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DIELECTRIC BEHAVIOR OF DRY SOIL OF DIFFERENT DISTRICTS OF HARYANA (INDIA) AT 5.3 GHZ

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Abstract: **The paper presents the study of the relationships of dielectric behavior of dry soil of different districts of Haryana (India) with their physical and chemical properties at 5.3 GHz under room temperature. Twenty one samples were collected from all twenty one districts of Haryana (India). Measurement of dielectric constant (ϵ') of all collected soil samples were done at microwave frequency of 5.3 GHz using waveguide cell technique and then analyzed statistically. The experimental results show that the ϵ' has positive correlation with sand percentage and Bulk density of soil whereas negative correlation with and porosity of soil, silt percentage, clay percentage and wilting point of soil. The results are highly useful in many remote sensing applications and agriculture.**

Keywords *– Bulk density, Dielectric constant, Haryana, Microwave frequency, Porosity, Soil.*

I INTRODUCTION

In the area of remote sensing of material found in the nature, dielectric constant is a major parameter as it depends on its physical and chemical properties. Soil of the different regions are different in their physical and chemical properties like color, bulk density, porosity, texture, grain size, pH, wilting point, dielectric constant, electrical conductivity,permeability, organic matter etc. Texture of soil is mainly characterized by its three mail components- sand, silt and clay [1]. It is composed of solid, liquid and gases in variable proportions. The proportion of liquid and gases depends on how the solid particles are packed together which in turn depends upon size of soil particles. Due to this soils of different regions are characterized differently. Dielectric constant is one of the important parameter in remote sensing techniques to study soil.

Measurements of dielectric characteristics of soil of different regions at different microwave frequencies have been studied by several researchers. The dielectric behaviour of three samples of dry soil and wet black soils at 5GHz have been studied [2] which indicates it to be a function of moisture content. Studies of soil on X-Band microwave frequencies for dielectric properties of soils were conducted using infinite sample method by some workers [3] [4]. The dielectric constant of soil of different areas has also been studied and reported as a function of moisture content [5] [7]. Srivastava and Mishra [8] studied the dielectric behavior of soils of Chhattisgarh region at X–Band microwave frequency and reported that dielectric constant of soils depend on its constituents–percentage of sand, silt and clay in it. Calla O. P. N. et al. [9] also studied the dependency of dielectric constant of dry soil with its physical constituents at microwave frequencies and found that dielectric constant is highly dependent on physical properties of soil of region under study.

The dielectric properties of dry soil at X-Band microwave frequency has also been reported as a function of its physical and chemical properties [10]. Sengwa and Soni [11] found dielectric constant as a function of density of dry minerals of soil at microwave frequency of 10.1 GHz. Kumar Rajeev and Sharma Anupamdeep studied the variation in complex dielectric constant of soil of Indo-Gangetic region of Haryana State of India with fertilizers content at C-Band microwave frequency and reported that it is dependent of fertilizer content in it [12].

As dielectric constant of soil is dependent of its physical and chemical properties, a detailed study is required to understand how dielectric constant of soil depends on such parameters. In the present study an attempt is made to understand statistically how the dielectric constant of soil of Haryana varies with its physical and chemical properties at 5.3 GHz.

II EXPERIMENTAL DETAILS

Sample preparation:

Twenty one samples of soil are collected from different districts of Haryana in zigzag pattern. Out of these twenty one samples five are loamy sand in texture, fourteen are sandy loam and two are loamy in texture. The samples of soil collected first grinded and sieved, coarse particles are removed. The fine particles obtained are then oven dried for several hours to remove moisture completely and make it dry. Physical and chemical properties of soil samples are given in Table 1.

Wang and Schmugge Model [13] is used to calculate *W* (Wilting Point) of soil samples:

W = 0.06774 – 0.00064 × (Sand %) + 0.00478 × (Clay %)

Porosity is calculated using the formula:

$$n = 1 - \frac{\rho_d}{\rho_p}$$

Where ρ_d is bulk density and ρ_p is particle density.

