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PREDICTION OF MICROWAVE EMISSION FROM SOIL SURFACE BY PASSIVE REMOTE SENSOR UNDER DUST STORM CONDITION BY FRESNEL'S RELATION

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In this paper an attempt has been made for estimation of Emission and Reflection coefficient of microwave communication link using the microwave emission model of surface. The entire length of microwave link has been considered as number of layer of sand, silt and clay particles in cascade form. The expression for emission and reflection coefficients of sand, silt and clay particles have been developed both for vertical and horizontal polarization. Emissive properties of microwave signal depends on frequency, angle of incidence, visibility, permittivity, permeability of soil which contains dust constituents. It is found that Reflection coefficient of microwave signal decreases with angle of incidence and visibilities and emission coefficient increase with angle of incidence and visibilities. It is also found that microwave has large penetration depth, large directionality, low fading effect, large gain and bandwidth, efficiency, low power loss.

KEY WORDS: Emisson coefficient, angle of incidence, microwave frequency, visibilty temperature brightness.

INTRODUCTION

The ground based studies of the emissivity properties of different earth constituent's any microwave frequencies are important as they provide a successful interpretation of various remote sensor's data. Microwave emission coefficient of soil surface is dependent on both the water content and physical characteristics of soil surface, dielectric constant, surface roughness, chemical compositions, physical temperature, frequency, polarization angle of incidence. Emission coefficient or temperature brightness is the very important parameter which provides information about soil surface. Temperature brightness is defined as the ratio of energy emitted by an object to that same physical temperature. The emission coefficient of soil surface also varies in different moisture contents. The knowledge of the emission coefficient of the soil surface is useful for building microwave sensors and microwave instrument for its application in agriculture. In present paper an attempt has bean made to evaluate Emission coefficient of microwave signals from soil surface through Fresnel's Relation [1], Kirchhoff's law, Ulaby Relation (1982) [2] of Reflectivity due to Horizontal, Vertical polarization for different particle.

Geometry of the problems

When the microwave signal wave passes through the earth surface it is affected both in phase and amplitude, this may cause large attenuation due to reflection and transmission of the signal. For sake of conveniences the geometry of problem is designed for soil surface having sand, silt and clay as dust constituents shown in fig. 1. It consists of input signal is defined as E_i/n and output signal E_0/n '*i*' show 1, 2, 3, …*n* number of particles.

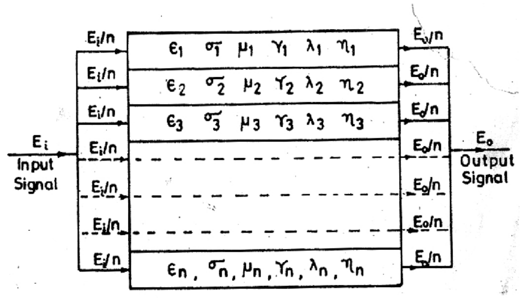

Fig. 1. Shows that Microwave link consist of sand silt and clay dust particle in cascade forms.

If it is assumed that all 'n' constituents have same number of particles per unit volume in the air, then each section of link have equal length "*L*". Let $\theta_1, \theta_2 \ldots, \theta_n$ are angle of incidence of microwave signals, η is permeability, and ν is frequency of microwave signals, $\sigma_1, \sigma_2 \ldots, \sigma_n$ shows conductivity of particles, λ is wavelength of signal respectively. The dust storm contains sand, silt and clay particles. The permittivity of free space is taken unity. The emission coefficient of microwave signal is taken for Vertical and Horizontal polarization.

