International Journal of Scientific Research in Science and Technology
Print ISSN: 2395-6011 | Online ISSN: 2395-602X (www.ijsrst.com)
doi : https://doi.org/10.32628/IJSRST523103165

Impact of Moisture on Electrical Properties of Irrigated Red Soil Using LCR Meter

Quadri F B
Assistant Professor, Department of Physics, Dr. Rafiq Zakaria College for Women, Aurangabad, India

ARTICLEINFO

Article History:

Accepted: 05 June 2023
Published: 19 June 2023

Publication Issue
Volume 10, Issue 3
May-June-2023

Page Number
914-918

ABSTRACT

Soil is an important component of various ecosystem pertaining to micro and macro organism. It is one of the complex entity comprising of chemical elements, micro sized flora and fauna. Study of soil has diversified aspects like physical, chemical, biological, electrical, etc. The present research paper deals with the electrical properties of soil of a particular location. It also tries to have an insight on the impact of moisture on these properties as a function of frequency. For the analysis part, IM 3570 HIOKI LCR meter from Aligent Technologies is used.

Keywords : LCR meter, broadband frequency, electrical parameters, dielectric constant, dielectric loss, conductivity, relaxation time, tangent loss.

I. INTRODUCTION

Soil is a complex mixture of organic matter, liquid and gases present in different proportions. Dielectric properties of soil is a tool to study this composition and determine vital parameters of the constituent particles. It is a function of wide number of variables like geographical location, climatic conditions under which the sample has been collected, type of soil, moisture content, physical properties, chemical composition, etc [1]. It also depends, to some extent on the method selected for its measurement. No two soil samples show same values of dielectric parameters. Large variations are noted in the dielectric parameters of the soil that is collected from the same region, even samples taken from same location, but with different vertical depth vary a lot.

Soil is one of the abundant natural resource that promotes the development of life on the earth. It takes thousands of years together to form a particular type of soil. It is home to a diversified form of microorganisms that form a part of the complex food chain. The soil is either rich or poor depending on the content of living microorganisms and soil organic matter. The soil that is rich in its content is termed as fertile soil that helps in the productivity of the crops. The Physio-chemical properties of the soil that includes its porosity, texture, bulk density, water holding capacity, pH, organic matter, available macronutrients and traces of micronutrients, etc [2 &

3] . These properties are very crucial in ascertaining the quality of the soil for agriculture. They can be managed and maintained to the desired value so that particular crop can be cultivated in the specific soil. Along with macronutrients like N, P and K, micro nutrients like B, Fe, Cu, Mn etc are also important in maintaining the quality of the soil for the growth of the crops. Excessive use of N P K fertilizers has reduced the concentration of the availability of micronutrients in the soil thereby affecting its health. An electrical property of soil includes its complex dielectric permittivity, relaxation time, ac conductivity [4]. These properties are the precursors to the composition of the soil. They give an insight on the physical properties as well as chemical composition of the soil. The moisture content of the soil is also indicated by the dielectric values so determined [5]. Dielectric properties are dependent on the physical and chemical properties of the soil [6 & 7].

II. LITERATURE REVIEW

Electrical properties of the soil have been studied at wide range of frequency [8]. The effects of salts present, on dielectric properties of the rocks have been studied in depth [9]. A database of effect of chemical and physical properties on the dielectric properties of rocks was established [10]. Complex dielectric permittivity and other dielectrical parameter of dry rocks were studied [11]. The effect of moisture in the soil in terms of its dielectric constant was noted [12]. Wide variations the dielectric properties of soil with its physical properties is noticed for soils of marble mining areas of Mewar region, Rajasthan state at X band[13]. The dielectric properties of the soil of Nasik region have shown dependence on its physio chemical properties [14].

III. Methodology

LCR meters are analogous to multimeters with multi functioning facility and it measures the electrical parameters at a wide range of frequencies ranging from 40Hz to 5MHz [Aligent Technologies] [15].
Presently IM 3570 HIOKI LCR meter and impedance analyzer is used for the measurements of the dielectric parameters. Soil with minimum moisture was collected from different region during the summer season. This soil was crushed to fine powder, sieved and oven dried at 1000 C for 4-5 hours to remove the moisture content of it . Distilled water in different concentration is added and, using suitable binders, pellets were formed by a mechanical compressor machine. These pellets were sintered at a temperature of 2000 C to evaporate the binder and the pellets were cooled down to the room temperature. The dimensions of the pellets were measured using screw gauge and were noted. The pellets were held between the sample holder and its parameters like parallel capacitance, series capacitance, quality factor, dissipation factor, etc were noted directly from the display of IM 3570 HIOKI for frequencies varying from 100Hz to 1 MHz
Formulae:
Dielectric Constant = $\varepsilon' = c_{(p \times d)/(\varepsilon_0 \times A)}$
Dielectric Loss = $\varepsilon'' = \tan \delta \times \varepsilon'$
AC conductivity = $\sigma = w \times \varepsilon 0 \times \varepsilon''$
Relaxation time = $\tau = (\varepsilon'' / \acute{\varepsilon}\ \omega)$
Where, Cp = parallel capacitance value,
d= thickness of the pellet,
A = surface area of the pellet,
$\varepsilon 0 = 8.85 \times 10\text{-}14$ F/cm,
$\tan \delta = 1/Q$, quality factor
ω = angular frequency = $2\pi f$.
The results are presented in the following table and graphs.

