



DIELECTRIC PROPERTIES OF ANKALESHWAR SALINE SOIL AT 5 GHz.

S.S. Deshpande¹, A.K. Dongare², A.B. Ietolika³

¹Asst. Prof.Deptt. of Physics. Rashtramata Indria Gandhi College, Jalna-431203, (M.S.)India.

²Asst. Prof.Deptt. of Physics, Padmabhushan Vasantdada Patil College, Patoda-, (M.S.)India.

³Asst. Prof.Deptt. of Physics JNE College Aurangabad.(M.S.)India.

santoshdeshpande@yahoo.co.in, akdheed@rediffmail.com,

ABSTRACT:

The dielectric properties, both ϵ' (real part) and ϵ'' (imaginary part) of complex dielectric constant are measured for Ankaleshwar (Gujarat) saline soil at 5 GHz. The study also includes measurement of dielectric properties for various percentages of moisture contents, 5%-30%, for saline soil. The Shorted waveguide technique is used for dielectric measurements using automated C-Band microwave bench set up. The least square fitting technique is used to calculate dielectric constant, ϵ' , and dielectric loss, ϵ'' , and errors in their measurements. From measured dielectric properties, emissivity and brightness temperature are theoretically calculated at different angles of incidence of moisture-contented soils using Fresnel equations. The laboratory data obtained are useful for the interpretation of data in remote sensing applications, particularly in agriculture.

KEYWORDS:

Saline soil, Dielectric properties, 5 GHz microwave frequency, Brightness temperature, Emissivity.

INTRODUCTION:

Certain parts of India contain saline soil due to natural process of weathering that includes chemical, geological, hydrological and biological effects. Agriculture productivity is affected badly due to salinity in soil. The agriculture pattern of cash crops is day-by-day becoming popular for obvious reasons. More and more irrigation facilities are used to increase yield of cash crops. However many agriculture land, it is found that excessive of water for cash crop like sugarcane, cotton is resulting into production of water logging areas ultimately causing the increase in salinity of soil. Inappropriate cropping systems, reduction in crop diversity, inadequate post-harvest infrastructure are other major areas of concern. Hence, mapping and monitoring of soil are highly important and usually done by microwave Remote Sensing.

Remote sensing (Eugene A. Sharkov, 2003; Ulaby et al., 1986) usually refers to the technology

of acquiring information about the earth's surface (atmosphere, land, vegetation, forest and ocean) using sensors onboard airborne (aircraft, balloons) or space-borne (satellites, space shuttles) platforms. The electromagnetic radiation is used as an information carrier in Remote Sensing. Remote sensing employs passive and/or active sensors. Passive sensors are those, which sense natural radiations, either reflected or emitted from the earth. On the other hand, the sensors, which produce their own electromagnetic radiation, are called active sensors (e.g. LIDAR, RADAR). In passive microwave, remote sensing the radiometer measures the emissivity of soil, whereas in active remote sensing the radar measures the back-scattering coefficient of the soil, both factors depend on dielectric properties of soil. The complex dielectric constant is a measure of the electric properties of the surface. It consists of two parts: the real part, known as the dielectric constant (ϵ') and is a measure of the

ability of a material to be polarized and store energy. The imaginary part (ϵ'') is a measure of the ability of the material to dissipate stored energy into heat. The two are related by the expression:

$$\epsilon^* = \epsilon' - j\epsilon''$$

MATERIAL AND METHOD:

The soil sample is collected from location latitude 21° 36' 38" N longitude 72° 69' 47" E, Ankaleshwar which is in Gujarat. The pH of the collected soil sample is 7.75 hence it is saline in nature. The saline soil sample dry and different percentage of moisture contain 5% - 30% are prepared. Dielectric measurements of all these samples are done at 5 GHz at room temperature.

Experimental set-up

The C-Band microwave bench setup (Von Hippel A.R., 1954) consisting of a low power microwave source VTO, isolator, coaxial-waveguide adapter, attenuator, SS tuner, slotted section and solid dielectric cell. The Block diagram of the setup is shown in figure 1.

