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# Signal Strength Evaluation of a 3G Network in Owerri Metropolis Using Path Loss Propagation Model at 2.1GHz

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***Abstract:*** *In this work, the path loss and the received signal strength of a 3G network at 2.1GHz was evaluated to determine its performance within the Owerri metropolis. Various measuring equipment such as Transmission Evaluation and Monitoring System (TEMS 11), Global positioning system (BU353 GPS) and laptop were deployed for the drive test within the selected urban and sub-urban regions. From the data collected, Owerri sub-urban region showed poor received signal power level compared to the Owerri urban region. The path loss exponents computed for the Owerri urban and sub-urban regions are 3.24 and 4.34 respectively, the mean square error was evaluated as 1.96 and 1.68. The result obtained showed deviations between the compared existing models (Hata and Cost 231) and the proposed models. However, the slope of the Hata plot was relatively close in comparison to the proposed model than that of Cost 231; hence, the proposed model was best suited for the environment followed by the Hata model.*
***Keywords:*** *Path loss, Hata, Cost 231, 3G, Received Signal Strength*.

## I. Introduction

It is no-longer novel that environmental factors such as buildings, trees, rain, snow, dust, fog and vapour has significant influence on the integrity of wireless transmitted signals. It is also worth noting that these signal-limiting factors which are found in the communication channels between the transmitting and receiving antennas, degrade the radiated signals through reflecting back some of the radiated signals into the initial medium, diffracting some of the signals, scattering some and also causing the medium to absorb some signals [1]. Hence, the efficiency of any wireless communication system is said to be essentially dependent on the propagation features of the system channel which has a great influence on the design of the propagation structure. Radio propagation models are a set mathematical formulations developed for the characterization of radio waves in a propagation environment as a function of frequency of transmission, distance and other conditions that influence the behaviour of the radio channel [2]. The models constitute a basic part in the design for wireless communication systems. The propagation models predict the received signal strength at a given distance from the transmitter, including the variability strength of the signal within a specific location. It is useful in predicting the signal coverage of a transmitter for any transmitter-receiver distance of separation. Also, it is valuable in predicting signal attenuation or path loss whose knowledge serves as a controlling factor for system analysis and performance and aids in system optimization of the signal coverage.

A number of path loss propagation models have been developed in the past and are presently deployed for coverage prediction. These models cannot be seen as generalized models owing to the fact that the environment from which they were developed differs from where they are being applied [3]. During the planning stage of cellular networks, models are employed to predict the behavioural characteristics of signals using similar attributes and constraints of the environment before deployment. An accurate estimation of channel characteristics is a requirement aimed at maintaining the interference at a minimum level. The study is aimed at analyzing the signal strength performance of the 3G network at 2.1GHz in Owerri urban and sub-urban metropolis and develops a suitable path loss model for the environment. The need for the research was prompted due to the persistent call drops on the level of received signal power experienced in 3G networks within the Owerri metropolis. The impact of this anomaly if not properly mitigated could result to heavy financial loss to the network providers through rapid migration of the subscribers from one network to another in search of quality service delivery.

## II. Radio Propagation Models

Radio propagation models are empirical mathematical formulations used in the characterization of radio wave propagation as a function of frequency, distance and other conditions [4]. Various developed models such as Free Space Model, Hata Model, Okumura-Hata Model, SUI Model, ECC-33 Model, COST 231 Hata Model, Lee Model, Sakagami Model, Kuboi Model are useful in the prediction of the behavior of propagation for all similar links under similar conditions, created for the purpose of formalizing the manner radio waves are propagated from one place to another. They are deployed for the prediction of path loss along a link or the effective coverage area of a transmitter and depend on frequency range, location and clutter type such as urban, sub-urban and rural. Some selected propagation models such as Hata model and COST 231 implemented in this article are further discussed.

**2.1 Hata Model**

The Hata model puts Okumura observations into a simple form as $C + D\log X$ , where C and D are frequency and antenna height functions and X is the distance. The prediction area is divided into a series of clutter and terrain categories namely urban, sub-urban and open area. The limitations on Hata model due to range of test results from carrier frequency 150MHz to 1500MHz, the distance from the base station ranges from 1km to 20km, the height of the base station antenna $h_b$ ranges from 30m to 200m and the height of mobile antenna $h_m$ ranges from 1m to 10m [5,6].

