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Electrical Status of the Black Soil Around the Aurangabad City

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Introduction: Soil is the outermost part of the earth surface that is exposed to the atmosphere. This soil is a complex material made up of solids, liquids and some gaseous molecules. Exploring this surface physically, chemically or electrically gives an insight of the composition of it. This research is carried out all around the globe in search of earth like planet that supports living organisms as well as flourishing flora in the space. It is a termed as remote sensing [1].**.** Remote sensing is done with the intention to study the soil in terms of its electrical properties. There is active remote sensing and also passive sensing in which radiations from some strange emitters are analyzed to have an idea about its composition.

Electrical properties[2] of soil are the indicators of its structural and chemical composition. These electrical properties include complex dielectric permittivity, ε^*. It is the sum of real part, dielectric constant and the imaginary part, dielectric loss. Dielectric constant gives the amount of energy stored in the material and dielectric loss is the amount of energy lost per cycle.

$\varepsilon^* = \varepsilon' - i\,\varepsilon''$, ε' = dielectric constant , ε'' = dielectric loss & $i = \sqrt{-1}$

The concept of dielectric constant and dielectric loss can be understood from polar and non polar materials. The insulating materials that are available in the nature can be categorized into polar and non polar molecules. Polar molecules have a permanent dipole moments .The centers of positive and negative charges are separated by slight distances forming dipoles even in the absence of external field.. These dipoles are randomly oriented when no field is applied, hence the net electric field inside the material is zero. Whereas, in case of non polar molecules, the centers of positive and negative charges overlap. When external electric field is applied, the centers of respective charges get displaced from their mean position, polarization is brought out. In the presence of the external field, in both types of materials, the induced dipoles get aligned according to the direction of the external applied field. Hence, electrical energy is stored in the material in the form of these polarization charges. When external field is removed, the dipoles go back to their original position. But all of the energy is not recovered. Some part is lost in aligning the dipoles. This part is called as dielectric loss. The time taken by these charges to align in the direction of applied field is called relaxation time, τ .

Experimental Setup: When electromagnetic waves are incident on the dielectric material, the part of the wave is reflected back. Hence a standing wave is formed between the forward wave and the reflected wave [3]. The shift in the minima of the standing wave pattern obtained without and with sample indicates the characteristics of the material through which it is reflected. Writing the impedance formula for the interface of air – dielectric material, the dielectric parameters of the material can be determined if the dimension of the waveguide and sample length are known[5].

In this method, the standing wave formed is scanned entirely with the slotted line and detector probe and the points of minima and twice of minima are determined.

Sample Preparation: The soil samples as particulate matter[3] were taken from seven different locations from and around the Aurangabad city. The samples are taken from a vertical depth of 10-15 cm from the agricultural land. The soil samples were crushed and oven dried. The dried samples were then sieved with a standard sieve of number 25. Now, this soil is called the material under test. The material under testis filled up carefully in the waveguide. Infinite sample method is deployed here for measurements of the electrical constants. The sample in the sample holder has to be uniformly inserted without any cavity in between .For this purpose a mechanical arrangement is used.

Procedure: Various techniques are available for the measurements of dielectric properties[4]. The one that is chosen here is infinite sample method. Initially, the slotted line is terminated with a short circuit and the distance between the two successive minima is noted. Twice of these distance gives the waveguide wavelength λ_g . The soil is inserted properly, as described above and the position of first minima is noted. And also, we determine the two points on the slotted line at which the power is twice the minimum value. This method is called twice the minimum method[5].

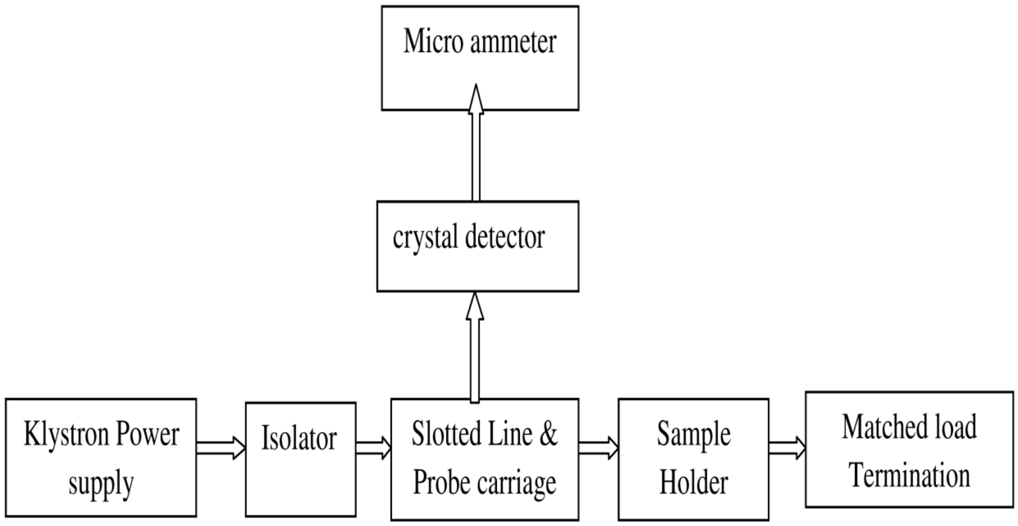

Fig (i) Block Diagram of the Experimental Setup

The Electrical parameters of the soil are determined by using the formula,

Formulae:

