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DIELECTRIC PROPERTIES OF CONTAMINATED AND RECLAIMED SOILS AT X-BAND MICROWAVE FREQUENCY

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ABSTRACT

In present study comparison of dielectric properties of contaminated and reclaimed soils were studied. The contaminated soil samples were collected at a depth 20 cm from ten different soil contaminated sites of North Maharashtra region. Then they are reclaimed. The dielectric constant (ε') and dielectric loss (ε'') of dry and wet soils at different moisture contents are measured using Waveguide Cell Method at 10.582 GHz frequency. These results shows that the dielectric constant and dielectric loss values of contaminated soil samples are higher than that of reclaimed soil samples. This study is very relevant to the farmers and for remote sensing.

Keywords: Dielectric properties contaminated and reclaimed soils, waveguide Cell Method.

INTRODUCTION:

Soil is a thin layer that covers earth's rocky surface. Soil is an intimate mixture of organic and inorganic materials, water and air. Productive soils are necessary for agriculture to supply the world with sufficient food. Now a day's soil contamination has become a severe environmental problem. There are different ways which pollute soil such as seepage of landfill, discharge of industrial waste into the soil, percolation of contaminated water into soil, rupture of ground storage tanks, excess application of pesticides, herbicides or fertilizers and solid waste seepage. The reclaimation of such contaminated soils is must to improve productivity of soils. The contaminated soils can be reclaimed by different reclaimants like Gypsum, Compost, Potash, Urea, Singal Super Phosphet etc. (11, 12)

Over the past decades Remote Sensing using Microwave Techniques is the emerging field for the study of natural planet earth. Remote sensing can play a role in the identification, inventory and mapping of soils that are on the surface of the earth. Microwave remote sensing of natural planet earth materials such as soil and water has a very close dependence on their electrical parameters. The most important parameters are the dielectric constant and dielectric loss. The knowledge of dielectric constant and dielectric loss helps in the study of dry and wet contaminated and reclaimed soils using microwave sensors. (9) The different methods are used to study electrical properties at X-Band microwave frequencies. (1, 2) It has been observed by several researchers that dielectric constant of dry soils lies between 2 and 4 and increase with increase in moisture content in the soil. Hence with the help of dielectric constant we can determine the moisture content in soil. (5, 7, 8)

The contaminated soil samples were collected from different contaminated sites from North Maharashtra Region. Then they are reclaimed. In present research paper dielectric constant and dielectric loss of ten contaminated and reclaimed soil samples were measured at frequency 10.582 GHz of X-band from 8 GHz to 12 GHz. The determined values of dielectric constant and dielectric loss of contaminated soil samples were compared with the determined values of reclaimed soil samples.

The objectives of present research work are to provide the detailed ground truth experimental data on the dielectric properties of different types of contaminated and reclaimed soils from North Maharashtra region, to

measure moisture content of the soils and to understand contamination and reclamation of the soils.

MATERIALS AND METHODS:

1. Sample preparation: The contaminated soil samples were collected from soil contaminated sites because of chemical factory, oil mill, sugar factory, textile mill etc of North Maharashtra region. The soil samples were first sieved by gyrator sieve shaker to remove coarser particles from the samples. The sieved fine particles were dried to a temperature of about 110°C for about half an hour to remove any trace of moisture completely. This dry sample was referred as dry base when compared with wet samples. The soil samples were analyzed for various chemical parameters like pH, Electrical conductivity, organic carbon, available Nitrogen, Phosphorus, Potassium, Iron, Manganese, Zinc, Copper etc by standard analytical methods. And then these soil samples were reclaimed by using Urea, compost, Potash, Single super phosphate and ciliated ferrous. Then the dielectric constant and dielectric loss of all contaminated and reclaimed soil samples will be measured using Waveguide Cell Method.

2. Measurement of Dielectric constant: Each soil sample was dried to a temperature 110°C, this soil sample was considered as dry or 0 % moisture content soil sample. Then on the basis of volumetric analysis 5%, 10%, 15%, 20%, 25% and 30% moisture content soil samples were prepared. Then the dielectric constant and dielectric loss of all contaminated and reclaimed soil samples were measured at microwave frequency 10.582 GHz. The X-band microwave set-up consists of a Gunn oscillator in combination with Pin modulator as a microwave source. The waveguide cell method was used for measurement of dielectric constant and dielectric loss of contaminated and reclaimed soil samples. (10) The equation of dielectric constant ε' is,

$$\varepsilon' = \frac{\left(\frac{a}{\pi}\right)^2 \left(\frac{x}{l_s}\right)^2 + 1}{\left(\frac{2a}{\lambda_g}\right)^2 + 1} \quad \text{-----} \quad (1)$$

where, a = inner width of rectangular waveguide,
λ_g = guide wavelength,
l_s = sample length,
in this equation (1) x is found by following equation,

$$\frac{\tan x}{x} = \frac{\tan[\beta (l_s + D_R - D]}{\beta l_s} \quad \text{-------} \quad (2)$$

where, $\beta = 2\pi / \lambda_g$, β is phase shift
$(D_R - D)$ is shift in minima
D_R is minima for without sample
D is minima for with sample

