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Behaviour of Dielectric Properties of Soil of Northeast Region of Nasik with Variation of Moisture Content

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Abstract*: This paper presents the measurement of dielectric constant of soils of Northeast of Nasik region of Maharashtra state (India) at X-band microwave frequencies. Soil samples were collected from agricultural land of Northeast of Nasik region. Further, the data on the physical and chemical properties of these soils are also reported.The soils were analyzed for the status of available nutrients. The pH and Electrical Conductivity of soil samples were measured by using soil testing kit. An automated X-band microwave set-up in the TE_{10} mode with Reflex Klystron source operating at frequency 9.88 GHz is used to determine their dielectric constant with varied amount of moisture contents. Dependence of dielectric constant on percentage of sand is also reported. These properties are important in better understanding of soil physics, agricultural application and analyzing the satellite data in remote sensing.

***Keywords*: Dielectric constant, tangent loss, microwave conductivity, relaxation time**

I. INTRODUCTION

Soil characterization in relation to evaluation of fertility status of the vineyard soils is valuable in context of sustainable agricultural production. Nitrogen, Phosphorous and Potassium are important soil elements that control its fertility and yields of the crops. The physicochemical analysis of soil is very useful in order to plan fertilization and to know the residues of fertilizers in relation to the crop, tillage and climate. An analysis can highlight shortages and help to understanding of the cause of an abnormal growth. Soil covers the vast majority of the exposed portion of the earth in a thin layer.

A wet soil medium is a mixture of soil particles, air pockets and liquid water. The water contained in the soil is usually divided into two fractions; viz. bound water and free water. The relative fractions of bound and free water are related to the particles distribution (or soil texture).These, in turn, is dependent upon the bulk soildensity and the shape of the particles water inclusions. Thus, a soil medium is considered electromagnetically a four component dielectric mixture consisting of air, bulk soil, bound water and free water. Due to the intensity of the forces acting upon it, a bound water molecules interacts with an incident electromagnetic wave thereby, exhibiting adielectric dispersion spectrum that is very different from that of free water.Many factors influenced dielectric properties of soils such as moisture contentin the soil, frequency and temperature. Soil moisture content has strong influence onits dielectric and hence emissive properties at microwave frequency. It is because; relaxation frequency of water lies in the microwave frequency region. Therefore,when soil is placed in the electromagnetic field, the dipolar relaxation of water molecules results in absorption of the microwave energy which can be used as a measure of soil moisture content. If the temperature variations during the experiments are very small or controlled by some means, then the dielectric properties can mainly vary only with moisture content and frequency. The valuable information about material characteristics can be obtained due to frequency dependent ability of dielectric properties. Electric conduction and various polarization mechanisms contribute to the dielectric loss factor. Ionic conductivity plays a major role particularly at lower frequencies for moist dielectric materials.

Microwaves play important role in the moisture detection in soil, plants and other agricultural products. Microwave remote sensing of natural earth materials such as soil, water and plants has a very close dependence on their electrical parameters. This paper discusses the use of microwaves and its response to soils and associated moisture content. Remote sensing of soil moisture depends on measurement of electromagnetic energy that has been reflected or emitted from soil surface. The presence of moisture also influences effective skin depth. As the moisture content increases, the skin depth decreases and the signal may be scattered from lesser thickness of the soil. Hence, for studying some of the basic properties of dielectric materials, microwaves become a very powerful experimental tool. Factors like moisture content, frequency and temperature affect the dielectric properties of soils. If the temperature variations during the experiments are not significant, then the dielectric properties can vary mainly with moisture content and frequency. Water has a strong influence on the soil dielectric properties (and hence the soil emissivity and scattering coefficient) at microwave frequencies. It is because; the relaxation frequency of water lies in the microwave frequency region. Thus, when placed in the electromagnetic field, the dipolar relaxation of water molecules results in absorption of the microwave energy which can be used as a measure of soil moisture content. The frequency-dependent trend of dielectric properties can provide important information of the material characteristics. Electric conduction and various polarization mechanisms contribute to the dielectric loss factor.

