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EGLI MODEL TESTING FOR TELEVISION PLANNING IN THE UHF BAND FOR SOUTH-SOUTH REGION OF NIGERIA

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ABSTRACT
Propagation models are very important tools deployed in planning a radio communication system like the television system. The paper presents the testing of the renowned Egli radio propagation model for television planning in the Very High Frequency (VHF) band for the south- south region of Nigeria. The work was carried out in Edo state through extensive signal strength measurement across selected routes. A handheld spectrum analyzer Sefram 7806 was set to the transmission frequency of the television station used for the investigation and signal strength values were collected at varying distances from the television station. A handheld global positioning Garmin 78CS GPS receiver was used to obtain the geospatial co-ordinates of points were signal strength values were recorded. The results showed that the Egli propagation model cannot be relied upon in the radio planning of future television system in the region due to the huge root mean error value (RMSE) between the pathloss prediction from the model and that obtained from the actual measurements.
Keywords: *Egli, Propagation, radio, television, pathloss, VHF.*

INTRODUCTION
Radio propagation models are needed in the planning of radio communication systems like the television system. Radio models are mathematical tools used for the planning, design and implementation of wireless mobile networks (Abhayawardhana 2005). Propagation models can also be used for analyzing existing radio communication system to determine current performance and without the use of such models at the planning stage of a radio communication system, the system will not perform optimally during physical deployment in the field (Ogbeide et al, 2014). Radio propagation models predicts the acceptable signal levels for a given transmitter-receiver separation distance. They are also very useful for performing interference studies for radio communication system during deployment (Faruk et al, 2013). The generalization of these models to any environment (urban, suburbs and rural), or specific cell radius (macrocell, microcell, picocell) depends on the diversity of environment variables where the radio communications occur (Haider et al, 2018). In general, there is a relationship between these models and types of environments for which they are suitable. These models can be broadly categorized into three types; empirical, deterministic and stochastic (Govind 2014).

Empirical models are those based on observations and measurements alone (Faruk et al, 2013). These models are mainly used to predict path loss, but models that predict rain-fade and multipath have also been proposed (Naima et al, 2014). The deterministic models make use of the laws governing electromagnetic wave propagation to determine the received signal power at a particular location (Yahia, 2014). . Deterministic models often require a complete 3-D map of the area under investigation. (Surajudeen-Bakinde et al, 2018). Stochastic models, on the other hand, model the environment as a series of random variables, these models are the least accurate but require the least information about the environment and use much less processing power to generate predictions (Thomas et al, 2001). Empirical models can further be divided into two subcategories and these are: time dispersive and non-time dispersive empirical models (Yahia, 2014). An example of time dispersive model is the Stanford University Interim channel model developed under the Institute of Electrical and Electronic Engineers (IEEE) 802.16 working group (Yahia, 2014). Examples of non-time dispersive empirical models are Hata and the COST-231-Hata models (Yahia, 2014). These models predict the path loss as a function of various parameters like distance, antenna heights frequency of transmission etc. However to deploy such empirical models, they will need to be tested first so as to determine their suitability. An empirical model of RMSE between 0 and 7 dB is considered acceptable for urban areas (Gupta et al, 2009), although for typical suburban and rural areas, up to 10–15 dB can still be acceptable. In previous works (Ogbeide et al, 2013, Ogbeide et al, 2014, Ogbeide et al, 2017) the applicability of different empirical models have been investigated however, the current work is aimed at testing the Egli pathloss models for prediction in the VHF band signal propagation in Edo State being in South-South region of Nigeria.

MATERIALS AND METHODS

This section comprises of the measurement procedure adopted for the work and a brief review of the Egli pathloss model.

Measurement Procedure for the Investigation

The investigation was carried out in Edo state within the south- south region of Nigeria which mainly falls within the tropical climatic zone of West Africa. Edo State lies roughly between longitudes 05° 04'E and latitudes 05°44'N and 07°34'N with an area of about 19,794 square kilometres. Figure 1 shows the digitized map of Edo state and the routes taken in the course of the measurement campaign.