3. Measurement of Loss tangent (tanδ):

The Loss tangent is calculated using the formula (Lance 1964)

$$tan\delta = \{|\Delta x_s - \Delta x| / \varepsilon' l_s\} \times (\lambda_o / \lambda_g)^2 \quad \text{------} \quad (3)$$

where, λ_o – free space wavelength
Δx - width at twice minima without sample
Δx_s - width at twice minima with sample in the waveguide touching the short circuit end.

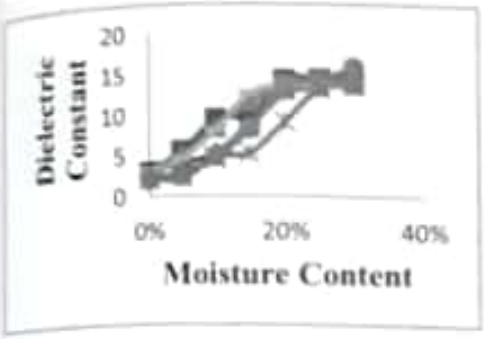
4. Measurement of Dielectric loss:

Loss factor (ε") is measured by equation (4).

$$\varepsilon'' = \varepsilon' tan\delta \quad \text{------} \quad (4)$$

RESULTS AND DISCUSSION:

The measured values of the dielectric constant (ε') and dielectric loss (ε") at 10.582 GHz microwave frequency for contaminated soil samples were plotted against various values of moisture content. The plots are shown in Fig.1 and Fig.2 respectively.



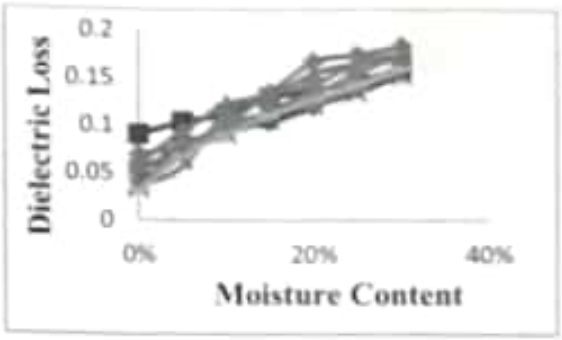


Fig.1.Variation of dielectric constant with moisture content for contaminated soil sample.

Fig.2. Variation of dielectric loss with moisture moisture content for contaminated soil sample.

Also the measured values of the dielectric constant (ε') and dielectric loss (ε") at 10.582 GHz microwave frequency for reclaimed soil samples were plotted against various values of moisture content. The plots are shown in Fig.3 and Fig.4 respectively.

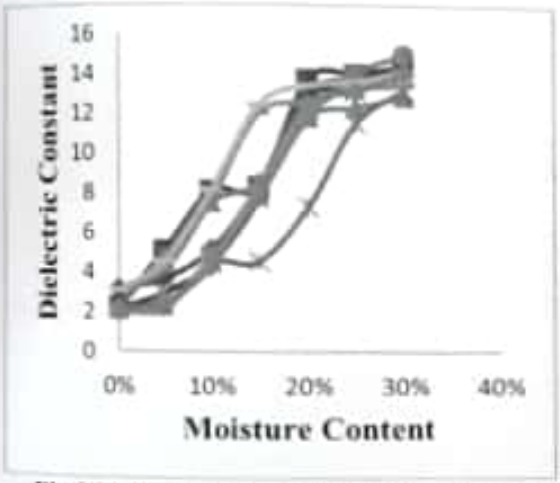


Fig.3.Variation of dielectric constant with moisture content for reclaimed soil sample.

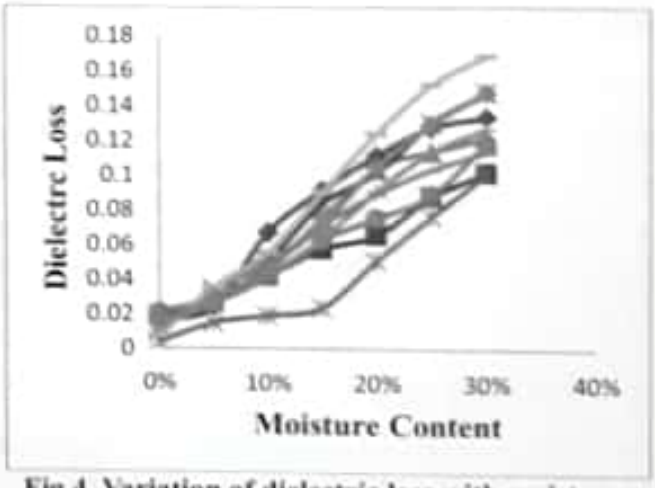


Fig.4. Variation of dielectric loss with moisture content for reclaimed soil sample.