Calla et al [1] have showed that the variations of dielectric constant for different soils depend on the physical composition of soil. They reported decrease in dielectric constant with increasing of sand percentages, whereas it increases with the increase in silt and clay. Sengwa and Soni [2] have studied the variation of dielectric constant with density of dry minerals of soil at 10.1 GHz. Njoku [3] measured the complex dielectric constant of sand as a function of moisture contents in the range from 0 to 30% by volume at frequencies of 0.679, 1.0, 3.0, 8.52, 14.0 and 20.0 GHz. It was observed that the relaxation occurs due to the presence of soil moisture at high frequency end, and shifts to a lower relaxation frequency as moisture content decreases. Several researchers have reported the findings of their studies on dielectric and emissive characteristics of soils from various part of the world at different microwave frequencies. The dielectric constant and emissivity of dry and wet black soils at C-band for three different soils types as a function of moisture content have been determined.[4] Researchers working on dielectric properties of soils studied dielectric parameter of different materials with various methods [5-17]. A knowledge of the emissivity of the soil is useful for the efficient use of soil [18]. The dielectric properties of soil depends on the presence of water content, temperature, texture, minerals and the organic matters present in it. According to Hallikainen *et al* [19], the soil texture shown to have an effect on dielectric behavior of soil, that is moisture retentive capacity of clayey soil, is more than that of sandy soil [20]. One of the more obvious applications for microwave remote sensing devices is that of conducting surface moisture surveys to help predict groundwater availability and the potential for flooding.

II. MATERIALS AND METHODS

A. *Study Area*

In Maharashtra State out of the total area under agriculture, about 84 percent is depending upon monsoon. Nashik District agriculture is depending upon monsoon. The agricultural land is depending upon monsoon. Soil, topography, climate and monsoon is few taluka in district are into favourable for agriculture. As a result per hectare yield is low, rather reducing due to low rainfall, draught in recent years. Nasik District is situated in north western part of Maharashtra. It lies between 19°35' and 20°50' north latitude and between 73°16' and 74°56' east longitude and falls in parts of Survey of India degree sheets 46-H, 46-L and 47-E and 47-I. The district has a geographical area of 15530 sq. km. It is surrounded by Dhule district in the north, Dangs and Surat district of Gujarat State in the northwest, Jalgaon in the east and northeast, Ahmednagar in the south, Aurangabad in the southeast and Thane in the west and southwest.

There is a need to develop field analysis techniques for the analysis of some important soil quality parameters. With the knowledge and experience gained during this study practical field analysis techniques for determination of different chemical characteristics can be developed in the future so that, the soil analysis could be done easily by the farmers in the field. This will be highly useful for them to get better quality produce with high yield. Farmers should be encouraged for soil analysis that will help in soil conservation and better environmental protection.

Onions constitutes a major crop in Nasik. It is widely grown in the Niphad taluka. The total Onion plantation in Nasik is more than 100,000 acres. Onions is one of the important crops for exports. Sugarcane growing provided major impetus for the growth of agriculture in Nasik. The co-operative spree helped the Sugar factories and the long neglected poor farmer in India started earning some money. The Sugar factories today form a strong footing for the politics of Maharashtra. There are sugar factories in Nasik district such as Niphad co-operative Sugar factory. Grapes prove to be one of the largest fruit exported from India and the majority of it comes from Niphad. Grapes also have a very large and profitable domestic market.

Details of agriculture land are given below:

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DETAILS OF FARMERS OF NIPHAD TAHSIL

