Review on Dielectric properties of soil at various bands of Microwave frequency

Syeda Ruhi nishat[1], Rabbani Gulam[2], A.R Khan[3],Y.H.Shaikh[4]
[1]Research scholar Maulana Azad college of Arts, science and commerce, Aurangabad 431 001(M.S) India.
[2]Maulana azad college of Arts, science and commerce Dr.Rafiq zakaria campus, Aurangabad 431 001(M.S) India.
[4]Shivaji Arts commerce and science college kannad, Dist. Aurangabad.

Received: July 03, 2018 Accepted: August 25, 2018

ABSTRACT *Review on Dielectric constant and dielectric loss of soil on different bands of microwave frequency like s-band,j-band,x-band is studied. Dielectric constant represents the ability o f a material to store electric energy, while the loss factor represents the loss of electric-field energy in the material. It is seen that the dielectric constant vary with the moisture content in the soils and frequency of measurement. Dielectric constant of soils slightly increases with increase in the moisture content in the soil up to the transition moisture, after that it increases rapidly with moisture content.*

Keywords: *Dielectric constant, dielectric loss, moisture*

1. Introduction:-

Over last two decades, Microwave remote sensing became the emerging field for the study of natural resources. It signify the interaction of electromagnetic waves with the materials under study. The study of dielectric properties of different earth constituents at microwave frequencies plays vital role as they provides interpretation of various remote sensing data. Dielectric properties are primarily a function of frequency, water saturation, porosity, texture, component geometry and electrochemical interactions. Dielectric dispersion in low frequency region is helpful to study the behaviors of induced polarization in the materials, while high frequency dielectric measurements are useful in planning ground penetrating radar survey.

2. Review of papers: from the study of Bapna[3] P.C and joshi it is mention that there are different methods available for the measurement of dielectric constant at a microwave frequency. In the present study, Two Point Method was used to measure the complex dielectric constant of soils.Bapna p.c and joshi.s[3] studied the dielectric constant at different moisture that whatever be the moisture condition and type of soils, the dielectric constant decreases with increase in frequency. All samples also show the frequency dispersion properties. Wet soil is a combination of soil particles, air voids and liquid water. The dielectric constant of water (approx 80) depends on the molecules' ability to align its dipole moment along an applied field. Anything thathinders the molecule's rotation (e.g. freezing, tight binding to a soil particle, etc.) therefore reduces the dielectric constant of water. The water molecules present in the first molecular layers surrounding the soil particles are tightly held by the soil particles, due to the influence of matric and osmotic forces, called bound water3,4. Thus the dielectric constant of bound water is low. The matric forces acting on a water molecule decrease very fast with the distance away from the soil particle surface. Thus the water molecules located several molecular layers away from the soil particles are able to move freely within the soil medium, called free water. Hence the dielectric constant of free water is high.

At moisture contents below the transition moisture in the soil there are more bound water molecules as compared to free water molecules. Thus the dielectric constant of soil at lower moisture percentage is low. As the moisture content in the soil increasesabove transition moisture in the soil, the free water molecules increase rapidly in the soil increasing the dielectric constant very fast. The sand has a small surface area per unit volume as compared clay particles. Therefore at given moisture content the clay particles are capable of holding more bound water molecules as compared to sand particle , i.e. there are more free water molecules in sand as compared to that in clay at given moisture percentage.

1. Physical properties:-

S.No.	Sample	Sand (%)	Silt (%)	Clay (%)	Texture	WHC (%)	PD (%)	BD (%)	Pore specs (%)
1	Kelwa (Rajsamand) White Marble	88	3	8	Loamy sand	14.5	23.34	1.62	53.5
2	Keshriya ji (Dungerpur) Green marble	71	26	4	Sandy loam	6.5	26.45	1.32	52.8
3	Babarmal (Udaipur) Pink Marble	87	9	3	Loamy Sand	74.2	25.4	1.43	51.6