The dielectric constant (ε') and dielectric loss (ε") of soils increases with increase in moisture content for all contaminated and reclaimed soil samples. The dielectric constant for both contaminated and reclaimed soil samples initially increases rapidly up to 20% moisture content and then it increases slowly from 20% to 30% moisture content. (5) The increase in dielectric constant and dielectric loss for soil sample number 05 is slow. This sample is strongly alkaline in nature, also the available Nitrogen and Phosphorous in this soil is very low.

From this study it is observed that the values of dielectric constant and dielectric loss of all soil samples at different moisture content decreases, which can be observed from figures 5, 6, 7 and 8. For example Fig. 5 and 6 shows the variation between dielectric constant of contaminated and reclaimed soil samples at different moisture content. Also the variation of dielectric loss of contaminated and reclaimed soils at different moisture content is plotted in Fig.7 and fig.8.

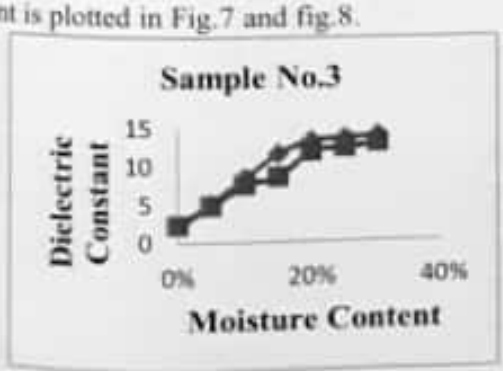


Fig.5.Dielectric constant of contaminated and reclaimed soil sample no.03

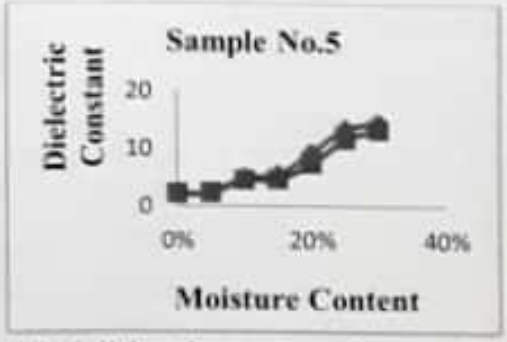


Fig.6.dielectric constant of contaminated and reclaimed soil sample no.05

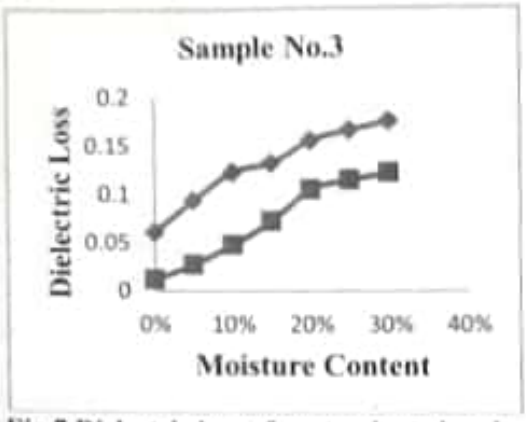


Fig.7.Dielectric loss of contaminated and reclaimed soil sample no.03

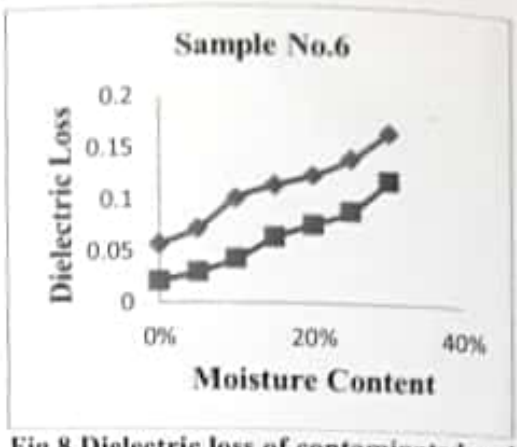


Fig.8.Dielectric loss of contaminated and reclaimed soil sample no.06

The values of dielectric constant and dielectric loss of soil decreases after reclamation of contaminated soil. The reclaimant i.e. Urea, Compost, Potash, Single Super Phosphate etc affect the electric properties of soil.

CONCLUSIONS:

Based on above research work, the following conclusions may be drawn,

1. The study of dielectric properties of soils with varied moisture is very important in correlating the data recorded by Remote Sensing data.
2. The existence of water in soil significantly affects the dielectric properties of soil.
3. The reclamation of soil affects the dielectric constant and dielectric loss of soils.
4. This study of dielectric properties of dry and wet reclaimed soils at microwave frequency is useful in agriculture.

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