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Research Article

Evaluation of diurnal variation of physical, chemical and dielectric properties of the soil.

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ABSTRACT

The aim of this study is to investigate the diurnal changes in dielectric, physical and chemical properties of the soil of selected spots of the chandanzira, Jalna. The present study was made to obtain the dielectric and chemical properties of soil of the chandanzira, Jalna during the month March, April and June 2024 at one Diurnal intervals i.e. summer and rainy seasons. The soil properties examined were soil pH, moisture content, bulk density, porosity, electrical conductivity (EC), organic carbon (OC), available Nitrogen (N), available Phosphorus (P), Calcium (Ca), Magnesium (Mg), Manganese (Mn), Zinc (Zn), Ferrous (Fe), Copper (Cu) and available Potassium (K). The chandanzira soil dielectric and chemical properties was analysed as silty loam. The pH and Organic carbon levels were Moderately alkaline during summer and high in monsoon. The monsoon season saw the highest levels of available N, P, K, electrical conductivity and moisture content, while the summer season had the lowest levels.

1 Introduction

The soil is very important natural resource. Dielectric properties are determined by several physical parameters, including moisture content, temperature, and incident frequency. The dielectric constant is important in satellite data retrieved from remote sensing, particularly for earth resources such as soil and vegetation. The study of seasonal variations in soil moisture and dielectric properties can have significant implications for the application of microwave remote sensing in agriculture [1-2].

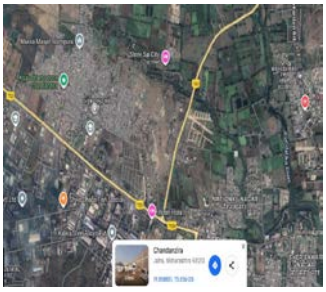
Soil analysis is an important tool for assessing soil quality and identifying the impacts of farming practices on soil health. Dielectric properties of soil, which are closely related to soil water content and other physical properties, have gained increasing attention in recent years as a valuable tool for soil analysis [3-4].

The dielectric properties of black soil have been studied with addition of organic and inorganic matter by V. V. Navarkhele at microwave frequency. The result shows that dielectric values obtained with organic matter are higher than that of inorganic matter [5]. There are several parameters on which dielectric properties depend. Some of the parameters are the characteristics of soil such as soil texture, bulk density, salinity, organic matter content & temperature among all the significant parameters is soil moisture other secondary parameters are density, texture & the local condition [6-7]. Another parameter on which dielectric constant & dielectric loss depend is chemical constituents & physical properties of soil. This conclusion is based on an experiment carried on soil using X band microwave frequency [8-9].

Just like soil surface area, soil bulk density is another important factor on which dielectric properties depend, but the sol bulk density has an inverse relationship with the moisture content of soil & bulk density depend upon soil texture [10-11]. Numerous researchers worked on dielectric properties of soil [12-16].

2 Material and Methods

Study Area



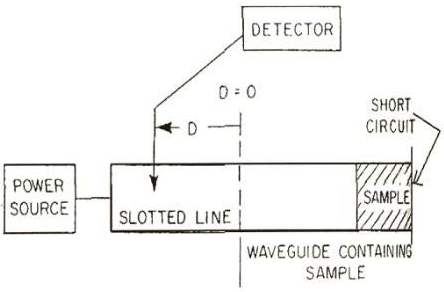


Fig. Showing Map Visualization of study area (Chandanzira, Jalna)

Chandanzira is situated in the Jalna District, Marathwada area. Its location at longitude E 75° 52' 0.0336', latitude N 19° 51' 28.9764" and altitude 508.9 m. 1669.8 ft.