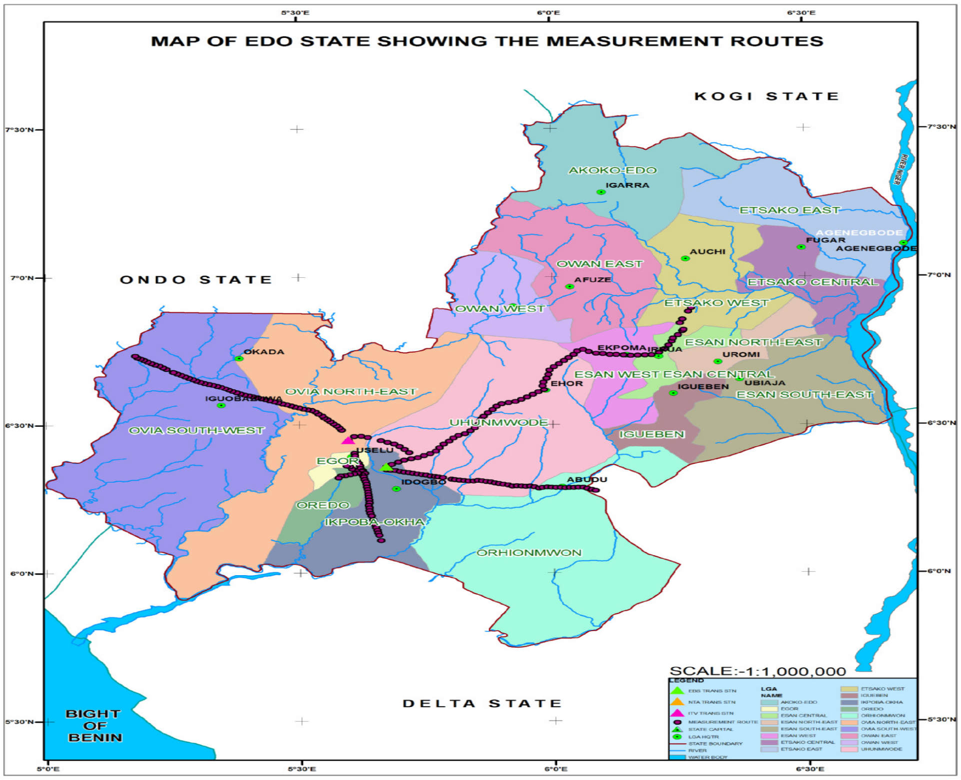

Figure 1: Digitized map of Edo Sate showing measurement routes

To measure the signal strength of the television broadcasting stations, a portable spectrum analyzer (Sefram 7806 analyzer) was used. It is a battery operated hand-held RF field strength meter capable of measuring radio frequency levels. The instrument provides a reliable measurements across a wide reception range of 45 to 865MHz. The characteristics of the Television station used for the investigation is as shown in Table 1

Table 1: Characteristics of broadcasting station

Station	Transmit Frequency (MHz)	Transmitter Height (m)	Channel	Transmitter Power (kW)	Frequency Band
NTA BENIN	189.25	150	7	10	VHF

A handheld global positioning system (GPS) –Garmin GPS 76CS receiver was used for obtaining the spatial coordinates of the various measuring points in angular degrees.