Sample No.	Name of the farmer	Survey No.	Area	Latitude	Longitude	Previous crop	New crop
1	Chandrabhan Popat Handge	421	Chatori	19°97"12'	73°99"51'	Onion, Soyabean	Sugarcane
2	Vithoba Nivrutti Derle	985	Shingave	20°02"16'	74°03"16'	Tomato,Maize, Cauliflower	Bitterguard, Grapes
3	Riyaz Nawab Shaikh	711	Nandurmadhmeshwar	20°01"23'	74°15"13'	Grapes (Black)	Grapes
4	Bhagwat Pandurang Borgude	33/2	Naitale	20°07"14'	74°18"20'	Onion	Grapes,Tomato
5	Dyaneshwar Popat Shelar	324	Niphad	20°10"07'	74°11"52'	Cauliflower,Grapes	Grapes
6	Yadav Dagu Kushare	492	Ravlas (Pimpri)	20°10"07'	74°07"00'	Tomato	Grapes
7	Ramrao Pandharinath Waghchaure	293	Karrsul	20°14"20'	74°03"70'	Onion	Grapes,Tomato
8	Kashinath Yashwant Chaudhari	1374	Palkhed	20°17"90'	74°05"99'	Capcicum	Capcicum
9	Anil Punjaji More	296/4	Pimpalgaon Baswant	20°16"62'	74°00"94'	Maize	Grapes
10	Balkrishna Sukhdeo Sawant	819	Chandori	20°05"32'	74°00"49'	Grapes, Coriander leaves	Sugarcane,Soyabean

Table 1: Details of agriculture land

B. Soil Sampling

Soil samples were collected from different agricultural land of Niphad , Nasik, Maharashtra, India. to determine the dielectric constant of dry soil samples and its variation with the physical properties. Before sampling 15 mm topsoil was removed locations at the depth of 15cm. in zigzag pattern across the required areas. Five pits were dug for each sample. A composite sample of about 4 Kg. was taken through mixing of represented soil sample. These soils were first sieved by gyrator sieve shaker with approximately 2 mm spacing to remove the coarser particles. The sieved out fine particles are then oven dried to a temperature around 110oC for several hours in order to completely remove any trace of moisture.

The samples were analyzed for chemical parameters such as pH, electrical conductivity, organic carbon and $CaCO_3$ by standard analytical methods .Also analyzed for their physical parameters texture, bulk density particle density, porosity. The dielectric constants were measured at the Department of physics in JES College Jalna using X band microwave set up.

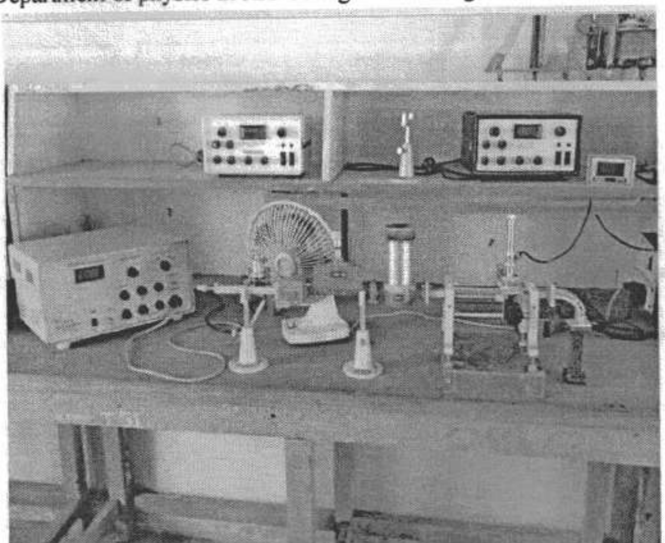

Fig.1Experimental set up of x-band microwave bench set up

C. Theory

The two-point method is best known and most widely used for the measurement of complex permittivity. It is best suited to either "lossless" dielectrics or the dielectrics with medium loss. The dielectric constant and dielectric loss of the soil samples were measured at 9.56 GHz (X-band) microwave frequencies using microwave bench and employing the two-point method. The reflex Klystron is used to generate X band microwave frequencies. The sample holder for X-band measurements was fabricated from the

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standard wave guide available. At the one end of the sample holder a metallic flange was connected so that it can be connected to main line and other end was carefully shorted.

