients. We have studied the effect of chemical fertilizers on coarse soils from sand dunes. Variation in various dielectric parameters like dielectric constant (ε'), dielectric loss (ε''), Relaxation Time (τ), loss tangent (tanδ) and AC conductivity (σ) with frequency (ν), moisture contents and contents fertilizer are recorded. The experiments are conducted in laboratory using two point method with waveguide techniques at X-band microwave frequency. The results obtained discussed to draw a useful inference.

Keywords: Dielectric Constant, Dielectric Loss, Loss Tangent, AC Conductivity, Dielectric Pernitivity and Relaxation Time.

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1. INTRODUCTION

The electromagnetic waves have perpendicular electric (E) and magnetic field (H) propagating normal to their oscillations. The electromagnetic wave with frequency range 300 MHz to 300GHz are known as microwaves. The interaction of electromagnetic waves with polar matter is very important to study their behavior and further decide their utility for various scientific, industrial and general applications. Based upon electromagnetic properties the material can be categorized in two group viz. conductor and insulator or dielectric. The dielectric material contains charges tightly bound in atom or molecule. When they are placed in external electric field the bound charges get separated, which is known as polarization. Due to this charge separation the amplitude and phase of electromagnetic wave change while propagating through the medium. Owing to this astonishing property of dielectric material they are used in wide spectrum applications like remote sensing, material characterization and dielectric spectroscopy etc.

The dielectric materials have capacity to store energy when subject to an external electromagnetic field. This astonishing feature of microwave equip with capacity to tune at selective frequencies and penetrate through the material at different depth. This interaction of microwave with material turns up in the form of absolute permittivity of medium (ε^*).

This complex permittivity of material $\varepsilon^* = \varepsilon' - j\varepsilon''$ consists of two components viz. real part (ε') and imaginary part (ε'') of permittivity. The real part measure the ability of dielectric material to store energy and imaginary part measure the loss factor or the dissipative ability of material which includes dielectric loss and conductivity. The real and imaginary parts of permittivity are normal to each other along with other parameters like conductivity (*σ*), resistivity (*ρ*), dielectric relaxation and loss tangent $(\tan\delta)$ etc constitutes important parameters to dielectric emissive behavior and possible mechanism of dielectric loss in substances.

Since most of the substance used in industry, agriculture and food grains are dielectric in nature. The high frequency electromagnetic waves have high penetrating power while wave in radio lower frequency region produce weak interactions. Therefore, the microwave segment of electromagnetic spectrum is optimum to study such substances for optimal determination of their properties. Microwave oscillations manifest in different bands with following standardizations:

Microwave Designation	Frequency Range
L-band	1 GHz - 2 GHz

S-band	2 GHz - 4 GHz
X-band	8 GHz - 12 GHz
Ku-band	12 GHz - 18 GHz
K-band	18 GHz - 26.5 GHz
Ka-band	26.5 GHz - 40 GHz
Q-band	30 GHz - 40 GHz
U-band	40 GHz - 60 GHz
V-band	50 GHz - 75 GHz
E-band	60 GHz - 90 GHz
W-band	75 GHz - 110 GHz
F-band	90 GHz - 140 GHz
D-band	110 GHz - 170 GHz

A waveguide is a device to confine electric and magnetic field in a hollow conducting tube. It may be of rectangular, circular, elliptical or any other shape. The X-band microwaves are medium penetrating microwave generally used in laboratories with wave guide and produced by klystrons. Soil is layer of sand covering the earth surface. It contains sand, clay, mineral and rocky materials in inorganic and organic forms and much useful for agriculture production. The dune soil is less fertile and require huge amount of chemical fertilizers to produce a considerable yield of grain. We have added Di Amonium Phosphate (DAP) and Urea to soil to enhance the fertility of sand dunes in Jhajjar district.

The rest of this paper is organized as follow: section 2 survey the existing literature in this area. Section 3 presents the experimental set up and procedure. Section 4 presents the results of experiments conducted in laboratory, Section 5 concludes the paper.

2. LITERATURE REVIEW

Nelson has measured various dielectric properties at radio and microwave frequency. Kraszewski has explored multiple approaches to conduct the dielectric study of food grains and seeds. He further classified the measurement techniques in reflection and transmission types using resonant and non-resonant theory. Icier et al have explored the advantage of Time Domain Spectroscopy in microwave regions. Njoku *et al.* have measured the dielectric properties of sand with varying moisture contents at microwave and radiowave frequencies. Hoekstra *et al.* have investigated the behaviour of soil at different microwave frequencies with varies water contents and temperature.

