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EVALUATION OF RADIO WAVE PROPAGATION THROUGH FOLIAGE IN PARTS OF CALABAR, NIGERIA

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Abstract – This paper present and compares the degree of propagation loss as radio signals travels through foliage. The propagation loss due to foliage, of CRBC signals transmitted on 519.25MHz was measured and compared with the Weissberger modified exponential decay model and the Early ITU model. The result shows a high correlation between the measured propagation loss and the model's predictions. The plots of the data obtained from the measurement against the predictions of the models shows a higher correlation between the measured data and the Weissberger predictions.

Keywords: Radio signals, propagation loss, Weissberger modified exponential decay model, Early ITU model, correlation

1. Introduction

As radio waves propagates from one point to another, the nature of the environment between and around the transmitter and receiver has major effect on the quality of the transmitted signal. [4, 10]. Therefore the significance of radio wave propagation loss prediction in the communication channel cannot be over emphasized. [2]

The obstruction of a propagating radio wave may result in reflection refraction, diffraction, absorption or scattering of the wave, which leads to attenuation of the signal. [2, 8, 10, 12]. Therefore, this paper seeks to measure the degree of attenuation of the Cross River Broadcasting Cooperation (CRBC) signal transmitted on 519.25MHz due to the foliage medium between its transmitter and most of its receivers in Calabar, Nigeria.

There are many radio wave propagation path loss models available and each model is mostly suitable for the environmental conditions under which it was derived. [6]. This limitation may affect their universal applicability. [1, 9] which necessitated this research aimed at comparing the experimental measurement obtained with the Weissberger and Early ITU models.

2. Review of the Weissberger's model

The Weissberger modified exponential decay model or simply Weissberger's model, is a radio wave propagation model that estimates the path-loss due to the presence of one or more trees in the point –to-point telecommunication link. The coverage frequencies ranges from: 230MHZ to 95GHZ and up to 400m depth of foliage. It was developed in 1982, it is a development of the International Telecommunication Union (ITU) Model for Exponential Decay (MED).

The Weissberger model is mathematically expressed as

$$L = \begin{cases} 1.33 f^{0.284}\, d^{0.558} & if\ 14 < d \leq 400 \\ 0.45\, f^{0.284} d & \text{if } 0 < d < 14 \end{cases}$$

Where,

L = the loss due to foliage in decibel (dB)

F = the transmission frequency (GHz)

d = the depth of foliage along the path (m)

The equation is scaled for frequency specified in GHz range and the depth of foliage must be in meter. [7, 13, 14, 15]

3. Review of the Early ITU model

The Early ITU vegetation model is a radio propagation model that estimates the path loss encountered due to one or more tress inside a point to point telecommunication link. The prediction of this model coincides with that of Weissberger's modified exponential decay model in low frequencies. The coverage frequency and depth of foliage of this model are not specified. It was adopted by CCIR, predecessor of ITU in the late 1986.

The Early ITU model is mathematically given by,

$$L = 0.2\, f^{0.3}\, d^{0.6}$$

Where

L = the path loss in decibel (dB)

f = the frequency of transmission in megahertz (MHz)

d = the depth of foliage along the link in meter (m).

The equation is scaled for frequency specified in megahertz (MHz) and depth of foliage must be in meters. [1, 3, 5, 8, 11]

4. Experimental setup and computations

In this experiment the outdoor signal strength of Cross River Broadcasting Cooperation (CRBC) channel 27 transmitted on 519.25MHz was measured. The measurements were carried out between October to December, 2016.

The Calabar botanical garden (site 1), the Margaret Ekpo International airport field Calabar (site 2), and the field by the side of NNS victory (site 3) were the sites used during the experiment. The criteria considered

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in choosing the sites includes, availability of the desired signal under review, availability of matured trees, site accessibility, and minimal human and traffic interference around the sites. During the period of measurement the trees were well foliated.

This research was carried out by measuring signal strength at different depths into a foliage channel away from the signal transmitter antenna with the aid of a GPS.

The experimental setup was such that a domestic antenna was mounted on a 5.8m pole and connected to a digital Community Access Television (CATV) analyser with 24 channels, spectrum 46MHz – 870MHz. The antenna and analyser were moved from one depth to another into the foliage channel and readings were taken accordingly.

In all cases, measurements were normally taken in an open field on the site to serve as the reference signal strength before the signal strength reading under the foliage canopies were taken. The difference between the measured reference signal strength and the signal strength reading under the foliage canopy gives the loss due to foliage.

Microsoft excel was used to compare the data obtained from each experimental site to the Weissberger and Early ITU's models.

