ESTIMATION OF THE SCATTERING COEFFICIENT AT MICROWAVE FREQUENCIES OF DRY AND WET SOILS OF INDIA USING MEASURED VALUES OF DIELECTRIC CONSTANT AND RELATING THE SAME WITH THE CONSTITUENTS OF THE SOIL

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ABSTRACT

The soil is characterized by its physical constituents like sand, silt and clay. The electrical parameters that are important for soil are its dielectric constant, emissivity and scattering coefficient. The dielectric constant of wet soil depends on amount of water present in the soil. In this study the dielectric constant of dry soil and wet soil with different moisture content is measured using waveguide cell method. The scattering coefficient is estimated using perturbation model for slightly rough surface for both polarization and different angles of incidence. The values of estimated scattering coefficient are related to constituents of the soil.

INTRODUCTION

The study of soil using microwave remote sensing techniques[1] can be done either by passive sensors or by active sensors. The parameters measured in case of passive sensor is the brightness temperature and the scattering coefficient is measured in case active sensors. The scattering coefficient is function of the material properties. There are physical properties and electrical properties. The texture is one element of the physical properties, which includes the constituents of the soil like sand, silt and clay. The electrical parameters include the dielectric constant of the material and others. The scattering coefficient is function of dielectric constant of the material, the polarization and angle of incidence. In this presentation the scattering properties of soils of India estimated from dielectric constant and related to the physical constituents will be presented.

METHODOLOGY

The dielectric constant of soil can be measured by different methods[1]:

The dielectric constant is measured using waveguide cell method.

Table 1-Different types of soil and their constituent percentage

Soil type	Constituent percentage of Different soils		
	A1	A2	A3
Fine sand and Coarse sand	31.3%	67.5%	51.5%
Silt	15.4%	17.37%	29.64%
Clay	52.95%	15.18%	17.15%

SCATTERING MODELS FOR SOIL SURFACES[2]

The backscattering of the soil surface depends upon the roughness of surface. There are different models available for estimating backscattering coefficient depending on the type of surface. The methods are

(i) Physical optics model
(ii) Geometric optics model
(iii) Perturbation model

The validity conditions are based on the values of the standard deviation (σ), surface correlation length (l), and the value of K ($K = 2\pi/\lambda$). The validity conditions for different models are given in Table 1.

PERTURBATION MODEL

For smoth or slightly rough surface whose standard deviation and correlation length are smaller than the wavelength, the perturbation model is used.

Table 1-Validity conditions for different models

Model	Validity condition
Physical optics model (Kirchoffs' model with scalar approximation)	M < 0.25 and $Kl > 6$
Geometric optics model (Kirchoffs' Model with stationary phase approxima-Tion)	$(2K\sigma \cos\theta)^2 > 10$, and $l^2 = 2.76\sigma\lambda$
Perturbation model	$K\sigma < 0.3$ $M < 0.3$

Note:
$K = 2\pi/\lambda$
σ = r.m.s. surface height
l = Correlation length
M = r.m.s. surface slope.

MODEL USED FOR ESTIMATION OF SCATTERING COEFFICIENT

The conditions to be full filled for use of perturbation model are
$K\sigma < 0.3$ and $M<0.3$
Where K= $2\pi/\lambda$, σ is r.m.s surface height ℓ is correlation length and M is r.m.s. Surface slope.

The scattering coefficient for dry and wet soils have been estimated for different angles of incidence and for both polarizations. The physical constituents of soils are separately obtained. The scattering coefficient and the physical constituents like sand, slit and clay are related as the dielectric constant and the constituents have some relation.

The dry and wet soils are used for measurement of dielectric constant for different percentage of soil moisture. The scattering coefficient is estimated using the measured values of the dielectric constant for dry and wet soil at X-band. The standard formulation for perturbation model applicable to slightly rough surface has been used for estimating the scattering coefficient for dry and wet soils.