Microwave generated by VTO are propagated through passive components of rectangular wavelength to the dielectric cell with perfect reflector at closed end. The source is tuned to give 5 GHz frequency by applying tuning voltage of 7 volts. The attenuator is used to keep the desired power in waveguide assembly of the bench. A slotted section with a tunable probe containing 1N23 detector with the square law characteristics has been used to measure power (current) along the slotted line. The detector is connected to a micro ammeter and to the PC to read and record the measured power. The probe sits on slot line such that the tip of the tunable probe is penetrated and it can be moved forward and backward along the slot line section. The depth of the tip is adjusted for its critical position to get a symmetrical standing wave pattern. The empty dielectric cell is connected to the other end of the microwave bench. The bench is tuned for symmetrical standing wave pattern in the slot line. The dielectric sample under consideration (soil sample) is inserted in the dielectric cell with a constant compaction. The probe is transverse along the slot line at equal intervals and the probe positions are recorded with corresponding power (current). This data is acquired and store in file using microcontroller interface system. This data makes use of α and β as fitting parameters, where α = attenuation factor, β =phase shift constant.

The data is stored for soil samples of different thickness. The dielectric properties of the solid material can be calculated for best fit of parameters. The guided wavelength, λ_g is measured from the minima of the standing wave pattern

$$\beta = \frac{2\pi}{\lambda_g}$$

The free space wavelength is determined using the relation

Where ϵ^* is complex dielectric constant.

The measurement of these parameters is significant for remote sensing applications.

$$\frac{1}{\lambda_0^2} = \frac{1}{\lambda_g^2} + \frac{1}{\lambda_c^2}$$

Where $\lambda_c^2 = 2a = 2 * 4.73 \text{ cm} = 9.46 \text{ cm}$, 'a' being the broader side of the C-band rectangular waveguide.

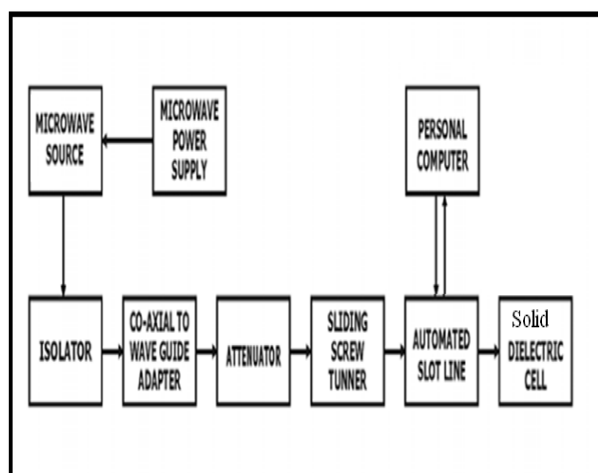
The real and imaginary parts of the complex dielectric constant are calculated using the relations

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

$$\epsilon'' = \frac{\lambda_0^2 \alpha \beta}{2\pi^2}$$

A source code for computing dielectric constant has been developed. The numbers of data files, for different thickness of samples are combined to get single input data, which can be used, in the source code for calculating dielectric constant and loss. Experimentally calculated dielectric constant ϵ' and loss ϵ'' with error in measurement in both $\Delta\epsilon'$, $\Delta\epsilon''$ are tabulated.

Figure 1 Block diagram of a C-band microwave bench



Brightness temperature and emissivity

Passive microwave remote sensing is based on the measurement of thermal radiation in the centimeter wave band of the electromagnetic spectrum T_b . This radiation is determined largely by the physical temperature and the emissivity of the radiating body and can be approximated by

$$T_{b(p)} \approx \epsilon_{s(p)} T$$

Where T_b observed brightness temperature; T physical temperature of the emitting layer; P refers to vertical or horizontal polarization; e_s smooth-surface emissivity. This emissivity is further defined as

$$e_{s(p)} = (1 - R_{s(p)})$$

Where R_s is the smooth-surface reflectivity. For a homogeneous soil with a smooth surface, the reflectivity at vertical and horizontal polarizations, R_{sV} and R_{sH} , are given by the Fresnel expressions

$$R_{sV} = \left| \frac{K \cos u - \sqrt{K - \sin^2 u}}{K \cos u + \sqrt{K - \sin^2 u}} \right|^2$$

$$R_{sH} = \left| \frac{\cos u - \sqrt{K - \sin^2 u}}{\cos u + \sqrt{K - \sin^2 u}} \right|^2$$