Measurement of dielectric constant of soil:

Waveguide cell technique [14] is employed in the present study for the measurement of dielectric constant of soil samples at 5.3GHz. A microwave bench operating at C-Band is used at 5.3 MHz in TE_{10} mode with Gunn source at room temperature. The microwaves are allowed to be incident on the soil sample. Standing wave pattern is observed due to the superposition between incident signal and the signal that reflects from soil sample. The dielectric constant is calculated using the relation:

$$\epsilon' = \frac{g_\epsilon + \left[\frac{\lambda_{gs}}{2a}\right]^2}{1 + \left[\frac{\lambda_{gs}}{2a}\right]^2}$$

Where g_ϵ and b_ϵ are real and imaginary parts of admittance, λ_{gs} is wavelength in air filled guide,

a = inner width of rectangular waveguide.

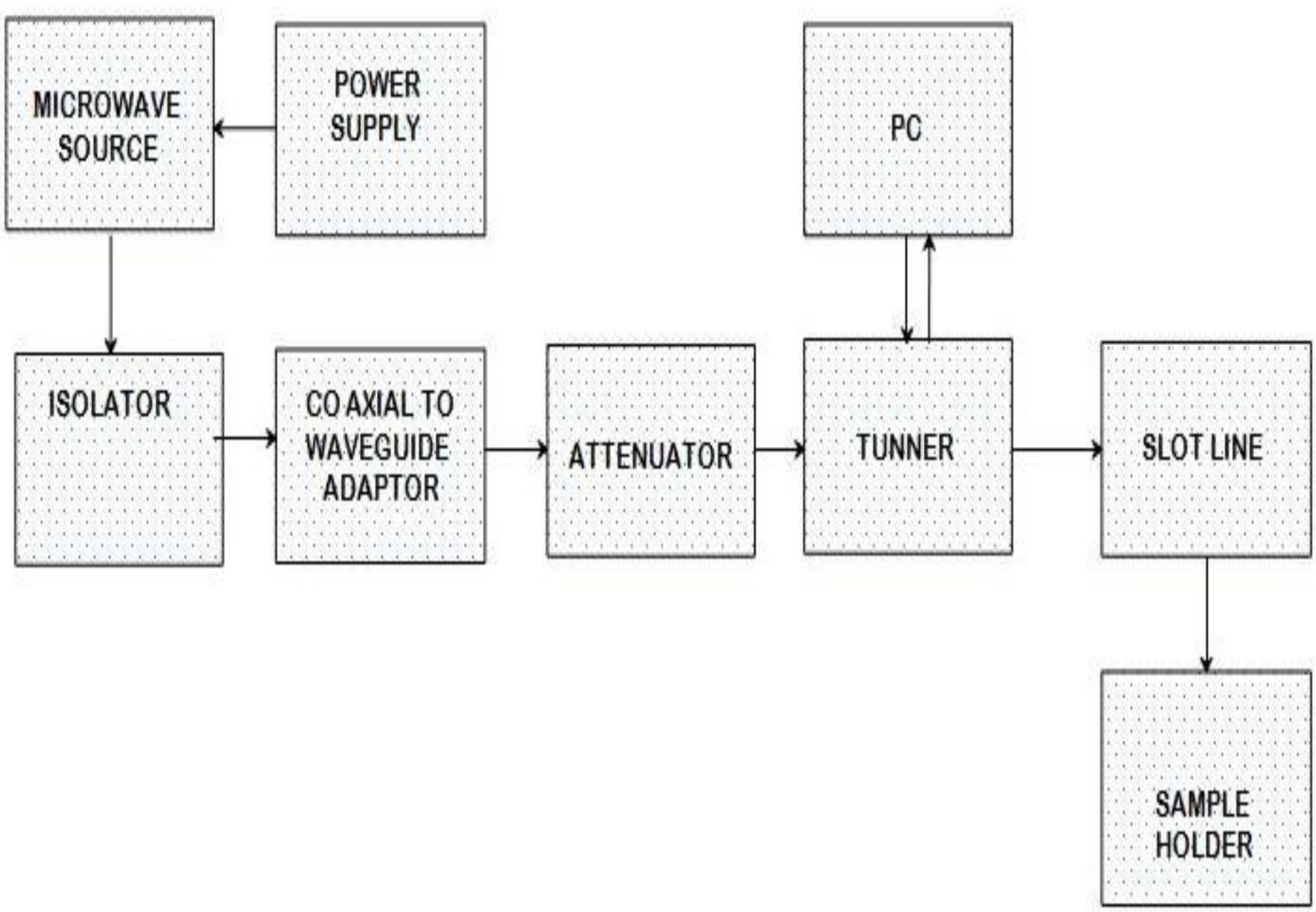

Figure 1 Block Diagram of Automated Experimental Set up of Microwave Bench to Measure Dielectric Constant of Soil