RESULTS AND DISCUSSIONS

The dielectric constant of dry soil has dependence on the constituents of soil. The scattering coefficient is function of dielectric constant and other parameters. And so the scattering coefficient also depends upon the constituents of the soil. The variability of scattering coefficient with sand, slit and clay is plotted in the graphs. The variability of scattering coefficient at different look angles and for different polarizations gives the indication of the effect of sand.
The scattering coefficient has been estimated for wet soils also for different moisture content The scattering coefficient has been estimated for different soil moisture contents and for different incidence angles as well as for both polarizations.

The graphs 1-3 give the variation of scattering coefficient with percentage of constituents for different incidence angles and for both polarizations

Three samples of soil are taken and the scattering coefficient is estimated at 9.125 GHz for both dry and wet soil The variation of scattering coefficient for dry and wet soil with 34.57% of moisture is plotted in fig.1. The variation for different angles 0^o to 80^o for both HH and VV polarizations have been given. The trend is shown in the fig.1 for sand.

The fig 2 gives variation of scattering coefficient with % clay in soil for both dry and wet having 34.57% moisture. The scattering coefficient for VV polarization is more as compared to HH polarization.

The variation of scattering coefficient with % silt is given in fig 3. For dry soil and wet soil with 34.57% moisture. Incase of silt, the scattering coefficient for VV is more as compare to HH polarization.

CONCLUSION

The variation of scattering coefficient with the constituents of soil for both dry and wet soil at 9.125 GHz has been presented. This shows that there is dependence of the scattering coefficient on the constituents of soils.

REFERENCES

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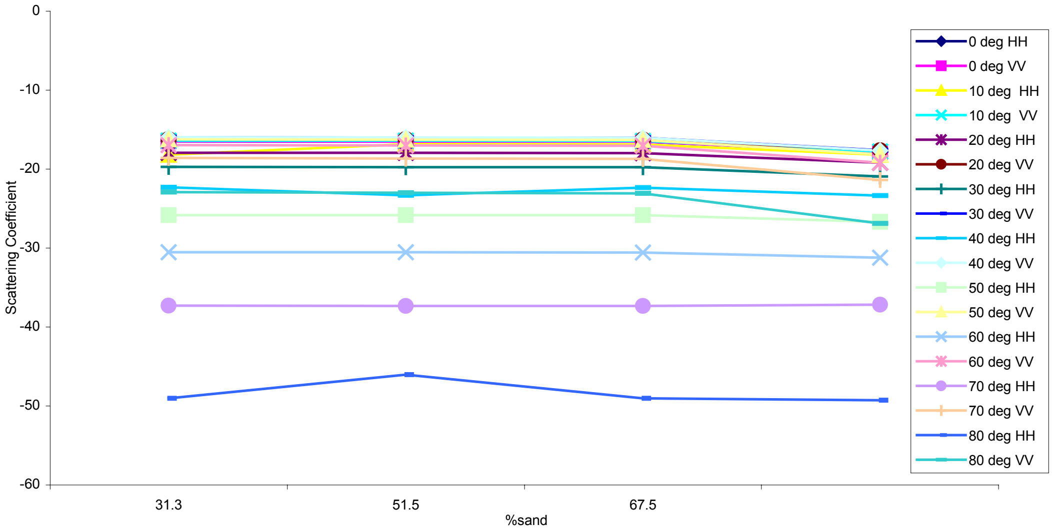

Fig 1 Scattering Coefficient V/s % of Sand at 9.125 GHz for dry soil and soil with 34.57% moisture content by weight