Egli Model

The Egli Model is an example of an empirical radio propagation model for path loss prediction. This prediction model was first introduced by John Egli in 1957 (Egli 1957). This propagation model can be applied at frequencies ranging from 40 MHz to 900 MHz and for distances less than 60 km. The model was developed from measurement data on the Ultra High Frequency and Very High Frequency television transmissions in several large cities and it predicts the total path loss for a point-to-point link (Mardeni et al, 2010). The Egli model is formally expressed as equation 1

$$P_L = G_B G_M \left[\frac{h_B h_M}{d^2}\right]^2 \left[\frac{40}{f}\right]^2 \quad (1)$$

Where:
P_L = Pathloss in dB
G_B = Absolute gain of the base station antenna.
G_M = Absolute gain of the mobile station antenna.
h_B = Height of the base station antenna. [m]
h_M = Height of the mobile station antenna. [m]
d = Distance from base station antenna. [m]
f = Frequency of transmission. [MHz]
Equation 1 presented in the logarithm form is shown in equation (2) and (3) for different height of mobile station

For hm < 10m,

$$Lt(dB) = 20Log(fc) + 40Log(R) - 20Log(hb) + 76.3 - 10log(hm) \quad (2)$$

for hm > 10m

$$Lt(dB) = 20Log(f_c) + 40LogR - 20Log(hb) + 85.9 - 10Log(hm) \quad (3)$$

Since the model typically suitable for communication scenarios for frequency in the range of 40MHz -900MHz (Mardeni et al, 2010). This the model applies to coverage frequency in the VHF and UHF spectrum transmissions.
The pathloss computed from the Egli model equation given in equation 2 is compared with the pathloss obtained from the measurement campaign using equation 4.

$$Pathloss(dB) = Power\ transmitted - Power\ received \quad (4)$$

RESULTS AND DISCUSSIONS

The field strength values measured for each station were converted into a path loss value called 'measured path loss' using equation 4 Path loss values were computed for the Egli propagation model using the Equation (2). The obtained path loss was compared to that of the measured path loss and the results are shown in Figures 2 to 7.

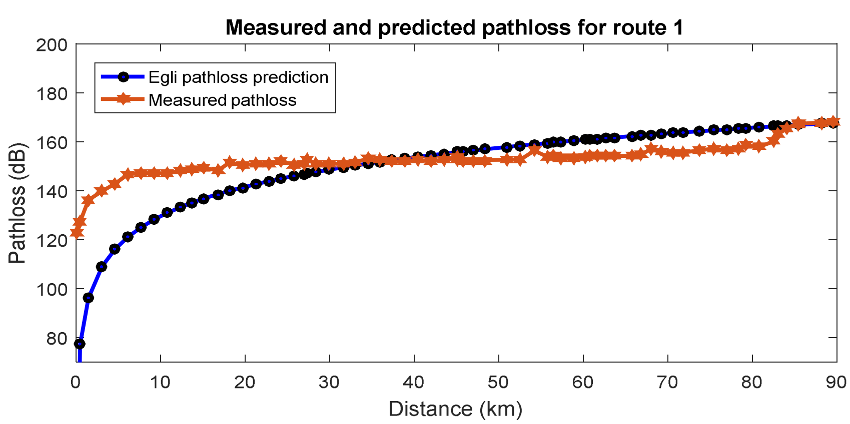

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Figure 2: Measured and Egli model predicted pathloss for route 1