Table 1 Physical and Chemical properties of Soil from different districts of Haryana

Area	Sand (%)	Silt (%)	Clay (%)	Texture	pH	BD	WP	Particle density	Porosity
Ambala	58	26	16	Sandy Loam	7.1	1.47	0.1071	2.56	0.425781
Bhiwani	73	17	10	Sandy Loam	7.9	1.44	0.06882	2.64	0.454545
Faridabad	74	17	09	Sandy Loam	8.1	1.46	0.0634	2.65	0.449057
Fatehabad	71	17	12	Sandy Loam	7.7	1.41	0.07966	2.63	0.463878
Gurgaon	79	14	07	Loamy Sand	7.2	1.50	0.05064	2.65	0.433962
Hisar	81	12	07	Loamy Sand	7.9	1.50	0.04936	2.66	0.436090
Jhajjar	68	18	14	Sandy Loam	7.8	1.39	0.09114	2.62	0.469466
Jind	66	18	16	Sandy Loam	7.8	1.37	0.10198	2.61	0.475096
Kaithal	51	31	18	Loamy	7.8	1.32	0.12114	2.52	0.476190
Karnal	52	31	17	Loamy	7.2	1.33	0.11572	2.51	0.470120
Kurukshetra	65	23	12	Sandy Loam	6.8	1.53	0.0835	2.58	0.406977
Mahendragarh	80	13	07	Loamy Sand	7.5	1.50	0.0500	2.66	0.436090
Mewat	78	15	07	Loamy Sand	7.1	1.50	0.05128	2.65	0.433962
Palwal	69	18	13	Sandy Loam	9.9	1.40	0.08572	2.62	0.465649
Panchkula	56	31	13	Sandy Loam	7.2	1.50	0.09404	2.56	0.414063
Panipat	61	22	17	Sandy Loam	7.9	1.35	0.10996	2.56	0.472656
Rewari	82	12	06	Loamy Sand	8.4	1.53	0.04394	2.66	0.424812
Rohtak	65	19	16	Sandy Loam	8.2	1.36	0.10262	2.57	0.470817
Sirsa	72	16	12	Sandy Loam	6.9	1.42	0.07902	2.64	0.462121
Sonipat	66	19	15	Sandy Loam	8.4	1.41	0.09720	2.61	0.459770
Yamunanagar	62	20	18	Sandy Loam	6.9	1.46	0.11410	2.57	0.431907

III RESULTS AND DISCUSSION

The graphical relationships between dielectric constant (ϵ') of dry soil of Haryana with sand percentage, silt percentage, clay percentage, bulk density, wilting point and porosity are plotted in figure 2 to figure 7 respectively. The plots clearly show that ϵ' of dry soil of Haryana increases with sand percentage in soil sample and bulk density of soil whereas it decreases with silt percentage, clay percentage, wilting point of soil and porosity of soil.

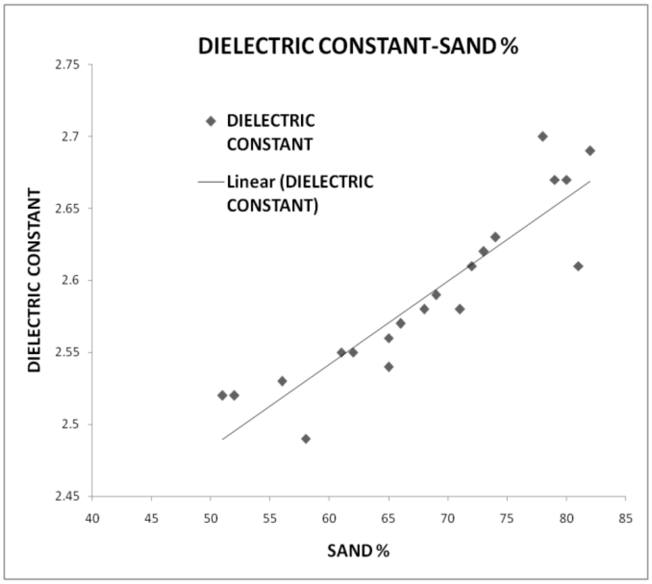

Figure 2 Variation of ϵ' of soil as a function of sand percentage in soil

The correlation coefficient between ϵ' of dry soil and sand percentage in soil is 0.886141. It shows that dielectric constant of dry has almost linear relationship with sand percentage. The results are in agreement with our previous study on dielectric behavior of dry and moist soil of the four samples of soil of Indo-Genetic region of Haryana at 5GHz [7].