**Pathloss for urban clutter**

The pathloss model for urban clutter is represented as**:**

$$L_P(urban) = 69.55 + 26.16\log(f) - 13.82\log(h_b) - a(h_m) + \{44.9 - 6.55\log(h_b)\}\log(d) + c_m \quad (1)$$

Where; $a(h_m) = (1.1\log(f) - 0.7)h_m - (1.56\log(f) - 0.8)$

$h_m$ is the height of the mobile antenna

$h_b$ is the height of the base station antenna

$f$ is the frequency

$c_m$ is the correction factor, given as 0dB for urban environment

**Pathloss for sub-urban clutter**

The pathloss model for sub-urban clutter is represented as**:**

$$L_P(suburban) = L_P(urban) - 2\{\log(f/28\}^2 - 5.4 \quad (2)$$

**Pathloss for open area**

The pathloss model for open area is represented as**:**

$$L_P(openarea) = L_P(urban) - 4.78\{\log(f)^2\} + 18.33\log(f) - 40.94 \quad (3)$$

**2.2 Cost 231 Hata Model**

The European Cooperative for Scientific and Technical Research (EURO-COST) constituted the COST-231 working committee in order to develop an extended version of the Hata model. COST-231 proposed the formula expressed in equation 4 to extend Hata's model to 2GHz. It employs suitable correction factors to improve the limitations of the Hata model. The proposed model for path loss is given in equation (4) [7].

$$P_L(COST-231)urban = 46.3 + 33.9\log(f_c) - 13.82\log(h_b) - a(h_m) + \\ \{44.9 - 6.55\log(h_b)\log\}\log(d) + C_m \quad (4)$$

$C_m = 0dB$ for medium sized city and sub-urban areas

$C_m = 3dB$ for metropolitan centres

The COST -231 extension of the Hata model is constrained to the range of parameters stated below:

$f_c$ : 1500MHz to 2000MHz

$h_b$ : 30m to 200m

$h_m$ : 1m to 10m

$d$ : 1km to 20km

## III. Literature Review

In [3], the study focused on investigative analysis of the effects of propagation environment on the wireless communication signals within some geographical domains in Port Harcourt, River State, Nigeria. Field measurements were carried out in some selected areas namely GRA phase II and Aggrey Road categorized as urban and sub-urban areas respectively using Sony Ericsson (W995) Test Phone and GPS receiver (BU353). The analyses were based on linear regression (mean square error) approach. The computed path loss exponents and standard deviation based on the empirical analyses conducted for urban and sub-urban environments were obtained as 3.57dB, 2.98dB and 19.6, 13.2, respectively. The results obtained were used to compare the performance of the various existing path loss prediction models such as Okumura-Hata, Cost 231 and ECC-33. From their observations, Okumura-Hata model showed better performance in urban environment while Cost 231 performed better in rural environment. Hence they recommended the deployment of optimized Okumura-Hata model in urban, while Cost 231for sub-urban areas.The authors of [8] researched on a Near-Ground path loss measurement and modeling for wireless sensor Network at 2.4 GHz. The authors presented three (3) near-ground scenarios whose path loss values were obtained through measurement. They used the least square linear regression approach in the analysis. The predicted and measured far field path losses were compared and the result obtained indicated that the proposed model performs better in near-ground scenarios than the compared generic models.The authors of [9] conducted an extensive study of the behavior of propagating electromagnetic waves within the office buildings and vegetation along possible line of sight. The study presented propagation loss measurements of Global systems at 951MHz, 952MHz, 954MHz, and 955 MHz along the line of sight (LOS). The study was carried out at Ladoke Akintola University of Technology in Oyo State, Nigeria. The environment comprised buildings and vegetation with average thickness of 0.1m to 0.5m and 0.7m to 15m respectively. The spacing between them ranges between 2m to 7.5m, building height ranging from 3m to 5m. A GSP- 180 model spectrum analyzer was used to measure the GSM signal power at a distance of 20m to 500m along a possible LOS. With the data obtained, a comparison was done between the measured and existing propagation loss models. The determined values obtained were 56.58 and 71.42 respectively.