5. Results and discussion

Figure 1, shows the measured foliage loss against the Weissberger‘s and Early ITU‘s models. As can be noticed in the figure the foliage loss keeps rising in the same manner as that of the Early ITU model, deviations however set in at points 50m and 90m. These deviation in the general rising nature of the foliage loss could be attributed to the existence of lesser foliage canopies at these points or due to reflection of signals. Though the Weissberger‘s model started on a downward trend before moving upward, it is observed that the measured foliage loss (experimental data obtained) is closer in form to the Weissberger‘s model than it is to the Early ITU model.

In Figure 2, it is observed that the measured foliage loss and the Early ITU's model moved in the same direction except at points 50m, 60m, 80m and 90m where marked deviations occurred at the foliage loss, most probably due to lesser foliage at this areas. Whereas the Weissberger's model started on a downward trend before rising upward the measured foliage loss is closer in form to the Weissberger's model than it is to the Early ITU model.

Figure 3 shows increase in signal loss in the measured foliage loss and Early ITU's model except at points 60m and 90m where the measured loss deviated, most likely due to lesser foliage density at these points or due to reflection of the signals. Whereas, the Weissberger's model showed a decrease in

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signal loss at the beginning before going upward, the measure foliage loss is closer in form to the Weissberger's model than it is to the Early ITU's model

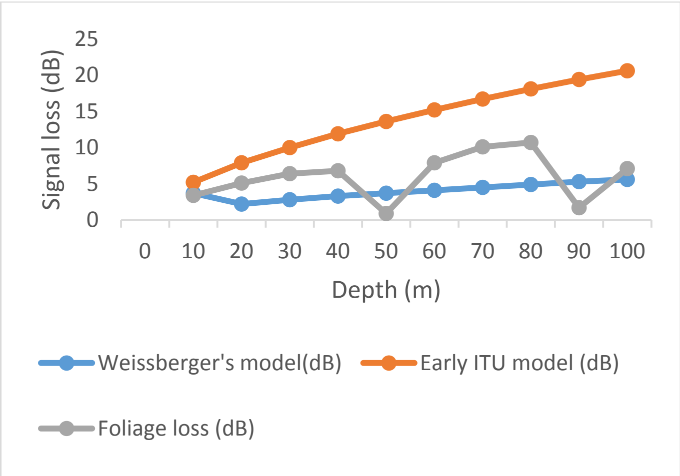

FIG. 1: Comparison between the Weissberger's model, Early ITU model and the measured foliage loss (Site 1)

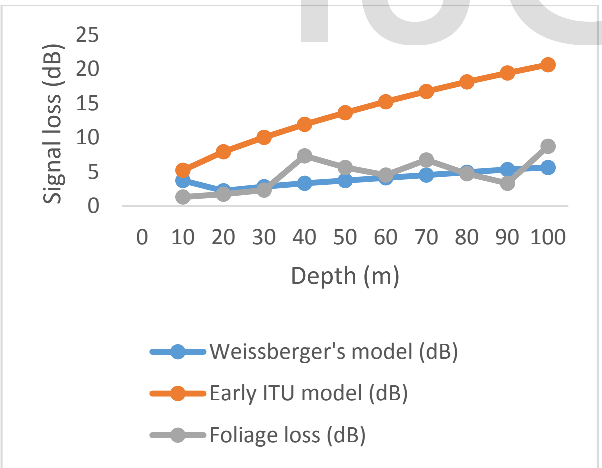

FIG. 2: Comparison between the Weissberger's model, Early ITU model and the measured foliage loss (Site 2)

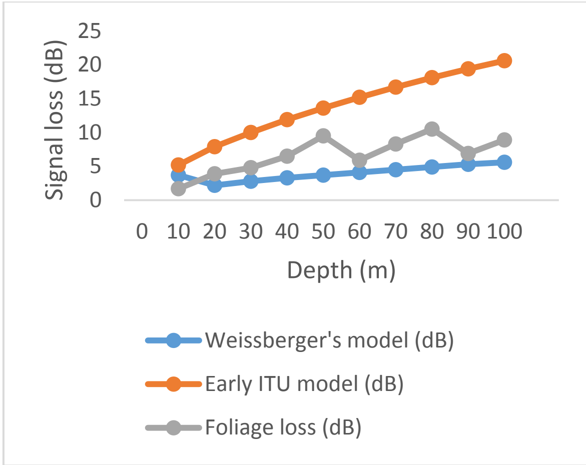

FIG. 3: Comparison between the Weissberger's model, Early ITU model and the measured foliage loss (Site 3)

6. Conclusion

It is quite revealing from the experiment that the presence of foliage along the path of radio wave attenuates its signal strength. The thickness of the foliage or foliage density and the depth of vegetation greatly determines the degree of signal loss. The experiment also shows site geometry, distance between transmitter and receiver, operating frequency as other factors that can determine the degree of foliage loss. Finally, in all the three sites considered for the experiment the predictions of the Weissberger's model fits better with the data obtained than that of the Early ITU model.

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