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Suitability of the Early ITU Model in Parts of Cross River State Nigeria

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Abstract

In order to investigate the effect of foliage on radio wave propagation and to evaluate the universal applicability of the Early ITU model, in parts of Cross River State, Nigeria, measurements of signal strengths outside and inside foliage channels at a frequency of 95.9MHz were taken in Calabar South, Calabar Municipality, Odukpani and Akamkpa local government areas as sites 1, 2, 3 and 4, respectively. The results show that foliage density contributed immensely to the degree of foliage loss. The results also showed that the correlation coefficient between foliage loss and vegetation depth in sites 1, 2, 3 and 4 are r = 0.5, r = 0.2, r = 0.9 and r = 0.9 respectively. The standard deviation of the measured foliage loss for sites 1, 2, 3 and 4 are 4dB, 4dB, 2dB and 3dB respectively. Finally, the data obtained is closely related to the Early ITU model predictions.

Keywords: *Early ITU model, foliage, radio wave propagation, foliage density.*

1. Introduction

The popularity and adoption of radio communication and related technologies has been the subject of so many researches all over the world [1]. Since radio communication is propagated by electromagnetic waves travelling through the earth's atmosphere [13], it becomes imperative to understand these waves and their propagation through different environments.

As radio waves travel through the earth's atmosphere it tend to experience losses due to several factors including foliage [3]. Foliage which can be defined as plant leaves especially tree leaves, considered as a group. A cluster of leaves**.** [6**]** It is one common environment where radio waves propagate. Due to the complex nature of the foliage channel, it has attracted lots of research for some decades and it is widely agreed that the presence of foliage, an indispensable feature of most outdoor wireless channel, attenuates radio waves and therefore reduces the Quality of Service (QOS) of the transmitting agency. [1, 12]

Many radio wave propagation models are mostly suitable for the environmental conditions under which they were formulated. [1,10]. This limitation may affect their universal applicability which necessitated this research aimed at generating experimental data from different locations and comparing the data obtained with the Early ITU model.

2. Review of the Early ITU Model

The Early ITU model or vegetation model is use to predict or estimate the path loss when they are trees in a point to point telecommunication link. In low frequencies this method of prediction coincides with that of Weissberger. The coverage frequency and depth of foliage of this model are not specified. It was adopted by Consultative Committee on International Radio (CCIR) in the late 1986**.**

The Early ITU model is mathematically given by,

$$L = 0.2 f^{0.3} d^{0.6} dB \quad (1)$$

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 foliage depth specified in meters (m). [4, 5, 7, 9]

3. Experimental Setup and Computation

In this experiment the outdoor signal strength of Hit FM transmitted on 95.9MHz were measured. The measurements were carried out between October to December, 2016.

The Calabar botanical garden, the Margaret Ekpo International airport field Calabar, a forested channel in Odukpani along the Calabar-Ikom highway and a forested area in the College of Education (COE) Awi-Akamkpa were the sites used during the experiment. The criteria considered in choosing the sites includes, availability of the desired signals 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 Early ITU's model.

4. Result and Discussion

Table 1 and Figure 1, compares the Early ITU model with the measured foliage loss from site 1. It is observed that both curves kept rising except at points 40m, 70m and 80m where the measured foliage loss deviated. These deviations are most likely due to lesser foliage density at these points which gives room for better line of sight between the transmitter and the receiver.

Table 2 and Figure 2, shows both the Early ITU's model and the measured foliage loss from site 2 rising except at points 50m, 60m, 80m and 100m where there were reversals in the measured foliage loss. These reversals are most likely due to the re-establishment of line of sight or reflection of signals towards the receiver's antenna at these points.

In comparing the Early ITU's model with the measured foliage loss from site 3, from table 3 and figure 3, it is observed that both curves moved in the same direction with exceptions to the 50m, 70m and 100m points. These exceptions can be attributed to the reflection of signals or lesser foliage canopies on those points. In general the measured foliage loss was quite consistent with the Early ITU's model.

Table 4 and Figure 4, which compares the measured foliage loss in site 4 with that of the Early ITU models shows both curves having their highest and lowest signal loss at the 100m and 10m points respectively. It is also observed, that both curves moved in the same direction, with some deviation on the 30m, 60m and 90m points. These deviations or reversals are most likely cause by the reflection of signals or lesser foliage canopies in the areas.

Table 1: Measurement from site 1 and the Early ITU model.

Depth (m)	Measured foliage loss (dB)	Early ITU's model loss (dB)
0	-	-
10	3.2	3.1
20	4.1	4.7
30	6.7	6.1

40	2.9	7.2
50	8.7	8.2
60	9.7	9.2
70	2.3	10.1
80	1.5	10.9
90	11.5	11.7
100	12.1	12.5

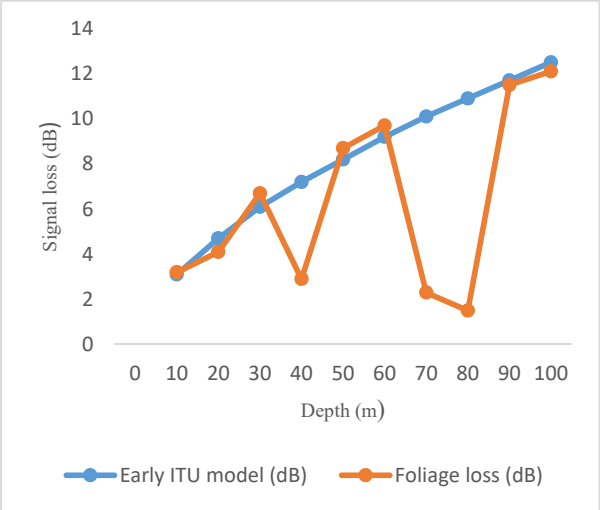

Fig. 1: Comparison between the Early ITU model and the measured foliage loss (Site 1)

Table 2: Measurement from Site 2 and the Early ITU model.