Robinson *et al.* have examined the dependence of complex dielectric constant of different type of sand on moisture using methods of Surface Capacitance Insertion Probe (SCIP) and Time Domain Reflectometery (TDR). Peplinski *et al.* measured the dielectric loss component of soil at L-band microwave frequency. Vyas *et al.* have studied the dielectric properties of Indian soil loam at X-band frequencies. Calla *et al.* have tested the best method to evaluate complex dielectric constant of soil with different moisture contents in the frequency range 2 GHz to 20 GHz. Ghose *et al.* have compared the dielectric properties of dry and wet soil at Ku-band microwave frequencies. Pancholi *et al.* have instigated dielectric permittivity of soil from Rajasthan while Kumar et al. have studied the dielectric properties of soil from Indo-Gangetic region of Haryana. Chaudhary *et al.* have measured the dielectric property of laden soil at X-band microwave frequencies.

3. EXPERIMENTAL SETUP AND PROCEDURE

For experimentation a microwave bench with rectangular wave guide is used. The bench use klystron to generate frequency in X-band. The block diagram of microwave bench is shown in figure 1, below.

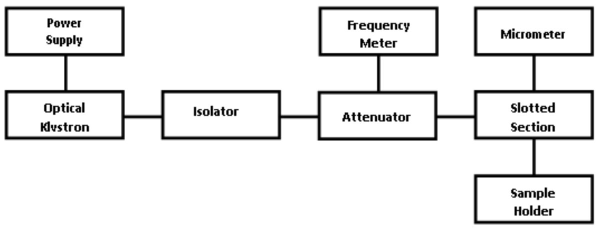

Figure 1: Block Diagram of Microwave Bench for X-band

The soil sample obtained from the dunes located in Salahawas development block of Jhajjar was finely grained and sieved. The sample was dried in oven at $105^{O}C$ for 24 hours. The distilled water is used to add the control the water contents. The DAP and Urea available in co-operative departmental stores in the district are used to test the effect of chemical fertilizers. For adjusting the various parameters of soil the method used by Wang and Schmugge Model is applied with following formulas:

(i) W_p (Wilting Point) of soil samples

$$W_p = 0.06774 - 0.00064 \times (\text{sand}\%) + 0.00478 \times (\text{Clay}\%) \text{ ...... (i)}$$

(ii) Transition moisture

$$W_t = 0.49 \times W_p + 0.165 \text{ .... (ii)}$$

(iii) Porosity

$$\eta = 1 - \frac{\rho_d}{\rho_p} \text{................. (iii)}$$

Where

$$\rho_d = Bulk\ density\ of\ soil$$

$$\rho_p = Particle\ density\ of\ soil$$

The characterization of soil under study for the experimentation in the present research study is provided in Table 1, below:

Location	Soil Type	Soil Texture				Wilting point	Transition Moisture	Porosity
		Clay	Silt	Sand	Gravels	W_p	W_t	(η)
Salhawas (Jhajjar)	Sandi Loam	60%	30%	3%	1%	0.043	0.1779	0.81

4. RESULTS AND DISCUSSION

The experiments were carried out in microwave bench operated in T10 mode with Klystron at different X-band frequencies. The DAP and Urea are added to soil sample by diluting it with distilled water. The sample length is taken in the multiple of $\lambda/4$. The shift in minima is recorded for standing wave pattern. Variation in dielectric constant (ε'), dielectric loss (ε''), Relaxation Time (τ), loss tangent (tan δ) and AC conductivity (σ) is recorded and plotted as shown below.

Both the dielectric constant and dielectric loss have positive correlation with amount of fertilizers while have negative correlation with frequency of oscillation. Further both the parameters are least for DAP, which envisage that it dissolve and assimilate with the soil in higher time. Further the peak of loss tangent for DAP is slight higher and shifted towards low frequency which reveals that Urea is easy to dissolve and assimilated in soil and more effective fertilizer for plants growth. The relaxation time for both fertilizers remain constant which mean the main constituent (Nitrogen) in both fertilizers is same and hence polarized equally. AC conductivity first decrease and then increase for both fertilizers which reflects that with slight increase in frequency the molecular vibration is resistive but with higher increase in frequency the molecular vibrations become prominent and they get polarized easily. Further addition of fertilizer increase the dielectric permittivity of soil.