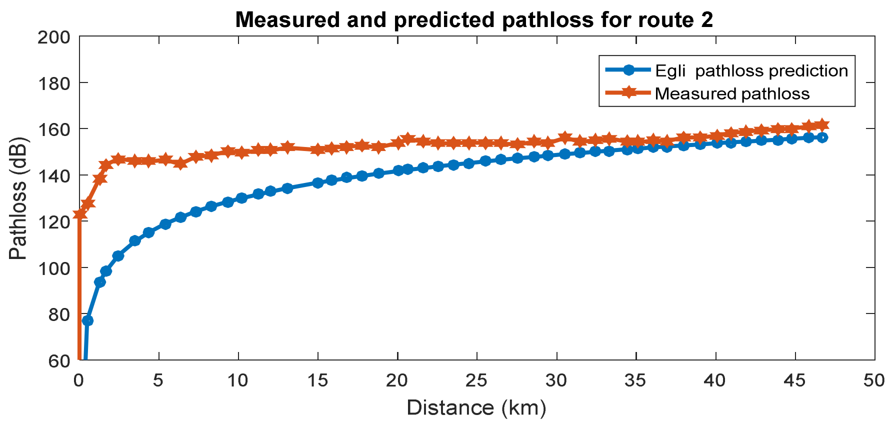

Figure 3: Measured and Egli model predicted pathloss for route 2

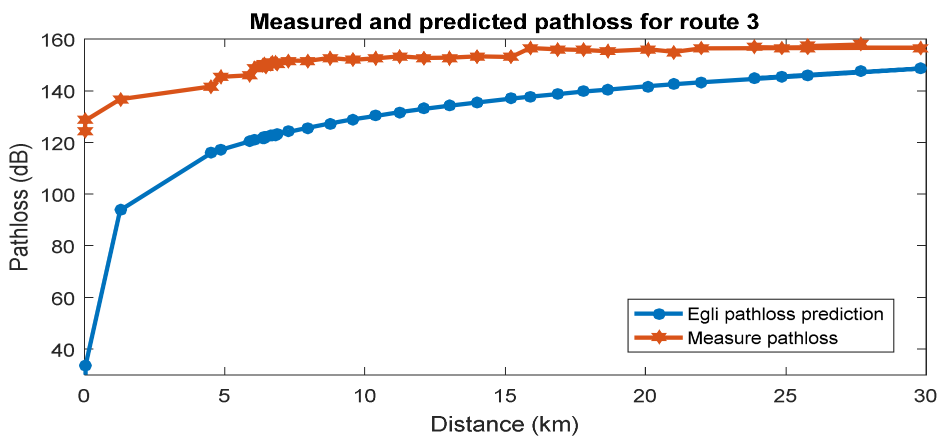

Figure 4: Measured and Egli model predicted pathloss for route 3

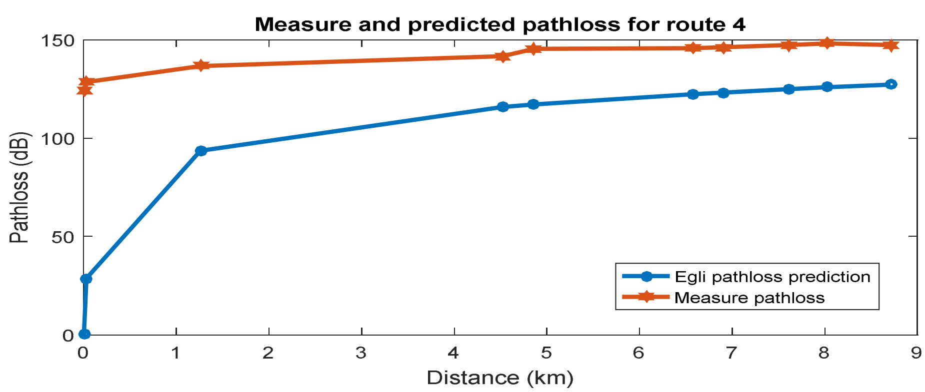

Figure 5: Measured and Egli model predicted pathloss for route 4

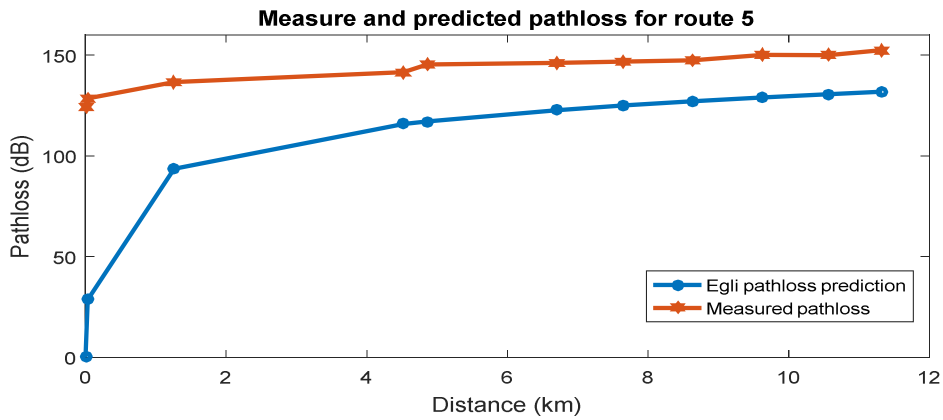

Figure 6: Measured and Egli model predicted pathloss for route 5

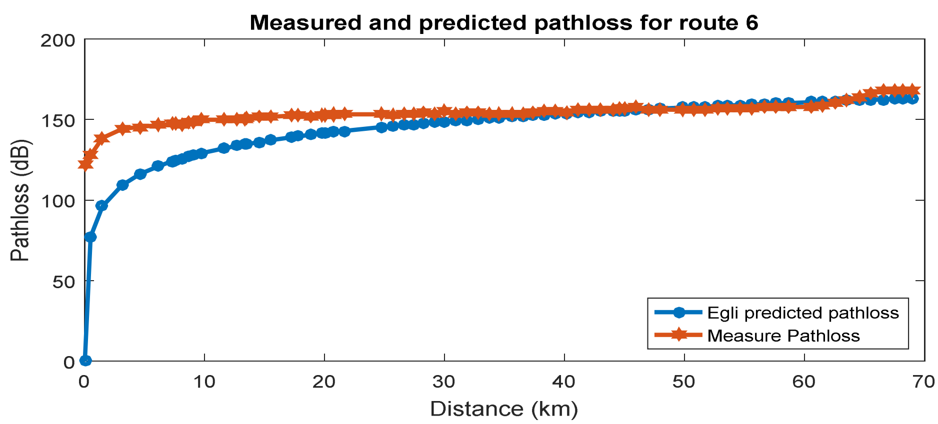

Figure 7: Measured and Egli model predicted pathloss for route 6

Correlation coefficients are used to assess the strength and direction of the linear relationships between the measured pathloss and the Egli pathloss prediction using equation 5 and the root mean square error value is determined using the equation 6

$$r = \frac{1}{n-1} \Sigma \left(\frac{x-\bar{x}}{s_x}\right)\left(\frac{y-\bar{y}}{s_y}\right) \quad (5)$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (X_{obs,i} - X_{model,i})^2}{n}} \quad (6)$$

The results of the correlation coefficient is as shown in the table 3. Furthermore, the RMSE value was calculated for each route and the results is as presented on table 4

Table 2: Correlation coefficient of measured and Egli predicted Pathloss

	Route 1	Route 2	Route 3	Route 4	Route 5	Route 6
	Egli Pathloss Prediction					
Measured Pathloss	0.8883	0.9112	0.9584	0.9774	0.9636	0.9177

Table 3: RMSE Statistical Analysis for each Route

Route 1	Route 2	Route 3	Route 4	Route 5	Route 6
Root Mean Square Error (RMSE) values					
19.083	24.103	33.3583	55.8726	53.4538	19.5005

From the Table 2 and 3, It can be seen that for all the routes investigated, that there was a strong correlation between the measured pathloss and pathloss predicted by Egli model however the high RMSE values shows that are far above the 0 – 7dB normally accepted for adopting a pathloss prediction models for an environment. The results also confirmed that Egli model prediction is less efficient for distances close to the transmitter as seen in the Figures 2 to 7.

CONCLUSION

Propagation models are very important tools for signal level prediction in a radio communication systems during the planning stage of the network design. Quite a number of these propagation models exist but the universal relevance of such models are based on the locality of deployments as no model is a universally acceptable due to difference in propagation conditions. The work has shown that the Egli model as an example of a renowned empirical propagation model does not explain the pathloss condition of the south-south region of Nigeria. The RMSE value key performance indicators for adopting an existing propagation model has being violated and therefore optimization of the model will be required before it can be deploy for radio planning in the south-south region of Nigeria.

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