Microwave emission model

Different theoretical models have been developed by Schmugge [3] and Burke *et al* [4] and Coherent model by Stogryn *et al* [5] and emission model by Choudhary [6] for estimation of microwave emission coefficient from soil surface. In this chapter we used simple emission coefficient model based on Fresnel's coefficient [1] derived from surface reflectivity. In this system microwave emission coefficient from a soil surface at polarization $p = [v, h]$ can be measured in terms of brightness T_B. For polarization p the brightness temperature is given as [6]

$$T_B = 1 + e_p(\Theta)(T - T_{sky}) \qquad \ldots (1)$$

where $e_p(\Theta)$ is written as emission coefficient of the soil surface, p refers polarization both vertical and horizontal $r_p(\Theta)$ is reflectivity at soil surface, *T* is the surface temperature and T_{sky} atmospheric radiation incident on the soil surface .The emission coefficient is given as

$$e_p(\Theta) = 1 - r_p(\Theta) \qquad \ldots (2)$$

According to Fresenel's equation of reflectivity for microwave signal is as follows,

For Vertical polarization $r_v(\theta) = \left| \dfrac{\varepsilon_{eff} \cos\theta - \sqrt{\varepsilon_{eff} - \sin^2\theta}}{\varepsilon_{eff} \cos\theta + \sqrt{\varepsilon_{eff} - \sin^2\theta}} \right|^2$ ... (3)

For Horizontal Polarization $r_h(\theta) = \left| \dfrac{\cos\theta - \sqrt{\varepsilon_{eff} - \sin^2\theta}}{\cos\theta + \sqrt{\varepsilon_{eff} - \sin^2\theta}} \right|^2$ ... (4)

where 'Θ', is angle of incidence from passive microwave remote sensor and ε_{eff} is dielectric constant for soil surface, which contain dust particle such as sand, silt and clay. At low visibility where particle concentration is high, effective permittivity is nearly equal to permittivity of dust. The effective permittivity is given as [7]

$$\varepsilon_{eff} = \frac{\varepsilon_0 \left[1 + 2\eta_0 \dfrac{9.43 \times 10^{-9}}{V^{\gamma} 4/3\pi a^3} \dfrac{(\varepsilon_s - \varepsilon_0)}{(\varepsilon_s + 2\varepsilon_0)} \right]}{\left[1 - \eta_0 \dfrac{9.43 \times 10^{-9}}{V^{\gamma} 4/3\pi a^3} \dfrac{(\varepsilon_s - \varepsilon_0)}{(\varepsilon_s + 2\varepsilon_0)} \right]} \quad \text{... (5)}$$

where ε_0 is permittivity of free space and η_0 is permeability of free space and visibility is given as V and now, N is total number of particles per unit volume is given by Ghobrial [8](1987), $\gamma = 1.07$

$$N = \frac{9.43 \times 10^{-9}}{V^{\gamma} 4/3\pi a^3} \quad \text{... (6)}$$

where 'a' is dimension of particle.

$$r_v(\theta) = \left| \frac{\varepsilon_{eff} \cos\theta - \sqrt{\varepsilon_{eff} - \sin^2\theta}}{\varepsilon_{eff} \cos\theta + \sqrt{\varepsilon_{eff} - \sin^2\theta}} \right|^2 \quad \text{... (7)}$$

$$r_h(\theta) = \left| \frac{\cos\theta - \sqrt{\varepsilon_{eff} - \sin^2\theta}}{\cos\theta + \sqrt{\varepsilon_{eff} - \sin^2\theta}} \right|^2 \quad \text{...(8)}$$

The reflectivity of microwave signal for vertical polarization on putting the values (5) in (7) we get:

$$r_v(\theta) = \left| \frac{\left[\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_s-\varepsilon_0}{\varepsilon_s+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_s-\varepsilon_0}{\varepsilon_s+2\varepsilon_0}\right)\right]}\right]\cos\theta - \sqrt{\left[\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_s-\varepsilon_0}{\varepsilon_s+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_s-\varepsilon_0}{\varepsilon_s+2\varepsilon_0}\right)\right]}\right]-\sin^2\theta}}{\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_s-\varepsilon_0}{\varepsilon_s+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_s-\varepsilon_0}{\varepsilon_s+2\varepsilon_0}\right)\right]}\cos\theta + \sqrt{\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_s-\varepsilon_0}{\varepsilon_s+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_s-\varepsilon_0}{\varepsilon_s+2\varepsilon_0}\right)\right]}-\sin^2\theta}} \right|^2 \quad \dots (9)$$

