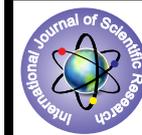


Effect of Cow Manure on Dielectric Properties of Clay Loam Soil at Microwave Frequency



Physics

KEYWORDS: Complex Dielectric Permittivity, Soil Moisture, Cow manure.

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ABSTRACT

Real and Imaginary parts (ϵ' & ϵ'') of the Complex Dielectric Permittivity (ϵ^*) of Clay Loam soil collected from Nanta Farm, CAD, Kota, Rajasthan have been measured using a Vector Network Analyzer with varied Moisture contents in the frequency range 150 MHz to 2.2 GHz. Measurements of Complex Dielectric Permittivity in this frequency Range were also carried out for different concentration of cow manure in soil. Both ϵ' and ϵ'' are observed to be strongly dependent on moisture content. The experimental observations show that ϵ' & ϵ'' decrease with increasing frequency and decreases with increasing percentage volume of cow manure.

Introduction

To study the microwave remote sensing of soil moisture, the dielectric constant is the most important parameter. There is a large variation in dielectric constant of various percentages of soil water mixtures. Hence it is necessary to have thorough knowledge of dielectric properties of soils to use microwave sensing technique for soil moisture estimation. The microwave remote sensing of soil moisture, strongly depends on its moisture due to the large contrast between the dielectric constant of water (80) and that of dry soil (3 to 5)[1]. Monitoring of soil moisture is considered important in agriculture. Its knowledge is important for the sowing, development, successful maturation of a crop along with rainfall runoff prediction agricultural yields forecasting.[2]. It has been observed by numerous researchers that the dielectric constant of dry soil lies between 3 to 5 and increases with increase in moisture content[3-7]. The different percentages of cow manure in the soil give rise to a large variation in the dielectric constant. Thus, the knowledge of the variation of dielectric constant of the soil with varied content of cow manure is necessary for the efficient use of soil.

The objective of the present study is to measure the complex dielectric permittivity of clay loam soil with varied moisture contents and cow manure contents in the frequency range 150 MHz - 2.2 GHz.

Sample Preparation

The soil samples were prepared by mixing different concentrations of cow manure in soil. The soil sample used in this study was collected from the field no. 7 of Nanta farm, CAD, Kota (Rajasthan). First, the stones and gravels were removed from the soil, and then it was oven dried and weighed. Then measured quantity of water and different quantity of cow manure was added and allowed 24 hours to facilitate internal drainage, subsequent homogeneous mixing and settlement. The texture structure of the soil has been given in Table 1. The Wilting Point (WP) and Transition moisture (Wt) have been calculated using the Wang and Schmutge model [8] as

$$WP = 0.06774 - 0.00064 \times Sand + 0.00478 \times Clay \quad (1)$$

$$Wt = 0.49 \times WP + 0.165 \quad (2)$$

Where, Sand and Clay stand for the sand and clay contents in percent by dry weight of the soil.

Wet soil samples were prepared with distilled water and The gravimetric soil moisture content in percentage W_g (%) is calculated using wet (W_1) and dry (W_2) soil masses using the relation

$$W_g(\%) = \frac{W_1 - W_2}{W_2} \times 100 \quad (3)$$

Hence, the volumetric moisture content was determined as

$$Wv = Wg \times \rho_b \quad (4)$$

Where, ρ_b is the dry bulk density of the soil

Table 1- Physical characteristics of soil used for permittivity measurement

Soil Type	Clay Loam
Sand (%)	27.41
Silt (%)	27.10
Clay (%)	45.49
Dry Bulk Density ρ_b	1.47
Wilting Point (WP), cm^3 per cm^3	0.2676
Transition moisture (Wt), cm^3 per cm^3	0.2961

Experimental Details

Complex Permittivity of soil samples for various moisture contents and cow manure content in the frequency range 150 MHz to 2.2 GHz were measured using Agilent made Vector Network Analyzer (Model-8714 ES). All measurements were carried out at room temperature. For measurement of complex dielectric permittivity a semi rigid coaxial probe of size 0.141 inch was used. The coaxial probe is connected to the VNA through the N-type male connector. The complex dielectric permittivity of the soils samples can be obtained from the measurement of the reflection coefficient at the defined reference plane which is located at the interface between the sample and the probe by the method suggested by Wei and Sridhar [9-10].

The probe end was first calibrated using the three calibration terminations described by Wei and Sridhar [9-10] and they are an open (air), short (mercury), and a standard liquid (acetone of AR grade) by measuring their reflection coefficients. A personal computer was set up to receive pairs of data (real and imaginary part of reflection coefficient for each frequency of measurement) and used for subsequent numerical analysis.

Results & Discussions

The measured values of the dielectric constant and dielectric loss of the clay loam soil using Vector Network Analyzer for various moisture contents and cow manure content in the frequency range 150 MHz-2.2GHz have been plotted in fig.(1&2). It is observed that at given moisture content both ϵ' and ϵ'' de-

crease with frequency. This decrease is rapid initially and becomes almost constant in the higher frequency side. Similar results have been observed in the soil with different percentage of cow manure. From fig.(2) it can be observed that higher cow manure contents have lower dielectric constant and lower dielectric loss in soil as compared to that low cow manure contents at a given frequency. The value of dielectric constant and dielectric loss decreases with increasing percentage volume of cow

manure. The reason may be the added cow manure that decomposes into humus and the humus molecules form cement particles of sand, soil, clay and cow manure decays into aggregates which will not breakdown in water. The cementing effect makes the soil aggregates stable in water or improves its water holding capacity. The presence of cow manure increases the bound water fraction and thus reduces the complex dielectric permittivity in the whole range of moistures.

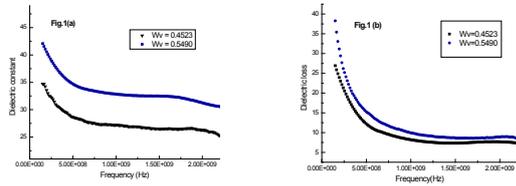


Fig.1 ϵ' & ϵ'' versus frequency at different moisture contents

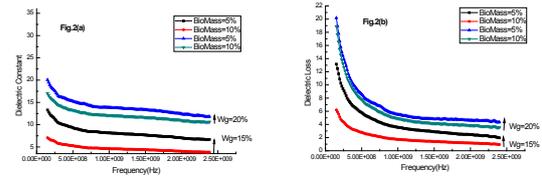


Fig.2 ϵ' & ϵ'' versus frequency at different cow manure contents

Conclusion

Study of the dielectric properties of clay loam soil with different percentage of cow manure at microwave frequencies in the laboratory is very useful in Agriculture. From the above result it is concluded that both ϵ' and ϵ'' of the soil show significant dependence on soil moisture & cow manure content in soil. These studies are also useful in understanding the structural behavior of soil. These results have great importance for increase the fertility of soil.

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