Table 1 : Electrical parameters of oven dried red soil with different amount of moisture added to it at a frequency range of 100 Hz -1MHz.

Sample No.	Electrical Parameter	% 0f water added	Frequency of measurement				
			100Hz	1000Hz	10KHz	100KHz	1MHz
1	Dielectric constant	0	852.12	358.12	163.25	62.78	42.65
		1	854.36	360.14	168.52	64.12	43.58
		2	868.47	365.24	172.45	67.02	45.13
		3	875.2	371.45	174.23	69.15	47.25
	Dielectric loss	0	655.54	190.25	80.23	28.12	12.30
		1	658.12	191.85	82.15	29.87	13.25
		2	661.45	193.45	83.96	31.25	17.52
		3	665.17	196.25	85.14	33.25	19.36
	AC Conductivity (µS/cm)	0	0.0356	0.125	0.478	0.8450	1.245
		1	0.0421	0.246	0.498	0.8670	1.345
		2	0.0563	0.312	0.542	0.9023	1.388
		3	0.0728	0.456	0.566	0.9450	1.456
	Relaxation time (µsec)	0	1360	920	455.2	256.1	58.23
		1	1380	922	475	284.2	65.12
		2	1392	936	495	299.5	68.45
		3	1410	945	512	345.2	72.14
2	Dielectric constant	0	792.12	252.18	146.22	52.76	33.64
		1	794.23	255.60	147.52	55.12	36.15
		2	799.15	257.40	150.24	58.45	40.15
		3	802.30	260.30	153.40	60.25	42.25
	Dielectric loss	0	484.23	142.52	67.26	25.26	10.30
		1	487.14	143.65	69.12	26.87	11.56
		2	490.52	146.58	71.85	27.85	13.24
		3	492.62	150.42	73.45	29.25	15.48
	AC Conductivity (µS/cm)	0	0.0265	0.118	0.396	0.785	1.156
		1	0.0302	0.136	0.412	0.812	1.172
		2	0.0336	0.212	0.492	0.896	1.188
		3	0.0528	0.356	0.516	0.9250	1.329
	Relaxation time (µsec)	0	1120	840	378	188.2	42.13
		1	1210	845	390	191.20	45.25
		2	1354	890	425	194.52	48.63
		3	1390	920	450	197.45	53.28

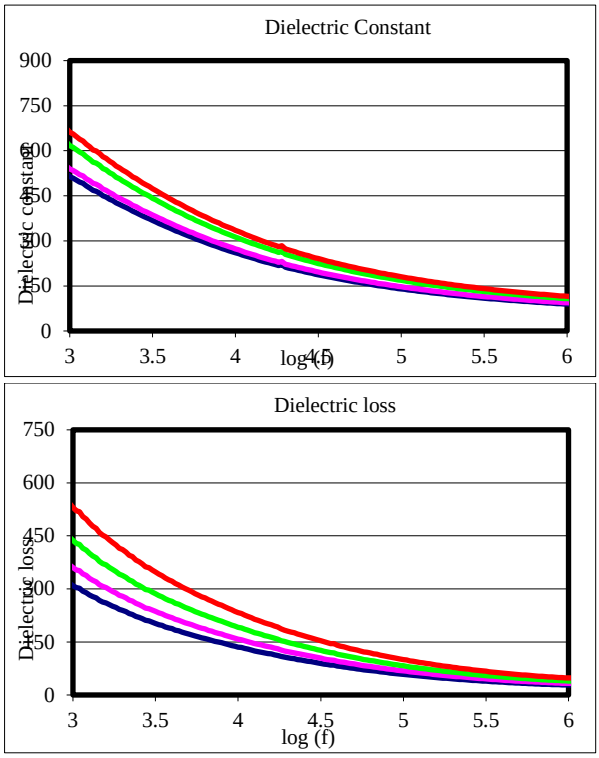

Fig (1.1& 1.2 showing dielectric constant & dielectric loss at different frequencies with % of moisture added for sample 1)