The reflectivity of microwave signal for Horizontal polarization on putting the values (5) in (8) we get:

$$r_h(\theta) = \left| \frac{\cos\theta - \sqrt{\left[\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_s-\varepsilon_0}{\varepsilon_s+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_s-\varepsilon_0}{\varepsilon_s+2\varepsilon_0}\right)\right]}\right]-\sin^2\theta}}{\cos\theta + \sqrt{\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_s-\varepsilon_0}{\varepsilon_s+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_s-\varepsilon_0}{\varepsilon_s+2\varepsilon_0}\right)\right]}-\sin^2\theta}} \right|^2 \quad \dots(10)$$

The reflectivity of microwave signal for sand dust particles due to vertical polarization is,

FOR SAND

$r_v(\theta)$ **(sand) =**

$$\left| \frac{\left[\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{sand}-\varepsilon_0}{\varepsilon_{sand}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{sand}-\varepsilon_0}{\varepsilon_{sand}+2\varepsilon_0}\right)\right]}\right]\cos\theta - \sqrt{\left[\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{sand}-\varepsilon_0}{\varepsilon_{sand}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{sand}-\varepsilon_0}{\varepsilon_{sand}+2\varepsilon_0}\right)\right]}\right]-\sin^2\theta}}{\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{sand}-\varepsilon_0}{\varepsilon_{sand}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{sand}-\varepsilon_0}{\varepsilon_{sand}+2\varepsilon_0}\right)\right]}\cos\theta + \sqrt{\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{sand}-\varepsilon_0}{\varepsilon_{sand}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{sand}-\varepsilon_0}{\varepsilon_{sand}+2\varepsilon_0}\right)\right]}-\sin^2\theta}} \right|^2 \quad \dots (11)$$

FOR SILT

$r_v(\theta)$ **(silt)** =

$$\left|\frac{\left[\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{silt}-\varepsilon_0}{\varepsilon_{silt}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{silt}-\varepsilon_0}{\varepsilon_{silt}+2\varepsilon_0}\right)\right]}\right]\cos\theta-\sqrt{\left[\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{silt}-\varepsilon_0}{\varepsilon_{silt}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{silt}-\varepsilon_0}{\varepsilon_{silt}+2\varepsilon_0}\right)\right]}\right]-\sin^2\theta}}{\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{silt}-\varepsilon_0}{\varepsilon_{silt}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{silt}-\varepsilon_0}{\varepsilon_{silt}+2\varepsilon_0}\right)\right]}\cos\theta+\sqrt{\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{silt}-\varepsilon_0}{\varepsilon_{silt}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{silt}-\varepsilon_0}{\varepsilon_{silt}+2\varepsilon_0}\right)\right]}-\sin^2\theta}}\right|^2 \quad \ldots(12)$$

FOR CLAY $r_v(\theta)$ **(clay) =**

$$\left|\frac{\left[\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{clay}-\varepsilon_0}{\varepsilon_{clay}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{clay}-\varepsilon_0}{\varepsilon_{clay}+2\varepsilon_0}\right)\right]}\right]\cos\theta-\sqrt{\left[\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{clay}-\varepsilon_0}{\varepsilon_{clay}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{clay}-\varepsilon_0}{\varepsilon_{clay}+2\varepsilon_0}\right)\right]}\right]-\sin^2\theta}}{\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{clay}-\varepsilon_0}{\varepsilon_{clay}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{clay}-\varepsilon_0}{\varepsilon_{clay}+2\varepsilon_0}\right)\right]}\cos\theta+\sqrt{\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{clay}-\varepsilon_0}{\varepsilon_{clay}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{clay}-\varepsilon_0}{\varepsilon_{clay}+2\varepsilon_0}\right)\right]}-\sin^2\theta}}\right|^2 \quad \ldots(13)$$