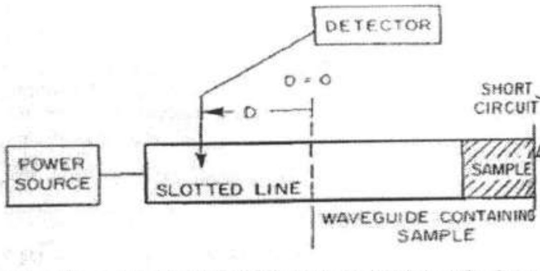

Fig.2 Two Point Method of Measuring Dielectric Constant

First, with no dielectric in the short-circuited line, the position of the first minimum DR in the slotted line was measured. Now the soil sample of certain length having certain moisture content was placed in the sample holder, such that the sample touches the short-circuited end. Then the position of the first minimum D on the slotted line and the corresponding VSWR, *r* were measured. The VSWR was measured using a VSWR meter. When the VSWR meter was connected, the amplitude modulation using pin diode was applied to the microwave signal set up. This procedure was repeated for another soil sample of same moisture content for another soil sample length.

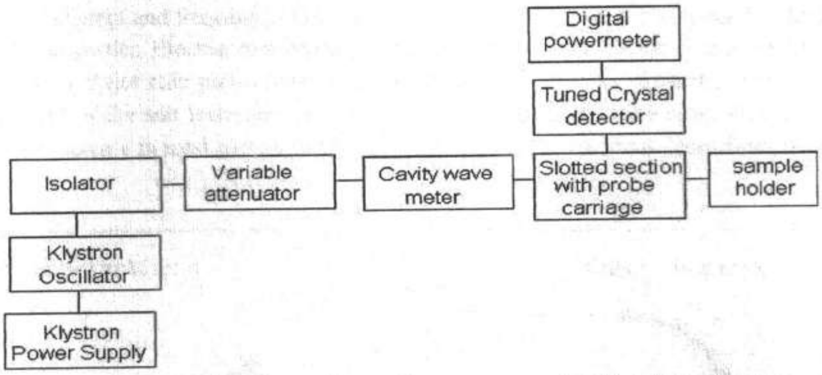

Fig. 3: Block diagram of experimental setup for measurement of dielectric properties.

The dielectric constant ε', dielectric loss ε'' emissivity ep(q) and a.c. conductivity (σ) of these soil samples are then determined from the following relations:

$$\varepsilon' = \frac{g_\varepsilon + \left(\lambda_{gs}/2a\right)^2}{1 + \left(\lambda_{gs}/2a\right)^2}$$

$$\varepsilon'' = \frac{\beta_\varepsilon}{1 + \left(\lambda_{gs}/2a\right)^2}$$

Where a = Inner width of rectangular waveguide.

λ_{gs} = wavelength in the air-filled guide.

g_ε = real part of the admittance

β_ε = imaginary part of the admittance

The emissivity ep(θ□□) for vertical polarization can be written as,

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ep(θ) = 1 - r p(θ) = 1 - □R p (θ)□

$$ep(\theta) = 1 - \frac{\varepsilon' cos\theta - \sqrt{\varepsilon' - sin^2\theta}}{\varepsilon' cos\theta + \sqrt{\varepsilon' - sin^2\theta}}$$

For horizontal polarization,

$$ep(\theta) = 1 - \frac{cos\theta - \sqrt{\varepsilon' - sin^2\theta}}{cos\theta + \sqrt{\varepsilon' - sin^2\theta}}$$

Where, θ= Angle of observation.

ep(θ) = Emissivity of the surface layer.

r p(θ) = Reflection coefficient.

R p(θ) = Fresnel reflection coefficient

III. RESULT AND DISCUSSION

Many factors influenced dielectric properties of soils such as frequency, temperature and moisture content in the soil. . As the relaxation frequency of water lies in the microwave frequency region, soil moisture content has strong influence on its dielectric and hence emissive properties at microwave frequencies Therefore, when soil is placed in the electromagnetic field, the dipolar relaxation of water molecules results in absorption of the microwave energy which can be used as a measure of soil moisture content. If the temperature variations during the experiments are very small or controlled by some means, then the dielectric properties can mainly vary only with moisture content and frequency. Information about material characteristics can be obtained due to frequency dependent ability of dielectric properties. Electric conduction and various polarization mechanisms contribute to the dielectric loss factor. Ionic conductivity plays a major role particularly at lower frequencies for moist dielectric materials. At higher moisture content the dielectric constant ∈' of the soil increases with increase in sand content in the soils. Further it can be seen that the dielectric loss ∈" decrease with increase in sand content in the soil. This confirms the textural dependence of dielectric properties of soils.