Where u is the incidence angles and k is the absolute value of the soil bulk dielectric constant, which is a measure of the response of the soil to an electromagnetic wave and is largely determined by the volumetric soil water content. Emissivity and Brightness temperature for different angle of incidence for 5% saline soil for different percentage of water content is calculated using Fresnel equations.

RESULT AND CONCLUSION:

The dielectric properties of dry Ankaleshwar saline soil are studied at 5 GHz at room temperature. Table 1 shows details of dielectric constant ϵ' and loss ϵ'' and error in measurement in both $\Delta\epsilon'$, $\Delta\epsilon''$.

Dielectric properties of dry Ankaleshwar saline soil are measured as a function of moisture contents shown in table 1. The sample was oven dried and considered at a level of 0% moisture. Then a desired weight of distilled water is added to achieve different moisture content levels. The

variations of moisture content up 5% to 30% are studied at 5 GHz. The response to the dielectric constant ϵ' is sensitive to moisture for saline soil, as soon as 5% moisture is added significant increase in dielectric constant is found, which remain increasing with addition of more moisture content in figure 2.

Higher is the magnitude of humidity, the stronger the effect of salinity on the imaginary part. Since ϵ'' is proportional to the conductivity, increase in soil moisture content increases conductivity. Thus, behavior of the increase in ϵ'' with increase in moisture content is seen in figure3. Similar trend is obtained by other workers (Wang. Jet al., 1978, 1980; Y. Lasne et al., 2008).

Figure 4. Plotted for emissivity against the angle of incidence for saline soil sample at 5%, 15%, 25%, 30%, moisture content. Decrease in emissivity values at normal incidence is seen with increase in moisture contain in saline soil. Reductions in emissivity values for horizontal polarization are seen; as angle of incidence increases. The curve for horizontal polarization shows a decrease in emissivity at a slow rate initially up to 20°, and above this angle, the emissivity reduces faster as the angle of incidence increases. The curve for vertical polarization shows a gradual increase in emissivity initially, which becomes faster as the angle of incidence 30°. For moisture content saline soil of 5%, 15%, 25%, 30% the emissivity curve changes for vertical polarization at 70°, 73°, 80°, 82°, respectively, instead of increase in the emissivity decreasing trends from these angles are found. Figure 5 the Brightness temperature at different angle of incidence is calculated, the nature of plot is found similar to emissivity

Table 1 Dielectric constant ϵ' , dielectric loss ϵ'' , error in dielectric constant $\Delta\epsilon'$ and loss $\Delta\epsilon''$ for different moisture content Ankaleshwar saline soil samples at 5 GHz.

Sr.No	Moisture Percentage %	AP(2) Factor	Dielectric Constant ϵ'	Error In Dielectric constant $\Delta\epsilon'$	Dielectric loss ϵ''	Error in Dielectric loss $\Delta\epsilon''$
1	0	0.137	5.93	5.91 E-002	2.20 E-002	5.48 E-002
2	5	0.112	6.92	4.80 E-002	3.18 E-002	4.95 E-002
3	10	0.102	9.68	2.35 E-002	4.15 E-002	2.73 E-002
4	15	8.30E-002	12.54	5.09 E-002	5.99 E-002	3.90 E-002
5	20	8.70E-002	15.43	5.20 E-002	6.10 E-002	6.96 E-002
6	25	7.60E-002	18.28	5.81 E-002	7.11 E-002	6.18 E-002
7	30	5.49E-002	21.73	6.41 E-002	8.32 E-002	7.52 E-002