2. Chemical analysis:-

S. No	Sample	pH	EC (dSm^{-1})	OC (%)	P2O5 ($Kgha^{-1}$)	K_2O ($Kgha^{-1}$)	Ca m.eq/ltr	Mg m.eq/ltr	Na ppm	$CaCO_3$ (%)
1	Kelwa (Rajsamand) White Marble	7.56	0.34	0.33	28.2	330.6	3.2	4.3	17.9	48
2.	Keshriya ji (Dungerpur) Green marble	7.27	0.54	0.93	25.1	206.6	6.6	5.7	12.7	15
3.	Babarmal (Udaipur) Pink Marble	7.01	0.42	0.38	21.8	358.1	6.7	2.3	21.1	11

Methods of measurement of dielectric properties:-

1. wave guide method:-

In the wave guide method the dielectric constant is measured by calculating the shift in minima of the standing wave pattern inside waveguide. The shift occurs due to change in the guide wavelength when dielectric material is introduced in the wave guide [11].

2.cavity method:-In this method a cylindrical cavity resonator is being used. The cavity is designed with the help of the mode chart which is a family of straight line when (Fd^2) is plotted against (D/L^2), Here f is the frequency, D is the diameter of the cavity and L is the length of the cavity. The operating rectangle operates within the frequency range 7.1-8.8 GHz in the TE_{011} mode.

3. Network analyzer method:-

In this method dielectric constant of the sample is measured by simply touching the co-axial probe of the network analyzer to the flat face of the soil surface. The system consists of swept RF source, a network analyzer (HP8510C) and associate data processing instrumentation.

4. Infinite sample method:-

When a dielectric material has a very high loss tangent, it becomes difficult to measure with the method usually applied to low and medium loss material. This is so because if, on one hand the sample is very short the error in the measured sample will be large; if on the other hand the sample is made longer a change in the terminal impedance does not cause the significant change in the output data. When a physically reasonable length of dielectric sample dissipates a sufficiently large portion of the microwave energy entering the sample, so that no energy is reflected to the in-pot, the sample may be considered to be of infinite length. Advantage can be taken of this condition when it occurs in the form of relative simple measurement procedure which require the determination of essentially only the normalized input impedance at the sample face.

Conclusion:

The dielectric properties of Indian soil is depend on the texture of soil, significant positive correlation of dielectric constant with sand content of soil and negative correlation with clay and silt content of soil was observed.

The relationship between dielectric properties and gravimetric waterContent is non linear.

Thus we see that the dielectric constant of soils depends onmany factors like frequency, moisture, and its physical andchemical compositions.

References:-

1. V. navarkhele*, a a shaikh[1]& r s ramshetti[2] dielectric properties of black soil with organic and inorganic matter at microwave frequency journal of radio & space physics vol. 38, april 2009, pp. 112-115
2. C. H. Chaudhri dielectric properties of soil of organic and inorganic material j- band microwave frequency. Int. J. Remote sens. Geosci. 4, 14-19 (2015)
3. Rajesh. Mohan. R, . M., p. Mohanan. Study and analysis of dielectric behavior of fertilized soil at microwave frequency. Euro. J. Adv. Engg. Tech2, 73-79 (2015).
4. Chaudhri, h. C. Dielectric properties of soils with inorganic matter at s-band microwave frequency. Ijcps 3, 59-66 (nov-dec 2014).
5. H. C. Choudhri, v. J. S. Dielectric properties of soil at x-band microwave frequency. Indian j. Pure appl. Phys.50, 64-66 (2012)
6. Bapna, p. C., joshi. S. Measurement of dielectric constant of soils of marble mining areas of mewar region, rajasthan state at x-band. Ijetee3, 66-69 (may-2013.).
7. Buliya, a. Complex dielectric permitivity of salt effected soil at lower microwave frequency. Indian j.sci.res.3, 127-130 (2012).
8. C. Choudhri, v. J. S. Dielectric properties of black and red soil at microwave frequency. Indian j. Radio space phys.39, 103-106 (april 2010).
9. H. Gadani, a. D. V. Measurement of complex dielectric constant of soils of gujarat at x- and c-band microwave frequencies. Indian j. Radio space phys.7, 221-229 (june 2008).
10. Chaudhari. H. C, s. V. J. Dielectric study of moisture laden soils at x-band microwave frequency. Int. J. Phys. Sci.3, 075-078 (march, 2008)
11. O p n calla comparative study of the method of measurement of dielectric constant at microwave frequency of dry and wet soil . Indian j. Radio space phys,108-113(vol 32,april 2003)