Depth (m)	Measured foliage loss (dB)	Early ITU's model loss (dB)
0	-	-
10	3.6	3.1
20	4.7	4.7
30	7.3	6.1
40	14.3	7.2
50	10.6	8.2
60	10.4	9.2
70	11.3	10.1
80	2.8	10.9
90	11.6	11.7
100	6.1	12.5

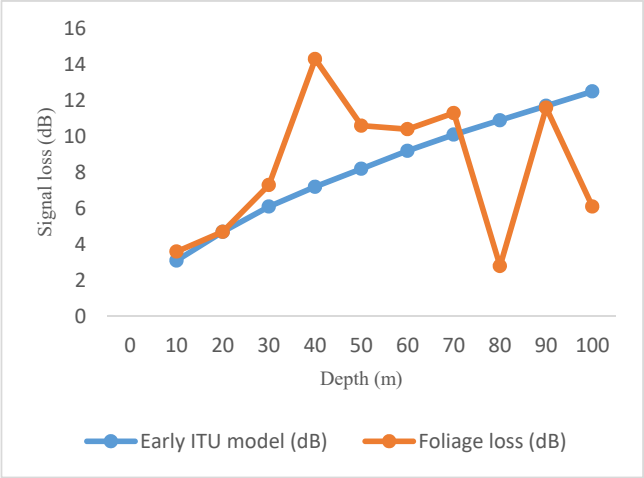

Fig. 2: Comparison between Early ITU model and the measured foliage loss (Site 2)

Table 3: Measurement from Site 3 and the Early ITU model.

Depth (m)	Measured foliage loss (dB)	Early ITU's model loss (dB)
0	-	-
10	3.9	3.1
20	4.9	4.7
30	6.8	6.1
40	7.1	7.2
50	6.6	8.2
60	8.0	9.2
70	7.8	10.1
80	8.7	10.9
90	11.8	11.7
100	9.7	12.5

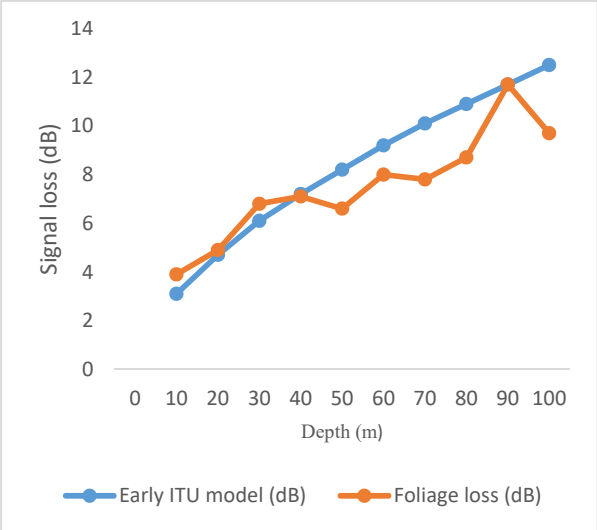

Fig. 3: Comparison between Early ITU model and the measured foliage loss (Site 3)

Table 4: Measurement from Site 4 and the Early ITU model.

Depth (m)	Measured foliage loss (dB)	Early ITU's model loss (dB)
0	-	-
10	3.2	3.1
20	5.3	4.7
30	4.2	6.1
40	8.1	7.2
50	10.2	8.2
60	7.4	9.2
70	10.1	10.1
80	13.1	10.9
90	10.0	11.7
100	13.2	12.5

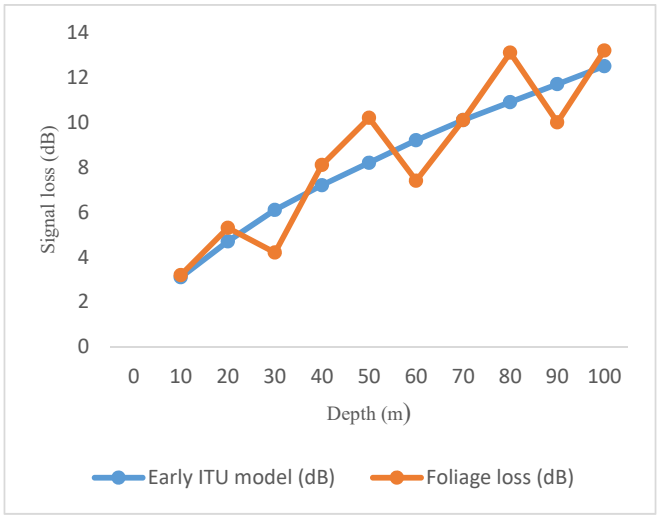

Fig. 4: Comparison between Early ITU model and the measured foliage loss (Site 4)

5. Conclusion

From the analyses of the experimental data obtained, there is a directly proportional relationship between foliage losses and depth of vegetation. Though there are some variations from path to path, the most likely cause being the degree or density of the foliage canopies along the chosen path. There were also variations in measured foliage loss on a site to site basis which can be traced to differences in site geometries, density of foliage canopies and the distance between the site and the transmitter. Conclusively, at a frequency of 95.5MHz the Early ITU models fits well with the data obtained from these parts of Cross river state, Nigeria.

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