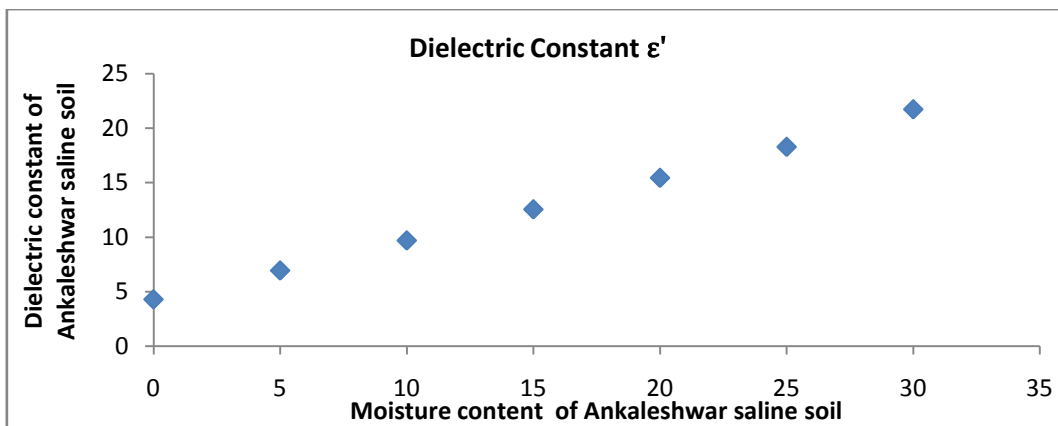


Figure 2 Variations of dielectric constant Versus Moisture% contain of Ankaleshwar saline soil.

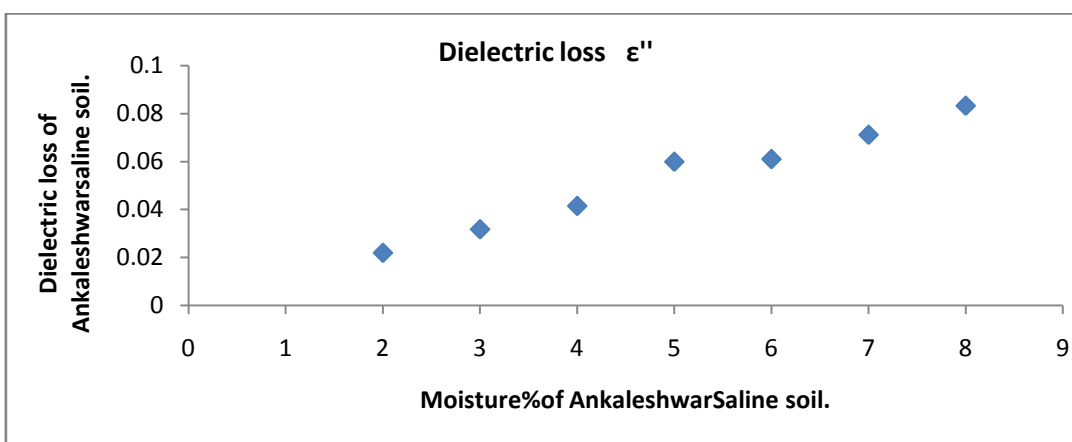


Figure 3 Variations of dielectric loss Versus Moisture% contain of Ankaleshwar saline soil.