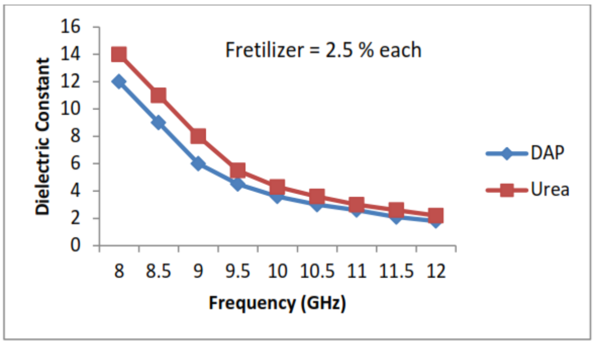

Figure 2: Variation of Dielectric Constant (ε') of Fertilizer Mix Soil with Frequency

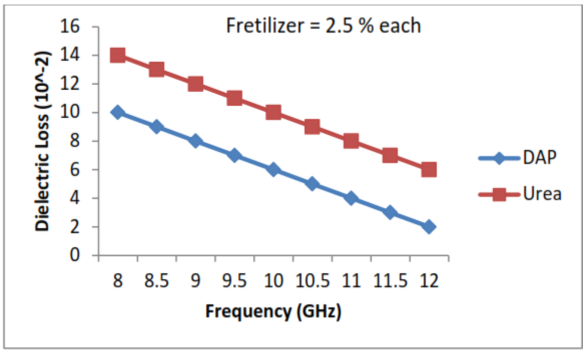

Figure 3: Variation of Dielectric Loss (ε'') of Fertilizer Mix Soil with Frequency

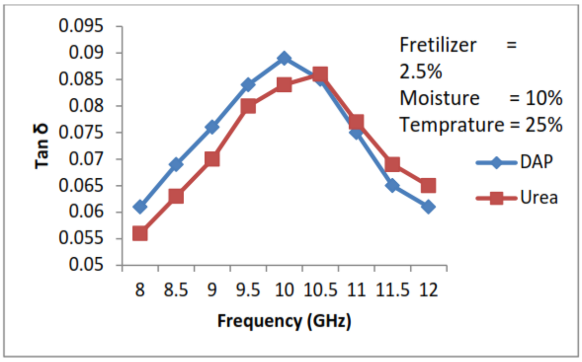

Figure 4: Variation of Loss Tangent (tan δ) of Fertilizer Mix Soil with Frequency