The soil samples were collected from Chandanzira spots of the Jalna in three different months i.e. March, April and June during the year 2024-2025. The samples were taken within 10–35 cm layer. The soil samples were taken aseptically using a sterile spatula & collected in a properly labelled sterile zip-lock pouch. The soil samples were air-dried and homogenized manually. Further, the soils were sieved using a 2 mm mesh to perform physical, chemical and dielectric analysis. Analysis of soil was carried out to determine the physical, chemical and dielectric analyses in the laboratory according to the standard techniques. These are properties of soil including pH, EC, Organic carbon, Available Nitrogen, Phosphorus, Potassium, Free lime, Calcium, Magnesium, Sulphur, Manganese, Zn, Ferrous, Copper, moisture content was analysed with the help of soil health clinic, Krushi Vigyan Kendra, M. S. S. M. Jalna. We also determined bulk density and porosity of the soil. All the determination was replicated thrice, and the mean values were used to obtain the depiction of samples.

3 Experimental Details

There are many methods for measuring the dielectric constant of soil. In the present work, we used Two-point method which is best known and most widely used for measuring dielectric properties of soil sample. It is appropriate to calculate dielectric constant and dielectric loss. The dielectric constant and dielectric loss of the soil sample were measured by automated microwave bench setup at different microwave frequency bands (X, J) and utilized the two-point method. The microwave bench setup consists of power supply, isolator, reflex klystron, slotted section, waveguide, attenuator, sample holder, frequency meter, pc [10]. The block diagram of setup is shown in fig (2 & 3).

The reflex klystron is a type of microwave vacuum tube that generates microwaves through the interaction of an electron beam with resonant cavity. The source is tuned for getting perfect standing wave for that we kept beam voltage 205V, beam current 17mA and Repeller voltage 77. The attenuator is used to keep the desired power in waveguide assembly of bench. The detector is connected to a circuit which measures current along slotted line and convert to digital value in pc. The probe fit on slot line such that tip of the tuneable probe is penetrated and moved backward and forwarded along the slot line. It is adjusted for its critical position to get identical standing wave pattern [5,17,18].

The empty sample holder was connected to the other end of the microwave bench. Then the bench was tuned for identical standing wave pattern in slot line. Soil sample was inserted in the sample holder with constant compaction. The probe was travelling along the slot line at equal interval and probe positions were recorded with corresponding power. This data was acquired and stored in Excel sheet using microcontroller interface system. The data was stored for soil samples of different thickness such as 1 cm, 2cm, and 3cm. For that we got 3 minima position at different probe position which helped us to calculate VSWR.

This data is used for getting the outputs of VSWR values. The dielectric properties of solid material can be calculated for best fit of parameters. The guided wavelength λg is measured from the minima of the standing wave pattern.

$\beta = 2\pi / \lambda g$

Fig 2. Two Point Method for Measuring Dielectric Constant

Fig. 3: The X- Band experimental set-up.

β= phase factor

The free space wavelength is determined using the relation

$1 / \lambda 02 = 1 / \lambda g2 + 1 / \lambda c2$

Where λc = 2a 'a' is the inner broader side rectangular waveguide.

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

$\varepsilon' = \lambda 02 \{1/ \lambda c2 + (\alpha 2 - \beta 2) / 4\pi 2\}$

$\varepsilon'' = \lambda 02 \alpha\beta / 2\pi 2$

ε′: - real part

ε″: - imaginary part

α: - attenuation factor

A text file for computing dielectric constant was developed. The number of data text files, for different thickness in cm of samples

were combined i.e. 1,2cm, 2,3cm, 1,3cm to get single input data file which can be used in the source code for calculating dielectric constant and loss.

4 Result and Discussion

The data of the three-month study (March, April, and June 2024) were pooled for three months and analyzed for Diurnal variations. The results showed a significant difference in physical, chemical, and dielectric properties in three different months. Physical, chemical, and dielectric properties of Diurnal variations in soil of study spots are given in (Fig 1). The samples collected from study areas indicated that the soil was Brown to Grey and the texture was silty loam and silt loam present in the soil of the Chandanzira.