## IV. Methodology

### 4.1 Material Specification, Measurement Environment and Configuration

The materials used for the investigation include Ericsson Transmission Evaluation and Monitoring System (TEMS 11), a global positioning system (BU353 GPS), and a laptop with installed TEMS software and a power supply system. This research was carried out in Owerri metropolis; the areas covered were categorized into two which are: urban area and sub-urban area. The urban area comprised Wethedral road, Nekede road, Royce road, Tetlow road, Government house, Akanchawa new road, World Bank road and new Owerri road. The Sub-urban area comprised Owerri-Obinze Express road and Federal University of Technology Owerri (FUTO) community. The measurements were carried out using a motion car with the speed kept within the limit and as constant as possible so as to ensure accuracy of signal recordings. The Received Signal Level (RSL) that existed between the Mobile Station (MS) and Base Transceiver Station (BTS) were recorded in a log file of the laptop with TEMS 11 investigation software. The Global positioning system (BU 353 GPS) was used to indicate the distance and location with regards to the base station which was also documented on the laptop. Figs. 1 to 6 represent the various field routes where the measurements were conducted. The curves stand for the routes followed during the drive test in the areas while the colour variations indicated the strength of the received signals as shown in the legend. The light blue colour represents the best received signal level while the red colour indicates the worst state in that order at the legend. The modal value of the aggregate received signal level was obtained as 728dB, which is 32.5% of the total received signal.