The reflectivity of microwave signal at horizontal polarization for sand dust particles is:

FOR SAND

$$r_h(\theta)\ \textbf{(sand)} = \left|\frac{\cos\theta-\sqrt{\left[\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{sand}-\varepsilon_0}{\varepsilon_{sand}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{sand}-\varepsilon_0}{\varepsilon_{sand}+2\varepsilon_0}\right)\right]}\right]-\sin^2\theta}}{\cos\theta+\sqrt{\frac{\varepsilon_0\left[1+2\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{sand}-\varepsilon_0}{\varepsilon_{sand}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\frac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\frac{\varepsilon_{sand}-\varepsilon_0}{\varepsilon_{sand}+2\varepsilon_0}\right)\right]}-\sin^2\theta}}\right|^2 \quad \ldots(14)$$

FOR SILT

$$r_h(\theta)\ \textbf{(silt)} = \left| \frac{\cos\theta - \sqrt{\left[\dfrac{\varepsilon_0\left[1+2\eta_0\left(\dfrac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\dfrac{\varepsilon_{silt}-\varepsilon_0}{\varepsilon_{silt}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\dfrac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\dfrac{\varepsilon_{silt}-\varepsilon_0}{\varepsilon_{silt}+2\varepsilon_0}\right)\right]}\right] - \sin^2\theta}}{\cos\theta + \sqrt{\dfrac{\varepsilon_0\left[1+2\eta_0\left(\dfrac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\dfrac{\varepsilon_{silt}-\varepsilon_0}{\varepsilon_{silt}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\dfrac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\dfrac{\varepsilon_{silt}-\varepsilon_0}{\varepsilon_{silt}+2\varepsilon_0}\right)\right]} - \sin^2\theta}} \right|^2 \quad \ldots (15)$$

FOR CLAY $r_h(\theta)$ **(clay) =**

$$\left| \frac{\cos\theta - \sqrt{\left[\dfrac{\varepsilon_0\left[1+2\eta_0\left(\dfrac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\dfrac{\varepsilon_{clay}-\varepsilon_0}{\varepsilon_{clay}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\dfrac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\dfrac{\varepsilon_{clay}-\varepsilon_0}{\varepsilon_{clay}+2\varepsilon_0}\right)\right]}\right] - \sin^2\theta}}{\cos\theta + \sqrt{\dfrac{\varepsilon_0\left[1+2\eta_0\left(\dfrac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\dfrac{\varepsilon_{clay}-\varepsilon_0}{\varepsilon_{clay}+2\varepsilon_0}\right)\right]}{\left[1-\eta_0\left(\dfrac{9.43\times10^{-9}}{V^{\gamma}4/3\pi a^3}\right)\left(\dfrac{\varepsilon_{clay}-\varepsilon_0}{\varepsilon_{clay}+2\varepsilon_0}\right)\right]} - \sin^2\theta}} \right|^2 \quad \ldots (16)$$

The above equations show for reflection coefficient due to vertical and horizontal polarization from soil surface which contain sand, silt and clay particle. Emission coefficient is calculated from Frensenl's and Ulaby"s relation $e_p(\Theta) = 1 - r_p(\Theta)$ for both vertical and horizontal polarization.

The microwave emission coefficient at vertical polarization for different dust particles is given as

$$e_v(\Theta) = 1 - \left| \frac{\varepsilon_{eff}\cos\theta - \sqrt{\varepsilon_{eff} - \sin^2\theta}}{\varepsilon_{eff}\cos\theta + \sqrt{\varepsilon_{eff} - \sin^2\theta}} \right|^2 \quad \ldots (17)$$

For Horizontal Polarization $e_h(\theta) = 1 - \left| \dfrac{\cos\theta - \sqrt{\varepsilon_{eff} - \sin^2\theta}}{\cos\theta + \sqrt{\varepsilon_{eff} - \sin^2\theta}} \right|^2$

where ε_{eff} is effective dielectric constant as described in eqn. (5).