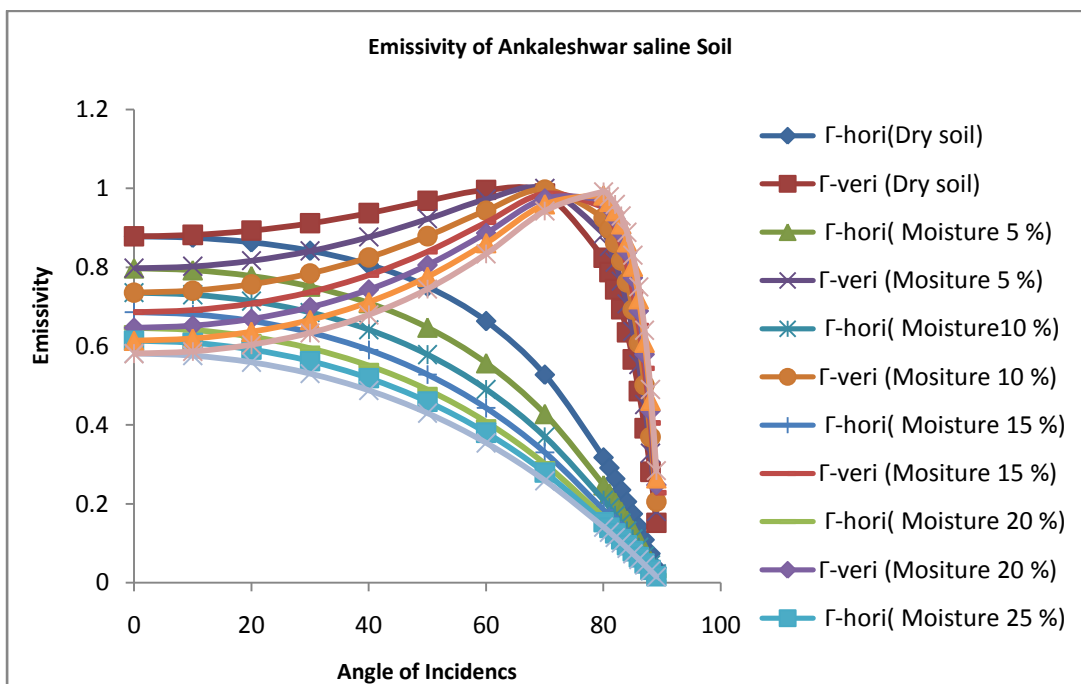


Figure 4 Emissivity Variations Ankaleshwar of saline soil.

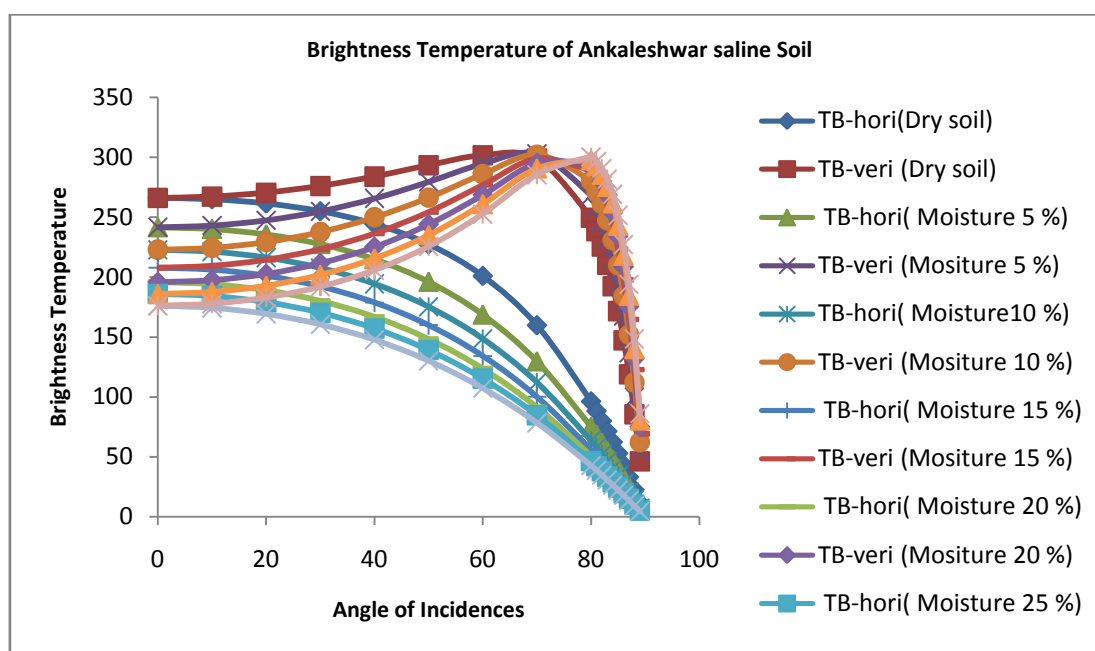


Figure 5 Brightness & Temperature Variations of Ankaleshwar saline soil

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