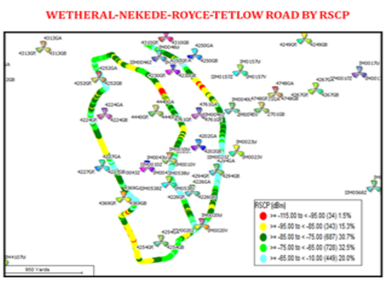


**Fig. 1:** The log of measurement along Wetheral-Nekede-Royce Tetlow Road.

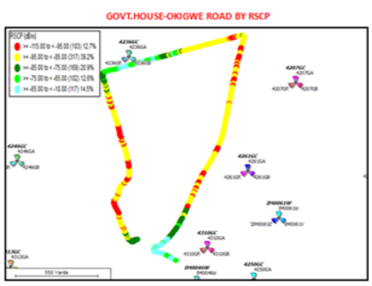


**Fig. 2:** The log of measurement along Government House- Okigwe Road

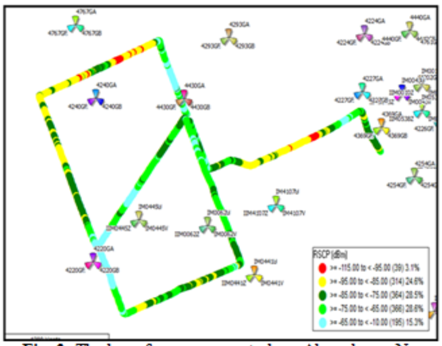


**Fig. 3:** The log of measurement along Akanchawa New Owerri- World bank Road

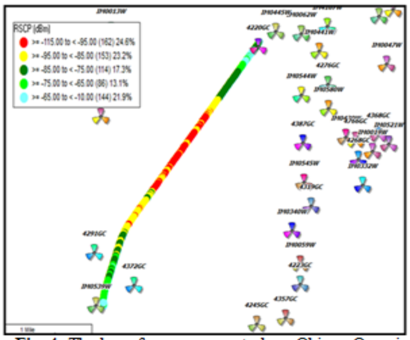


**Fig. 4:** The log of measurement along Obinze-Owerri Express Road.

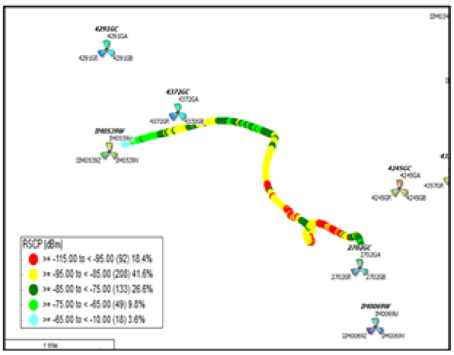


**Fig. 5:** The log of measurement along FUTO1 road.

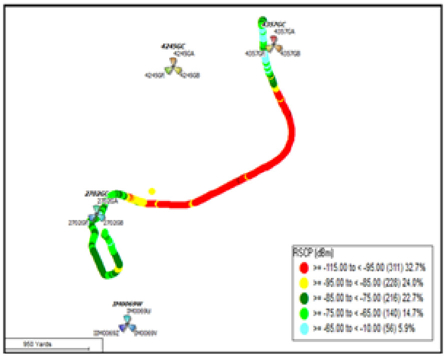


**Fig. 6:** The log of measurement along FUTO 2 road

To develop the proposed models, the following parameters were obtained accordingly; the path loss exponent, reference path loss, predicted path losses, and standard deviation. In order to determine the path loss within Owerri metropolis, the data obtained from the field measurement was collected and has its validity tested in order to derive an appropriate model that best predict the signal path loss within the metropolis. Table 1 listed the transmission parameters deployed for the study while Tables 2 and 3 indicated the median values of the measured Received Signal Levels (RSL) and corresponding values of measured path losses for specified distances, 0.1km≤ di ≤1.0km of the routes as generated from the Actix analyzer software. The values did not ultimately follow a decreasing order with distance which could possibly be as a result of interferences from other transceiver stations other than the reference transmitting station at the start of the drive test. The path loss model for predicting the Path loss is represented in equation (5) [10]. Substituting the values of the path loss exponent, reference path loss, and standard deviation provides the path loss model of the environment of study.

$$L_P(dB) = L_P(d_0) + 10n\log({}^{d_i}\!/\!_{d_0}) + \delta \qquad (5)$$

Where;

$L_P$ is the predicted Path loss in dB, $d_0$ is the reference distance, $d_i$ is the distance between the transmitter and receiver, $L_P(d_0)$ is the reference path loss at a close-in distance of $d_0$, $n$ is the Path loss exponent and $\delta$ is the standard deviation.

**Table 1:** Transmission Parameters for the Network

| S/N | Transmission parameters | Values |
|---|---|---|
| 1 | Transmitter power | 30W |
| 2 | Transmitter height | 35m |
| 3 | Mobile Station height | 1.5m |
| 4 | Gain of transmitter | 18dB |
| 5 | Gain of receiver | 1.76dB |
| 6 | Frequency of operation | 2.1GHz |

**Table 2:** Median Receive Signal Levels (RSL) and corresponding measured path loss for Owerri urban.

| Distance(km) | Median RSS (dBm) | Measured Path loss (dB) |
|---|---|---|
| 0.10 | -54 | 85 |
| 0.20 | -57 | 96 |
| 0.30 | -62 | 97 |

| | | |
|---|---|---|
| 0.40 | -97 | 158 |
| 0.50 | -66 | 99 |
| 0.60 | -83 | 113 |
| 0.70 | -66 | 148 |
| 0.80 | -76 | 109 |
| 0.90 | -80 | 112 |
| 1.0 | -81 | 113 |

**Table 3:** Median Receive Signal Levels (RSL) and corresponding measured path loss for Owerri sub-urban.

| Distance(km) | Median RSS (dBm) | Measured Path loss (dB) |
|---|---|---|
| 0.10 | -58 | 91 |
| 0.20 | -64 | 97 |
| 0.30 | -76 | 115 |
| 0.40 | -90 | 158 |
| 0.50 | -87 | 137 |
| 0.60 | -79 | 112 |
| 0.70 | -87 | 120 |
| 0.80 | -89 | 123 |
| 0.90 | -84 | 120 |
| 1.0 | -90 | 158 |

**Computation of Path loss from existing models**

Two existing models were considered for modeling the Owerri Metropolis 3G network. They are Hata model, and COST 231 model, with distance in kilometer, frequency in megahertz and antenna height in meters.