NUMERICAL COMPUTATIONS

The dielectric constant (permittivity) for sand, silt, clay $\varepsilon_{sand} = 1.2$, $\varepsilon_{silt} = 2.3$, $\varepsilon_{clay} = 3.4$ is taken for different visibility. The dielectric constant ε_0 for air is taken as 1; the permeability of free space η_0 is 1.

RESULT AND DISSCUSSION

Emissive properties of Microwave signal passes through different constituents of dust storm condition (such as sand, silt, clay) varies with angle incidence of signal, permittivity, permeability, visibility, frequency from surface polarization of passive sensor. The Reflection and Emission of microwave signal is taken for both vertical and horizontal polarization. The value of reflection and emission coefficient for sand, silt and clay particle for vertical and horizontal polarization can be calculated by equation 1 to 16 at different visibilities and angle of incidence at frequency 40 GHz. The results obtained are tabulated in tables 1 to 4 and their variation in figs. 2 to 5.

Table 1. Variation of Reflection coefficient with respect to visibilities for angle of incidence at 10° at frequency 40 GHz

S. No.	Visibility (km)	Reflection coefficient for Horizontal Polarization (m^2)			Reflection coefficient for Vertical Polarization (m^2)		
		Sand	silt	Clay	Sand	Silt	Clay
1.	0.001	2.3×10^{-3}	2.0×10^{-3}	1.7×10^{-3}	2.3×10^{-3}	2.2×10^{-3}	1.83×10^{-3}
2.	0.01	2.5×10^{-3}	2.1×10^{-3}	1.8×10^{-3}	2.7×10^{-3}	2.5×10^{-3}	1.85×10^{-3}
3.	0.1	2.53×10^{-3}	2.2×10^{-3}	1.82×10^{-3}	2.8×10^{-3}	2.7×10^{-3}	1.90×10^{-3}
4.	1	2.6×10^{-3}	2.2×10^{-3}	1.89×10^{-3}	$2.8\,9 \times 10^{-3}$	2.8×10^{-3}	1.92×10^{-3}

Table 2.Variation of Emission coefficient with respect to visibility for angle of incidence at 10° at frequency 40 GHz.

S. No.	Visibility (km)	Emission coefficient for Horizontal Polarization (dB/Km)			Emission coefficient for Vertical Polarization (dB/Km)		
		Sand	Silt	Clay	Sand	Silt	Clay
1.	0.001	1.0023	1.0020	1.0017	1.00236	1.00212	1.00183
2.	0.01	1.0024	1.0021	1.0018	1.00271	1.00251	1.00185
3.	0.1	1.0026	1.0022	1.00188	1.00288	1.00272	1.00791
4.	1	1.0027	1.0022	1.00189	1.00289	1.00278	1.00192

Table 3. Variation of Reflection coefficient with angle of incidence at Visibility 1 Km

S. No.	Angle of incidence	Reflection coefficient for Horizontal Polarization (m^2)			Reflection coefficient for vertical Polarization (m^2)		
		Sand	Silt	Clay	Sand	Silt	Clay
1.	10°	4.7×10^{-3}	1.1×10^{-3}	1.2×10^{-3}	4.7×10^{-3}	1.6×10^{-3}	2.1×10^{-3}
2.	20°	8.3×10^{-3}	5.7×10^{-3}	3.8×10^{-3}	8.2×10^{-3}	5.5×10^{-3}	$5. \times 10^{-3}$

3.	30°	9.1×10^{-3}	6.3×10^{-3}	4.5×10^{-3}	9.3×10^{-3}	6.2×10^{-3}	$6. \times 10^{-3}$
4.	40°	9.8×10^{-3}	7.1×10^{-3}	5.3×10^{-3}	9.6×10^{-3}	7.3×10^{-3}	7.1×10^{-3}

Table 4. Variation of Emission coefficient with angle of incidence at visibility 1 Km