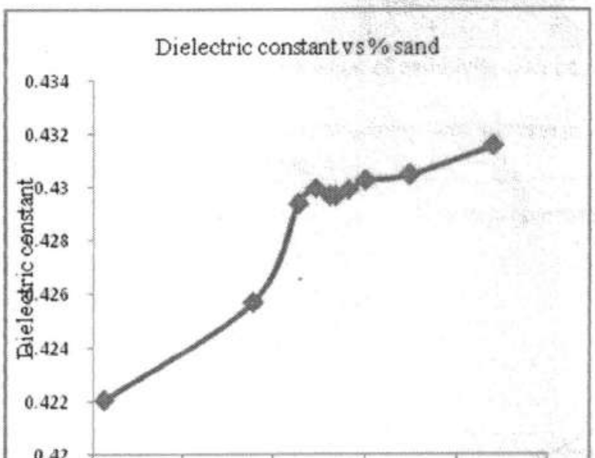

Fig.4: Variation of Dielectric constant with sand %

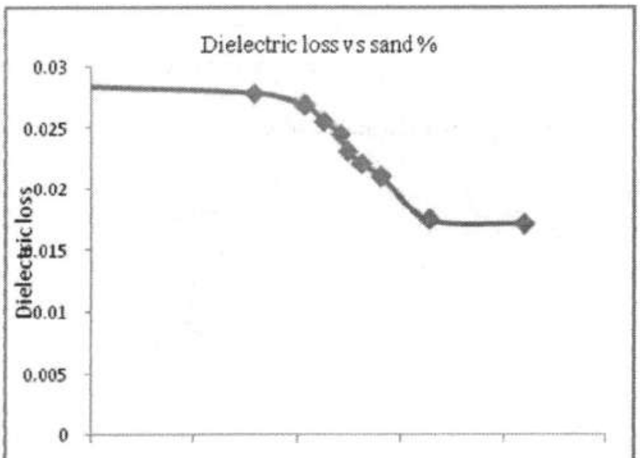

Fig.5: Variation of Dielectric loss with sand %

The dielectric constant (ε') and dielectric loss (ε"), for all soil sample are found to increase with increase in MC from 0% to 30 %.

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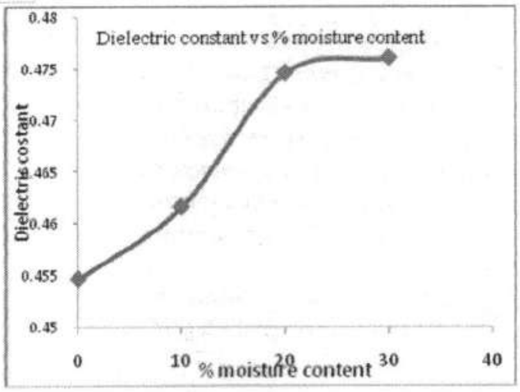

Fig. .6: Variation of dielectric constant with % moisture content

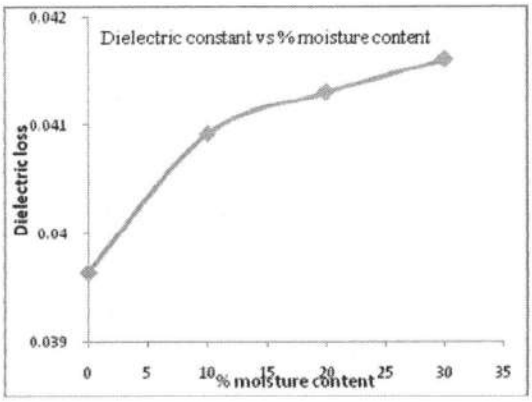

Fig.7: Variation of dielectric loss with % moisture content

The emissivity of soil decreases as the gravimetric MC (%) of soil samples increases. Variation of emissivity with percentage moisture content for soils at 9.88 GHz is shown in fig.3.