**Computation of Hata model for Owerri urban**

Using the transmission parameters in Table 1 and equation (1), the Hata model is computed as shown in equation (6)

$$P_L(HATA)_{urban} = 69.55 + 26.16\log(2100) - 13.83\log(35) - (1.11\log(2100) - 0.7)1.5$$
$$-(1.5\log(2100) - 0.8) + (44.9 - 6.55\log(35)\log(d)$$
$$\therefore P_L(HATA)_{urban} = 126.46 + 34.79\log(d) \tag{6}$$

**Computation of Hata model for Owerri sub-urban**

Using equation (2), the path loss model for sub-urban is obtained as shown in equation (7).

$$P_L(HATA)_{suburban} = 126.46 + 34.79\log(d) - 2\{\log(^{2100}/_{28}\}^2 - 5.4$$

$$\therefore P_L(HATA)_{suburban} = 124.83 + 34.79\log(d) \tag{7}$$

**Computation of COST 231 Extension of Hata Model for Owerri urban:**

Also, using the transmission parameters in Table 1 and equation (4), the COST 231 model for urban is computed as shown in equation (8) with $c_m = 3dB$.

$$P_L(COST231)_{urban} = 140.58 + 34.79\log(d) \tag{8}$$

**Computation of COST 231 Extension of Hata Model for Owerri sub-urban:**

From equation (4) the COST 231 Path loss model for sub-urban environment was obtained as represented in equation (9).

$$P_L(COST231)_{suburban} = 137.28 + 34.79\log(d) \tag{9}$$

## V. Result And Analysis

The value of the path loss exponent for the Owerri Urban is calculated from the measured data using linear regression method as shown in Table 4.

**Table 4:** Computation of path loss exponent for Owerri urban using linear regression method.

| Distance (km) | $X_i = 10\log(d/d_0)$ | $Y_i = P_L(dB)$ | $X_i$^2 | $X_iY_i$ | $Y_i$^2 |
|---|---|---|---|---|---|
| 0.10 | 0.0000 | 85 | 0.0000 | 0 | 7,225 |
| 0.20 | 3.0103 | 96 | 9.0619 | 288.9888 | 9,216 |
| 0.30 | 4.7712 | 97 | 22.7645 | 462.8064 | 9,409 |
| 0.40 | 6.0206 | 158 | 36.2476 | 951.2548 | 24,964 |
| 0.50 | 6.9897 | 99 | 48.8559 | 691.9803 | 9,801 |
| 0.60 | 7.7815 | 113 | 60.5519 | 879.3095 | 12,769 |
| 0.70 | 8.4510 | 148 | 71.4191 | 1250.748 | 21,904 |
| 0.80 | 9.0309 | 109 | 81.5572 | 984.3681 | 11,881 |
| 0.90 | 9.5424 | 112 | 91.0579 | 1068.7488 | 12,544 |
| 1.00 | 10.0000 | 113 | 100.0000 | 1130 | 12,769 |
| **SUM** | **65.5976** | **1130** | **521.5159** | **7708.2047** | **132,482** |

Where, $d_0$ is the close in distance = 0.10km, $Y_i$ is the measured path loss.
The path loss exponent for urban region is given in equation (10).

$$n_{urban} = \frac{N\left\{\sum_{I=1}^{n}(X_iY_i) - (\sum_{i=1}^{n}X_i)(\sum_{i=1}^{n}Y_i)\right\}}{N(\sum_{i=1}^{n}X_i{}^2) - (\sum_{i=1}^{n}X_i)^2} \tag{10}$$

Where $N$ is the total number of data points.

$$= \frac{(10*7708.2047) - (65.5976)*(1130)}{(10*521.5159) - (65.5976)^2}$$

$$= \frac{(77082.047) - (74781.264)}{(5215.159) - (4303.045)}$$

$$= \frac{2956.759}{912.1139} = 3.2417$$

$$\approx 3.24$$

$$\therefore n_{urban} = 3.24$$

**Computation of the Reference Path Loss for Owerri urban:**
The reference path loss is computed using equation (11) and Table 4.

$$L_P(d_0) = \frac{\sum_{i=1}^{n}Y_i - n\sum_{i=1}^{n}X_i}{N} \tag{11}$$

$$\frac{1130 - (3.24*65.5976}{10} = \frac{917.4638}{10}$$

$$\therefore L_P(d_0) = 91.75dB$$

**Computation of the Standard Deviation for Owerri urban**
Standard deviation of the distribution was evaluated using the mean square error method. The sum of the mean square error is as represented in equation (12).

$$e(n) = \sum_{i=1}^{k}\left[L_m(d) - L_p(d)\right]^2 \tag{12}$$

Where $L_m$ is the measured path loss and $L_P$ is predicted path loss.