S. No.	Angle of Incidence	Emission coefficient for Horizontal Polarization (dB)			Emission coefficient for Vertical Polarization (dB)		
		Sand	Silt	Clay	Sand	Silt	Clay
1.	10°	1.0047	1.0013	1.00112	1.0032	1.0016	1.0010
2.	20°	1.0083	1.0057	1.0038	1.0082	1.0056	1.0032
3.	30°	1.0091	1.0063	1.0045	1.00903	1.0062	1.0043
4.	40°	1.0097	1.0071	1.0053	1.0096	1.0070	1.0051

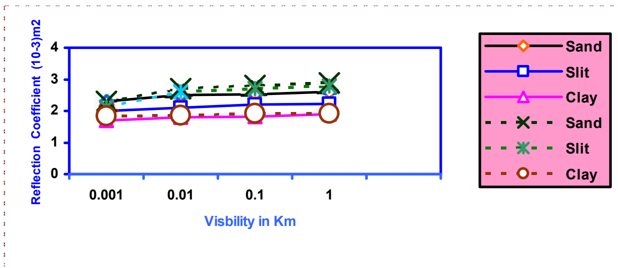

Fig. 2. Variation of Reflection coefficient (m^2) with visibility in Km at angle of incidence 10°

(**NOTE**-Bold line shows Vertical polarization Dashed line shows that Horizontal polarization)

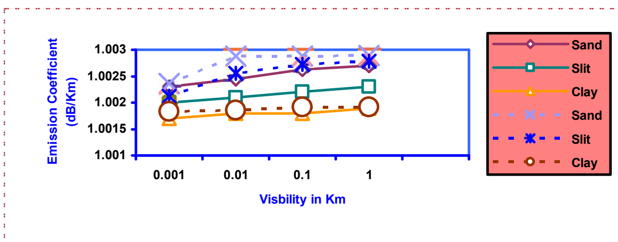

Fig. 3. Variation of Emission coefficient (dB/Km) with visibility in Km at angle of incidence 10°

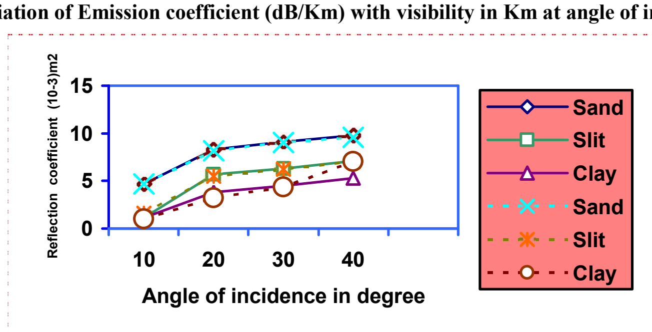

Fig. 4. Variation of Reflection coefficient (m^2) with angle of incidence and at visibility 1 Km

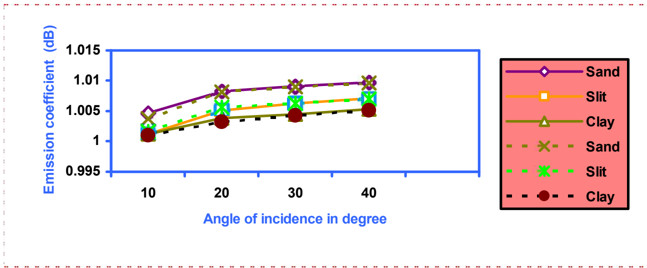

Fig. 5. Variation of Emission coefficient (dB) with angle of incidence and at visibility 1 Km.

Conclusions

From above discussion it is concluded that reflection and emission coefficient depends on frequency, angle of incidence, visibility, permittivity, permeability of soil constituents. Reflection coefficient of microwave signal decreases with angle of incidence and visibilities. And emission coefficient increase with angle of incidence and visibilities. Clay particle passes large dielectric constant in comparison to sand and silt particle. Reflection coefficient in clay particles passes higher value than sand, and silt particle and emission coefficient in clay particle have less value than sand, silt particle.

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