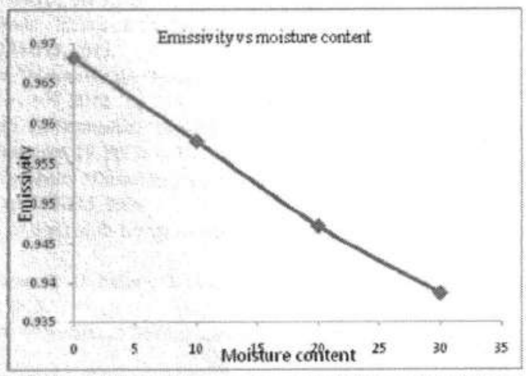

Fig.8: Variation of emissivity with percentage moisture content for soils at 9.88 GHz

The result shows increase in a.c. conductivity with increase in moisture content. The variation in a.c. conductivity with change in moisture content are shown in Fig. 6.

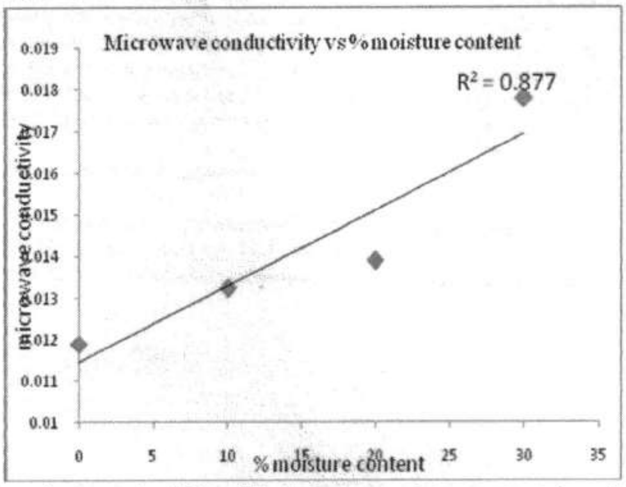

Fig.9: Variation of a.c. conductivity with percentage moisture content for soils at 9.88 GHz

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IV. CONCLUSION

A. At higher moisture content the dielectric constant ∈' of the soil increases with increase in sand content in the soils. Further it can be seen that the dielectric loss ∈" decrease with increase in sand content in the soil.
B. The dielectric constant and dielectric loss increases with increase in moisture content.
C. The emissivity of soil decreases as the gravimetric MC (%) of soil samples increases.
D. The result shows increase in a.c. conductivity with increase in moisture content.

Thus we see that the dielectric constant of soils depends on many factors like percentage of sand in soil, moisture content, and its physical and chemical compositions.