The correlation coefficient between ϵ' of dry soil and clay percentage in soil is -0.8652. It shows that dielectric constant of dry soil has inverse relationship with clay percentage.

The correlation coefficient between ϵ' and silt percentage in soil is -0.77472. It shows that dielectric constant of dry soil has inverse relationship with silt percentage.

The correlation coefficient between ϵ' of dry soil and pH value of it is not significant. It shows that dielectric constant of dry soil is independent of pH which is also in agreement with our previous study on dielectric behavior of dry and moist soil of the four samples of soil of Indo-Genetic region of Haryana at 5GHz [7].

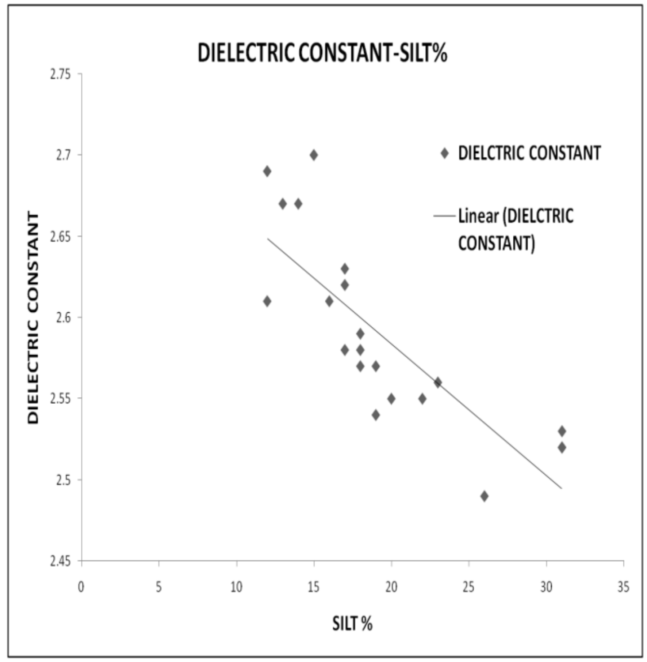

Figure 3 Variation of ϵ' of soil as a function of silt percentage in soil

Bulk density of soil samples collected from Haryana varied from 1.32 to 1.53mg/m^3. The correlation coefficient between Bulk density of soil and dielectric constant of dry soil is 0.552596. It shows that ϵ' is in almost linear relationship with bulk density.

The coefficient of correlation between ϵ' of dry soil and porosity (n) is -0.24716. It shows that ϵ' is in inverse relationship with porosity (n).