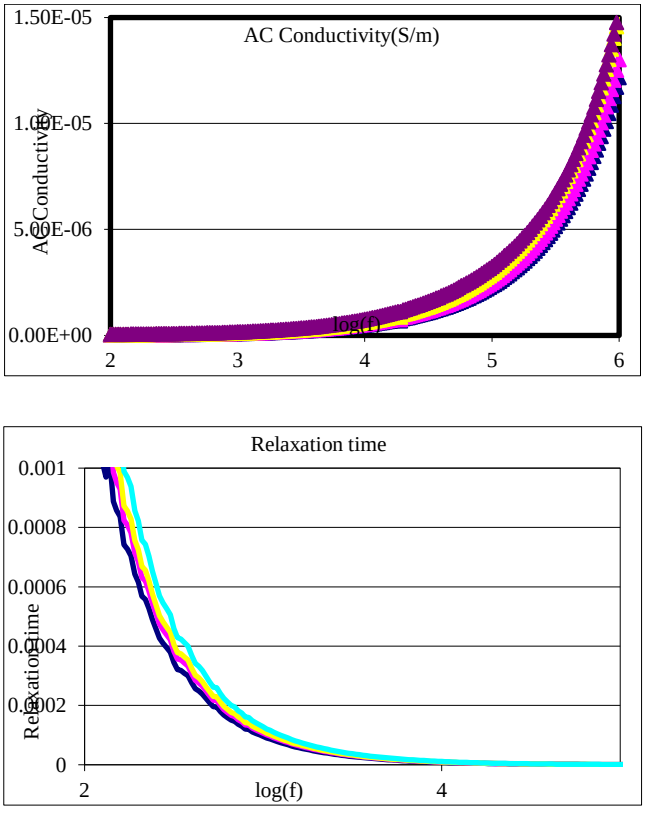

Fig (1.3 & 1.4 showing AC conductivity & Relaxation time at different frequencies with % of moisture added for sample 1)

IV. Result

Variation with Frequency

The table and graph above shows that frequency of measurement has a great impact on the values of measurement of electrical parameters of the soil.

i. At lower frequencies the parameters like dielectric constant and dielectric loss show high values,

ii. Relaxation time is in microsecond and with increasing frequency the values goes on decreasing.

iii. AC conductivity increases as the frequency of measurement increases.

iv. Soil shows low but finite conductivity.

Variation with Moisture

The table above shows the variation of electrical parameters with the addition of moisture to it.

i. Moisture increases the electrical factors of the red soil at all frequencies.

ii. As the amount of moisture added increases, the parameters also increases.

V. REFERENCES

[1]. Kiran G. Chaudhari. "Studies of the physicochemical parameters of soil samples". Advances in Applied Science Research, 4(6): 246-248. 2013.

[2]. Kekane SS, Chavan RP, Shinde DN, "A review on physio-chemical properties of soil". International Journal of Chemical Studies, 3(4): 29-32, 2015.

[3]. Phogat VK, Tomar VS and Dahiya Rita. "Soil Science: An Introduction" [Online] 2015 [cited2016Mar11]Availablefrom:URL:https://www.researchgate.net/publication/297737054/chap-6,135-171.

[4]. Hoekstra P and Delaney A, "Dielectric Properties of Soils at UHF and Microwave Frequencies". Journal of Geophysical Res., 79(11): 1699-1708, 1974.

[5]. Wang J R and Schmugge T J, "An empirical model for complex dielectric permittivity of soils as a function of water content". IEEE Trans. on Geosci. and RemoteSensing,; 18:288-295, 1980.

[6]. Jackson T J , "Effects of Soil Properties on Microwave Dielectric Constants" .Transportation Res. Record , 1119: 126-131, 1987.

[7]. Gadani D H and Vyas D, "Measurement of complex dielectric constant of soils of Gujarat at X and C band microwave frequencies". International Journal of Radio and Space Physics, 37:221-229, 2008.

[8]. Hoekstra P. and Delaney A. "Dielectric Properties of Soils at UHF and Microwave Frequencies", Journal of Geophysical Research, 79(11): 16-99, 1974.

[9]. Anabalagan G. "Microwave Dielectric Properties of Water Saturated Carbonate Rocks", Review and research: Journal of Pure and Applied Physics, 4(1):28-35, 2016.

[10]. Jackson T. J. and O' Neill P. E. "Effects of Salinity on the Microwave Emission of Soils". IEEE Transactions on Geoscience and Remote Sensing, Vol. GE-25: 214-220, 1987.

[11]. Ulaby FT, "Microwave dielectric properties of dry rocks". IEEE Transactions Geoscience and RemoteSensing.28:325-336, 1990.

[12]. Wang J. R. and Schumgee TJ, "Dielectric constant of soil as a function of moisture content", IEEE Transactions of Geoscience and remote sensing, GE18; 288-295, 1980.

[13]. Bapna P. C. and Joshi S. "Measurement of dielectric constants of Soils of marble mining areas of Mewar region, Rajasthan State at X band", International Journal of Emerging trends in Electrical and Electronics, 3(3):66-69, 2013.

[14]. Dhiware M. D., Nahire S. B. and Deshmukh S. "Complex Dielectric Behavior of Soil from Nasik Region at X - Band Microwave Frequency", International Journal of Scientific and Research Publications; 6(12):77-89, 2016.

[15]. Agilent, Basics of Measuring the Dielectric Properties of Materials, Application Note, Aligent technologies, Inc. June 26, 5859-2589 EN, 2006.

Cite this article as :

Quadri F B, "Impact of Moisture on Electrical Properties of Irrigated Red Soil Using LCR Meter ", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 10 Issue 3, pp. 914-918, May-June 2023. Available at doi : https://doi.org/10.32628/IJSRST523103165
Journal URL : https://ijsrst.com/IJSRST523103165