V. ACKNOWLEDGMENT

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REFERENCES

[1] O.P N Calla, Dinesh Bohra, SanjeevKumar Mishra, M. Alam, D. Hazarika and L. Ramawat, Variability of dielectric constant of dry soil withits physical constituents at microwave frequencies and validation of the CVCG model. Indian J. of Radio and Space Physics, 33 , pp.125- 129,2004
[2] R. J. Sengwa and A. Soni, Dielectric properties of some minerals of western Rajasthan, Indian J. of Radio and Space Physics, 37, pp.57- 63,2008
[3] Njoku Eni G., and Kong Jin-Au, "Theory for Passive Microwave Remote Sensing of Near-Surface Soil Moisture", *Journal of Geophysical Research*, 82/2 (1977) 3108.
[4] Vidya D. Ahir, D.V. Ahire and P.R. Choudhari "Dielectric constant and emissivity of dry and wet black soils at C-band microwave frequency" Journal of Chemical, Biological and Physical Sciences Fb;, vol 1.2 no. 2 pp 937-946, 2012
[5] Asha Buliya, K. C. Pancholi, R. K. Paliwal, "Effect of Cow Manure on Dielectric Properties of Clay Loam Soil at Microwave Frequency", International Journal of Scientific Research, 2(2), pp.374-375, 2013.
[6] Franco M. Francisca, Marcos A.Montoro, "Measuring the Dielectric Properties of Soil Organic Mixtures Using Coaxial Impedance Dielectric Reflectometry", Journal of Applied Geophysics, 80, pp. 101-109, 2012.
[7] A. Comegna , A. Coppola, G. Dragonetti, A. Sommella, "Dielectric Response of a Variable Saturated Soil Contaminated by Non-Aqueous Phase Liquids (NAPLs)", Proceding Envionmental Sciences, 19, pp. 701- 710, 2013
[8] V. V. Navarkhele, A. A. Shaikh, R. S. Ramshetti, "Dielectric Properties of Black Soil with Organic and Inorganic Matters at Microwave Frequency" ,Indian Journal of Radio and Space Physics, 38, pp. 112-115, 2009
[9] H. C. Chaudhari, "Dielectric Properties of Soils with Inorganic Matter at S-band Microwave Frequency", International Journal of Chemical and Physical Sciences , 3(6), pp. 59-66, 2014.
[10]] H. C. Chaudhari, V. J. Shinde, R.P. Zingare, B. U. Jadhav, "Dielectric Properties of Soils with Organic Matter at S-band Microwave Frequency", Journal of Deccun Current Science, 8, pp. 137-142, 2013.
[11] H. C. Chaudhari, V. J. Shinde, "Dielectric Properties of Soils at X-band Microwave Frequency",Indian Journal of Pure and Applied Physics, 50, pp. 64-67, 2012.
[12] D. H. Gadani, V. A. Rana, A. D. Vyas, S. P. Bhatnagar, "Effect of Saline Soils on Emissivity of Soil", Indian Journal of Radio and Space Physics, 40, pp. 218-225, 2011.
[13] P.R. Chaudhari, D.V. Ahire, V.D. Ahire, "Variation of Dielectric Constant of Dry Soils with their Physical Constituents and Available Nutrients at C-Band Microwave Frequency ", Journal of Chemical, Biological and Physical Sciences, 2(2), pp. 1001-1009, 2012.
[14] L. K. Dospatliev, I. T. Ivanov, B. K. Paarvanova, N. T. Katrandzhiev R. T. Popova, "Determining the Relationship between the Dielectric Properties and the Basic Physical and Chemical Parameters of the Air-Dry Soil", International Journal of Scientific and Research Publications, 4(7), pp. 1-7, 2014.
[15] Vivek Yadav, Anil Kumar, Sudeep Sharan, A.K.Sinha, "Analysis of Dielectric Properties of Fertilizers (urea and diammonium phosphate) in Aqueous Solution at Different Temperatures in Microwave Frequency", International journal of the physical sciences, 5(16), pp. 2466-2470, 2010.
[16] S.K. Srivastava and G.P. Mishra, "Study of the Characteristics of the Soil of Chhattisgarh at Xband Frequency", Sadhana, 29(4), pp. 343-347, 2004.
[17] H. C. Chaudhari, "Dielectric Study of Soils with varied Organic Matter at Microwave Frequency", International Journal of Chemical and Physical Sciences, 4(3), pp.45-53, 2015.
[18] O. P. N. Calla, and R. K. Singh, Emission characteristics of dry and wet loamy sand soil layered packed at microwave frequency, *Indian J. Radio Sp. Phys.*, **31**, 285–292 (2002)
[19] M. T. Hallikainen, T. U. Fawwaz, C. D. Obson, M. A. El-Rayes, and L.-K. Wu, Microwave dielectric behavior of wet soil-Part 1: Empirical models and experimental observations, *IEEE Trans. Geosci. Remote Sensing*, **23**, 25–34 (1985).
[20] 20. F. N. Dalton, and M. Th. van Genuchten, The time-domain reflectomtery method for measuring soil water content and salinity, *Geoderma*, **38**, 237–250 (1986)