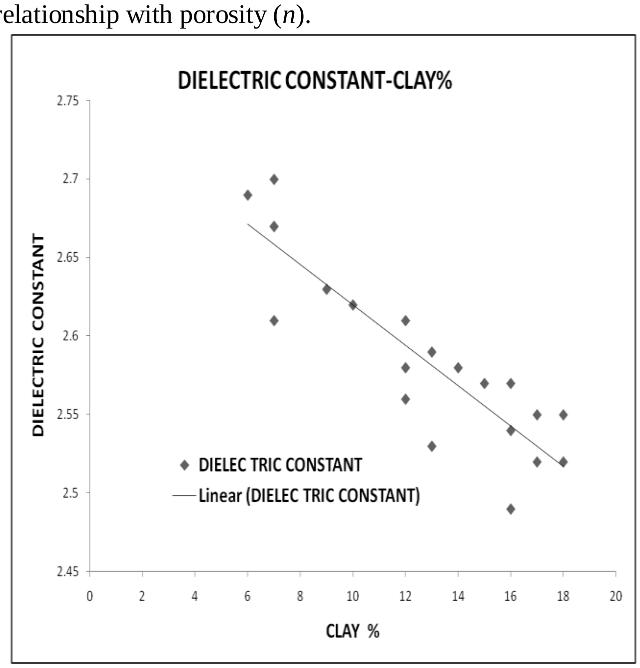

Figure 4 Variation of ϵ' of soil as a function of clay percentage in soil

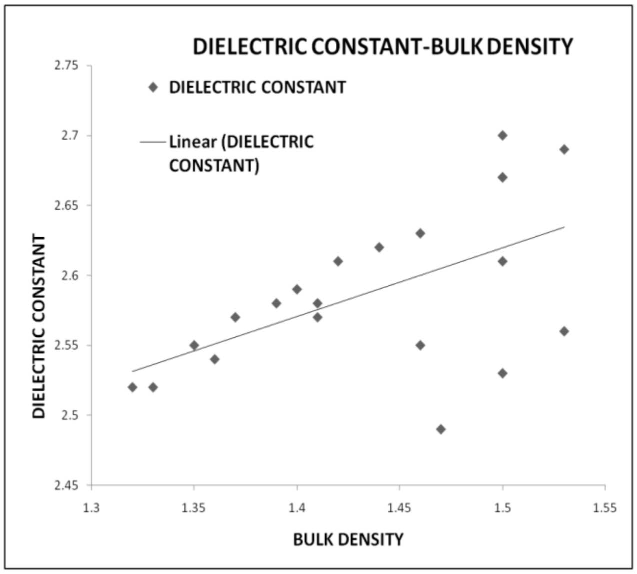

Figure 5 Variation of $\in'$ of soil with Bulk Density of soil

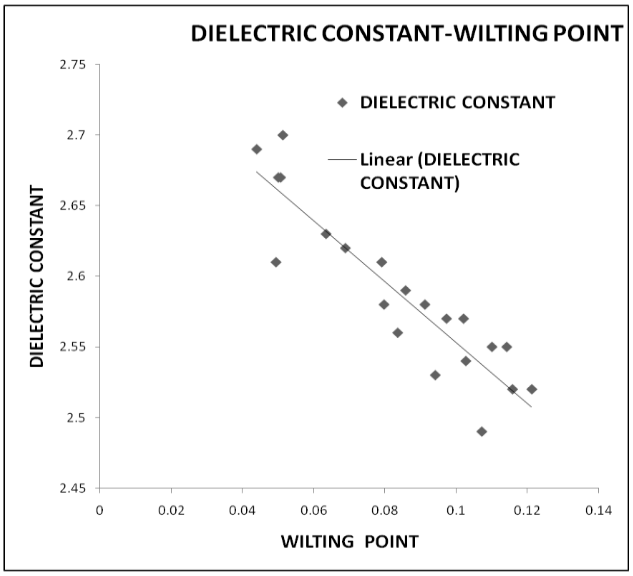

Figure 6 Variation of $\in'$ of soil with Wilting Point of soil

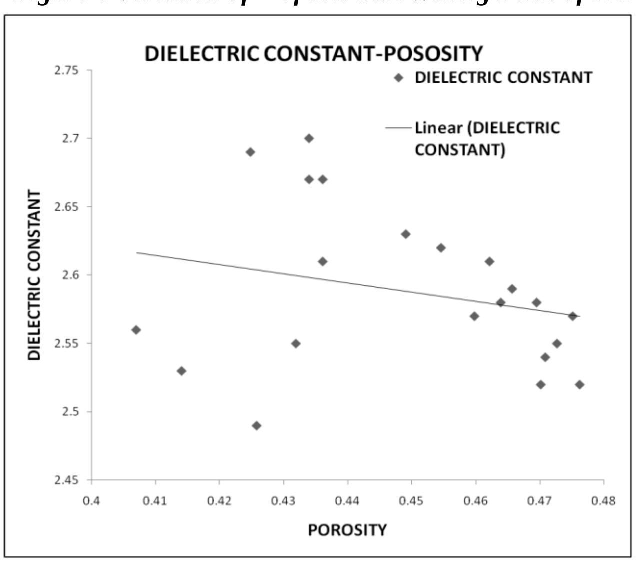

Figure 7 Variation of $\in'$ of soil with Porosity of soil

IV CONCLUSION

From above results and discussion, following conclusions may be drawn:

- $\in'$ of dry soil is almost proportional to sand content.
- Negative significant correlation is observed between $\in'$ and silt percentage in soil.
- Negative correlation is observed between $\in'$ and porosity.
- Negative significant correlation is observed between $\in'$ and Bulk density.
- Negative significant correlation is observed between $\in'$ and wilting point.
- $\in'$ of dry soil is independent of pH of soil of Haryana.
- Negative significant correlation is observed between $\in'$ and clay percentage in soil.

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