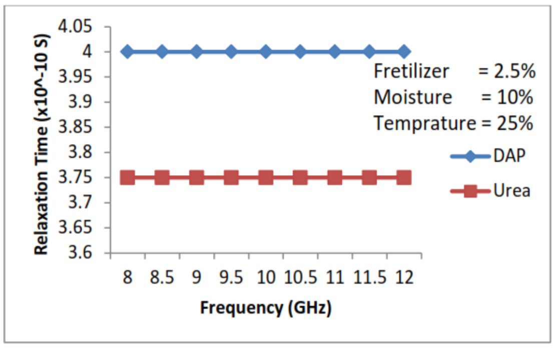

Figure 5: Variation of Relaxation Time (τ) of Fertilizer Mix Soil with Frequency

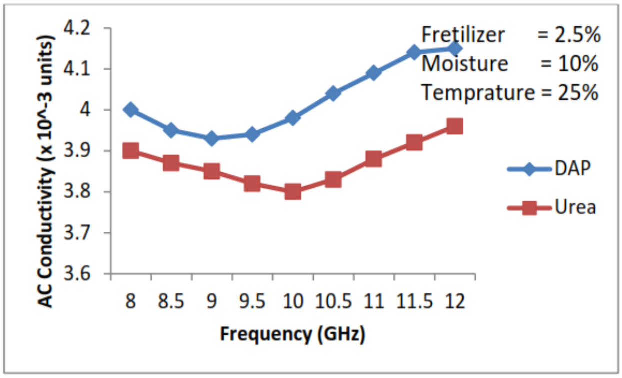

Figure 6: Variation of AC Conductivity (σ) of Fertilizer Mix Soil with Frequency

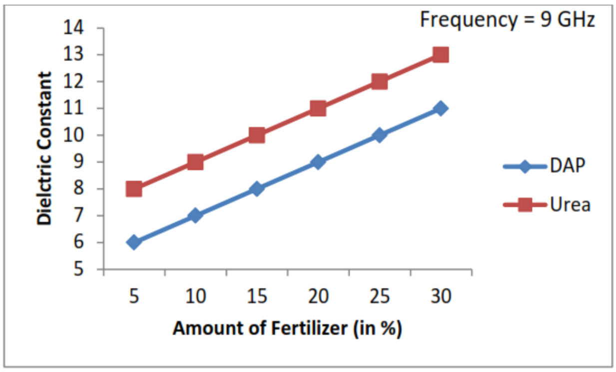

Figure 7: Variation of Dielectric Constant (ε') Soil with Amount of Fertilizers

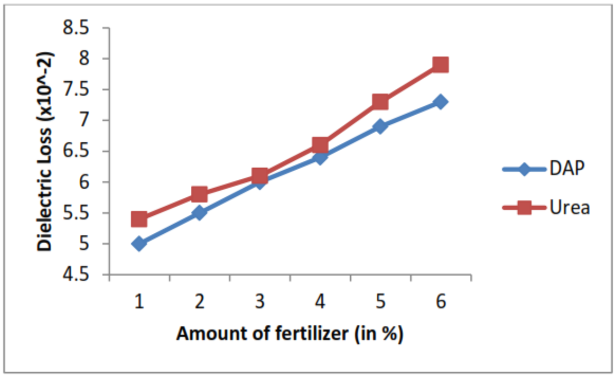

Figure 8: Variation of Dielectric Loss (ε'') of with Amount of Fertilizers

5. CONCLUSION

This research study experimentally examines the dielectric behaviors of chemical fertilizer mixed soil at X-band frequency. The figure 2,3,4,5,6,7 and 8 gives the plot of various dielectric parameters with frequency and amount of fertilizer mixed with soil. It is observed that both fertilizers reflect similar behaviour with relative gap in values. Also it is observed that the behaviour of fertilizers is frequency dependent and they can be sensed properly through Remote Sensing Applications.

REFERENCES:

1. Rajesh. Mohan. R, SM., Mohanan P. (2015). Study and Analysis of Dielectric Behavior of Fertilized Soil at Microwave Frequency. Euro. J. Adv. Engg. Tech. 2. pp. 73-79.

2. Njoku E. G. and Kong J. (1977). “Theory for Passive Microwave Remote Sensing of Near-Surface Soil Moisture”, Journal of Geophysical Research, 82(2), 1977, pp. 3108.

3. Hoekstra P. and Delaney A. (1974). “Dielectric Properties of Soils at UHF and Microwave Frequencies”, Journal of Geophysical Res., 79(11), 1974, pp. 699.

4. Robinson D. A., Kelleners T. J., Cooper J. D., Gardner C.M.K., Wilson P., Lebron I., and Logsdon S. (2005). “Evaluation of a Capacitance Probe Frequency Response Model Accounting for Electrical Conductivity: Comparison with TDR and Network Analyzer Measurements”, Vadose Zone Journal, 4 (11), 2005, pp. 992.

5. Peplinski Neil R., Ulaby F. T. and Dobson M. C. (1995). “Dielectric Properties of Soils in the 0.3-1.3 GHz Range”, IEEE Trans. Geosciences & Remote Sensing, 33(3), pp. 803.

6. Vyas A. D. (1982). “Complex Permittivity of Sand & Sandy Loam Soils at Microwave Frequency,” Indian Journal of Radio & Space Physics, 2, pp. 69.

7. Calla O. P. N, Borah M. C., Vashishtha P., Mishra R., Bhattacharya A. & Purohit S. P. (1999). “Study of the Properties of dry and wet loamy sand soil at microwave frequencies”, Indian J. of Radio and Space Physics, 28, 1999, pp. 109.

8. Ghosh A., Behari J. and Pyne S. (1998). “Dielectric parameters of dry and wet soils at 14.89 GHz”, Indian J. of Radio and Space Physics, 27, 1998, pp. 130.

9. Pancholi K. C. and Khameshra S. M. (1994). “Complex dielectric permittivity of some Rajasthan soils at 7.114 GHz”, Indian Journal of Radio and Space Physics”, 23, 1994, pp. 201.

10. Kumar R. and Sharma A. (2015). “Dielectric properties of soil of Indo-Gangetic region of Haryana at C – Band microwave frequency” AIP Conference Proceedings, 1675(1), pp. 427.

11. Chaudhary H. C. and Shinde V. J. (2008). "Dielectric study of moisture laden soils at X-band microwave frequency", International Journal of Physical Sciences, 3(3), pp. 75.

12. Gadani, D.H., Vyas, A.D. (2015). Dielectric Mixing Model for the Estimation of Complex Permittivity of Wet Soils at C and X Band Microwave Frequencies. Indian Journal of Pure & Applied Physics. 53. Pp. 190-198.

13. Sengwa R. J. and Soni A. (2008). "Dielectric properties of some minerals of western Rajasthan", Indian J. Radio and Space Physics, Vol. 37, February (2008) pp. 57.

14. Sucher, M. and Fox J. (1963). Handbook of microwave measurements, (1963) pp. 504.

15. Wang J. R. and Schmugge T. J. (1980). "An empirical model for complex dielectric permittivity of soils as a function of water content", in IEEE Transactions on Geoscience and Remote Sensing (USA), 18, (1980) pp. 288-295.

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