$$\varepsilon' = \frac{1}{1+(\frac{\lambda_c}{\lambda_g})^2} + \frac{(\frac{\lambda_c}{\lambda_g})^2}{1+(\frac{\lambda_c}{\lambda_g})^2}\left[\frac{(r^2-E^2)(1-r^2E^2)+(2rE)^2}{(1-r^2E^2)^2+(2rE)^2}\right]$$

$$\varepsilon'' = \frac{(\frac{\lambda_c}{\lambda_g})^2}{1+(\frac{\lambda_c}{\lambda_g})^2}\left[\frac{2rE((1-r^2E^2)-(r^2-E^2))}{(1-r^2E^2)^2+(2rE)^2}\right]$$

$$\sigma_{ac} = \omega\,\varepsilon_0\varepsilon'', \quad \tau = \frac{\varepsilon''}{\omega\varepsilon'} \quad \text{and tangent loss} = \varepsilon''/\varepsilon'$$

Where ,

$K = 2\Pi / \lambda_g$

λ_g = guide wavelength

λ_c = cutoff wavelength in the waveguide = 2a , a = wider dimension of the waveguide

r = VSWR

D = Position of first minima with sample

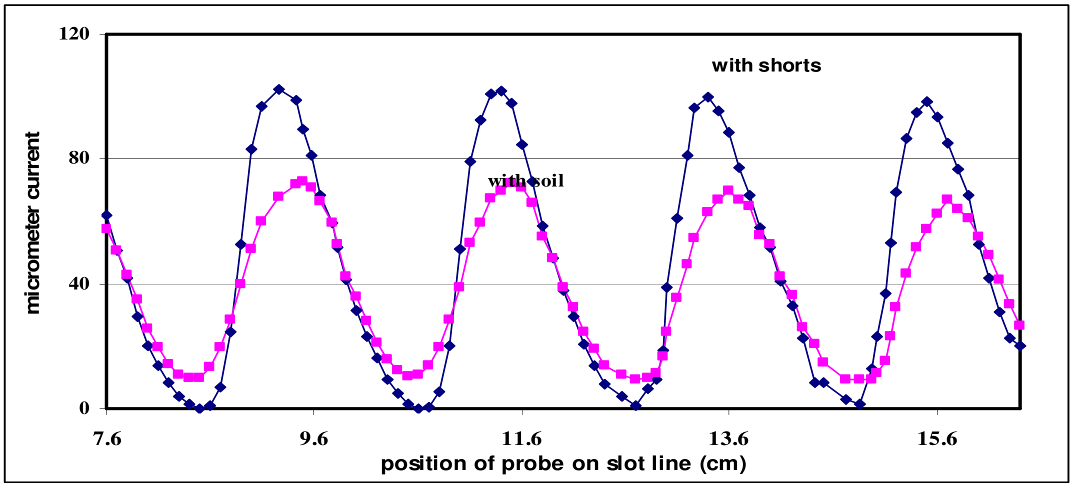

fig (ii)standing waveform within the waveguide

The dielectric parameters of the soil calculated are tabulated as,

Dielectric Parameters					
Sample No	Dielectric constant	Dielectric loss	Ac conductivity(S/m)	Relaxation time (psec)	Tangent loss
1	2.42	0.76	0.412	5.13	0.3143
2	2.72	0.72	0.314	4.97	0.3044
3	1.84	0.41	0.224	3.66	0.2243
4	2.34	0.69	0.377	4.84	0.2967
5	2.31	0.79	0.429	5.59	0.3424
6	2.44	0.92	0.509	6.16	0.377
7	2.81	1.11	0.6	6.43	0.3944
8	1.86	0.42	0.23	3.72	0.2281
9	2.26	0.63	0.343	4.54	0.279
10	2.94	1.5	0.816	8.33	0.5108

Result and Conclusion:

Even though the sample that has been collected from ten different locations appears to the same, the dielectric parameters show a wide variations. The value of dielectric constant for dried soil at a frequency of 9.8 GHz ranges from1.84 - 2.94 .These values vary from region to region and also with the vertical depth of the soil, the parameters goes on changing. Out of the ten samples collected, almost all are black in color except sample number 3 and 8. Both these soil samples have somewhat brownish color because of the presence of iron and its compounds. Dielectric constant as well as other parameters for these soil samples are found to be less in comparison to other samples.

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