The moisture content in March and April is 3 % less than the June and 3 % higher in June, the pH value and average electrical conductivity is nearly the same for all the three months. As the bulk density of soil increases, the dielectric constant of soil shows same trend. Porosity decreases in month of April then increases in the month of June. There is variation in the average Organic Carbon (%) of June than March, April month, while in the June month which is 24% more than the March. More than 100% average variation in the available Nitrogen of June than March and April. Magnesium, Calcium and Potassium content in the soil decreased from the month March to April and then found intermediate value than that of March and April in the month of June. Nitrogen content in the soil is higher in the month June than that of month March and April. Dielectric constant values against Nitrogen content in the soil shows same trend. The available Phosphorus is higher in the April than that of month March and June. The value of dielectric constant of the soil in the month March and June is higher than that of month April against dielectric constant values. Same trend is observed in case of free lime content in the soil. Copper content in the soil is higher in the month June than that of the month March and April. Dielectric constant approximately shows same trend against copper content in the soil. Zinc content in the soil decreased from the month of March, April to June. But dielectric constant shows reverse trend against zinc content in the soil. Sulphur content in the soil shows decreasing trend from the month March, April to June. Dielectric constant for the Sulphur content in the soil is higher in the month of June than that of the month March and April. Ferrous content in the soil shows increasing trend from month of March, April, and June whereas dielectric constant value against Ferrous content shows higher value in month of June than that of March and April month (Table 5). The dielectric constant of soil primarily depends on its water content and bulk density.

Table: 1: Avg dielectric constant on X-Band (Real)

REAL					
X-BAND					
MONTH	SR NO	1 CM	2 CM	3 CM	AVG-X-REAL
MARCH	1	1.67936	2.29996	2.41317	2.13
APRIL	2	2.51434	1.03819	2.67719	2.08
JUNE	3	3.50868	2.5077	2.37501	2.80

Table: 2:Avg dielectric constant on X-Band (Img)

IMG					
X-BAND					
MONTH	SR NO	1 CM	2 CM	3 CM	AVG-X-IMG
MARCH	1	0.31505	0.48439	0.28659	0.36
APRIL	2	0.47315	0.11275	0.24668	0.28
JUNE	3	0.23803	0.65016	0.71805	0.54

Table: 3: Avg dielectric constant on J-Band (Real)

REAL					
J-BAND					
MONTH	SR NO	1 CM	2 CM	3 CM	AVG-J-REAL
MARCH	1	2.23645	3.12098	1.65813	2.68
APRIL	2	3.79357	1.22267	1.74907	2.26
JUNE	3	6.75381	4.92279	5.65311	5.78

Table: 3: Avg dielectric constant on J-Band (Img)

IMG					
J-BAND					
MONTH	SR NO	1 CM	2 CM	3 CM	AVG-J-IMG
MARCH	1	5.67487	0.52952	0.27063	2.16
APRIL	2	0.72461	0.15907	0.16953	0.35
JUNE	3	0.23803	0.65016	0.71805	0.54

Table 5: Diurnal indices for each month and all soil Properties.

Diurnal Indices for month Soil Properties	**March**	**April**	**June**
Moisture Content (%)	1.36%	1.03%	4.20%
Porosity	1.3422	1.0067	4.0268
Bulk Density	0.9865	0.9898	1.04
pH	8	7.7	7.9
Electrical Conductivity (ms)	0.27	0.25	0.26
Organic Carbon (%)	42	23	60
Available Nitrogen (Kg/ha)	188	147	390
Available Phosphorus (Kg/ha)	14.2	16.2	14.2
Available Potassium (Kg/ha)	416	375	412
Free lime (%)	11	12.3	9.8
Calcium (meq/100 g)	4.2	3.1	3.2
Magnesium (meq/100 g)	3.3.	1.3	2.4
Sulphur (ppm)	4.5	4.3	1.4
Manganese (ppm)	2.7	1.3	1.4
Zn (ppm)	0.07	0.06	0.02
Ferrous (ppm)	0.72	0.81	1.3
Copper (ppm)	0.43	0.82	1.03

5 Conclusion

The Present study concludes that all soil physical, chemical and dielectric properties found in normal criteria of healthy soil. Bulk density and porosity of the soil have positive correlation. There were diurnal variations in the physical, chemical, and dielectric properties of soil. The investigation of physical, chemical, and dielectric properties of soil samples indicated different significances at various times. It is due to the irregular status of various parameters present in the soil. Such kinds of observation of soil samples are beneficial to know the concentrations of different parameters present in soil samples.

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