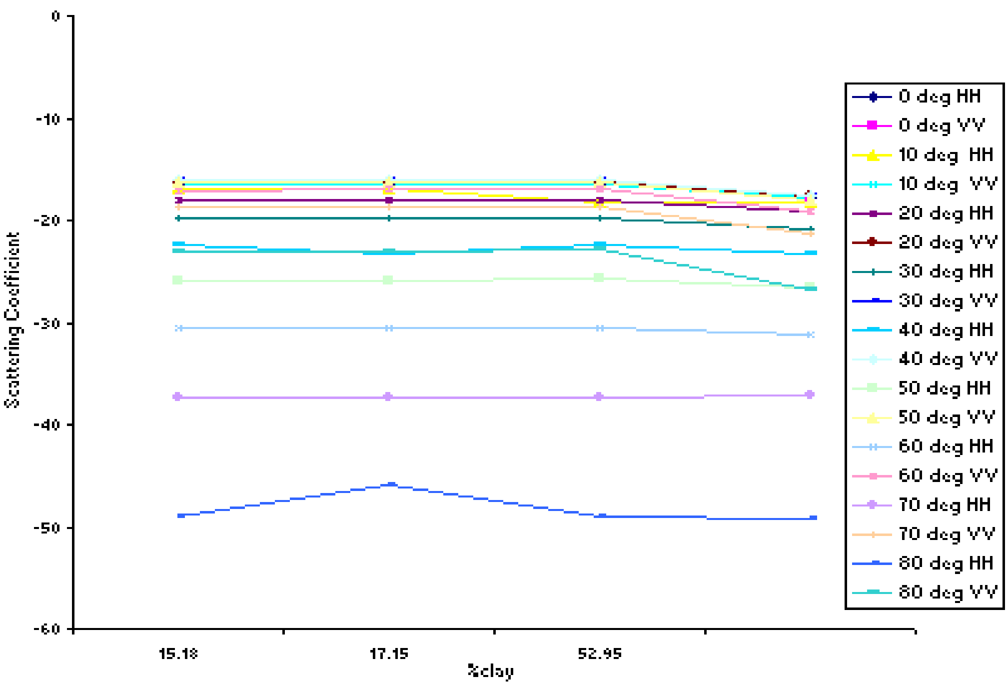

Fig 2. Scattering Coefficient V/s % of Clay at 9.125 GHz for dry soil and soil with 34.57% moisture contents with weight

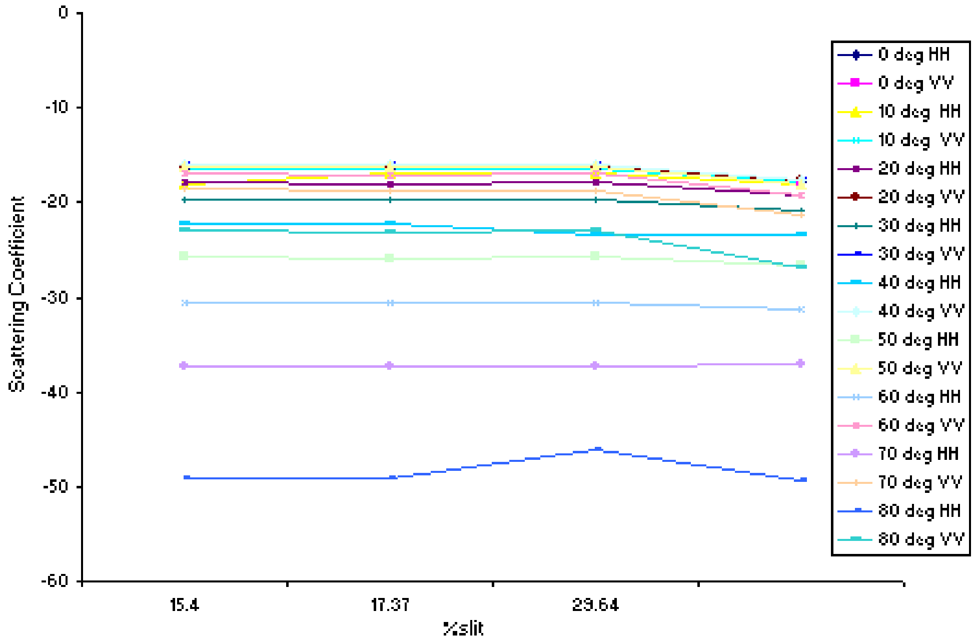

Fig 3 Scattering Coefficient V/s % of Slit at 9.125 GHz for dry soil and soil with 34.57% moisture contents with weight