The values of the measured path losses and predicted path losses shown in Table 5 were substituted in equation 12 in order to get the sum of the Mean Squared Errors (MSE) of the system.

**Table 5:** Mean Squared Error calculation table for Owerri urban.

| Distance(km) | Measured Path loss $L_m(d)$ (dB) | Predicted path loss $L_p(d)$ (dBm) | $[L_m(d) - L_p(d)]^2$ |
|---|---|---|---|
| 0.10 | 85 | 91.7500 | 45.5625 |
| 0.20 | 96 | 101.5033 | 30.2863 |
| 0.30 | 97 | 107.2086 | 104.2155 |
| 0.40 | 158 | 111.2566 | 2184.9454 |
| 0.50 | 99 | 114.3965 | 237.0522 |
| 0.60 | 113 | 116.9619 | 15.6967 |
| 0.70 | 148 | 119.1310 | 833.4192 |
| 0.80 | 109 | 121.0099 | 144.2377 |
| 0.90 | 112 | 122.6673 | 113.7913 |
| 1.00 | 113 | 124.1498 | 124.3180 |

$\therefore e(n) = 3{,}833.5248$

The standard deviation, $\delta$ was calculated using equation (13).

$$\delta = \sqrt{\sum \frac{[(L_m) - (L_P)]^2}{N}} \tag{13}$$

Where N is the total number of data points which is 10 in this case.

$$= \sqrt{\frac{3833.5248}{10}}$$

$\therefore \delta = 19.58dB$

By substituting the values obtained to equation (13), the predicted path loss is obtained as

$$P_L = 91.75dB + 32.4\log\left(\frac{d}{d_o}\right) + 19.58dB \tag{14}$$

$$P_L = 111.33dB + 32.4\log(D)$$

Where $D = \dfrac{d}{d_0}$

The Mean Square Error $(e)$ of the distribution is obtained using equation (15).

$$e = \frac{\delta}{N} \tag{15}$$

$\therefore e = 1.96$

**Computation of the Path Loss Exponent for Owerri sub-urban:**

The value of the path loss exponent for the Owerri sub-urban is calculated from the measured data using linear regression as shown in Table 6.

**Table 6:** Computation of path loss exponent for Owerri sub-urban using regression method.

| Distance (km) | $X_i = 10\log(d/d_0)$ | $Y_i = P_L(dB)$ | $X_i{}^\wedge 2$ | $X_i Y_i$ | $Y_i{}^\wedge 2$ |
|---|---|---|---|---|---|
| 0.10 | 0.0000 | 91 | 0.0000 | 0 | 8,281 |
| 0.20 | 3.0103 | 97 | 9.0619 | 291.9991 | 9,409 |
| 0.30 | 4.7712 | 115 | 22.7645 | 548.688 | 13,225 |
| 0.40 | 6.0206 | 158 | 36.2476 | 951.2548 | 24,964 |
| 0.50 | 6.9897 | 137 | 48.8559 | 957.5889 | 18,769 |
| 0.60 | 7.7815 | 112 | 60.5519 | 871.528 | 12,544 |
| 0.70 | 8.4510 | 120 | 71.4191 | 1014.12 | 14,400 |
| 0.80 | 9.0309 | 123 | 81.5572 | 1110.8007 | 15,129 |
| 0.90 | 9.5424 | 120 | 91.0579 | 1145.088 | 14,400 |
| 1.00 | 10.0000 | 158 | 100.0000 | 1580 | 24,964 |
| **SUM** | **65.5976** | **1231** | **521.5159** | **8471.0675** | **156,085** |

Using equations 10, 11, 12, 13, and 15 and also tables 6 and 7, the path loss exponent $n$, the reference path loss, the sum of the mean square error, the standard deviation, and the mean square error for Owerri sub-urban are obtained as 4.34, 94.63dB, 2,829.6148, 16.82dB and 1.68 respectively.

**Table 7:** Mean Squared Error calculation table for Owerri sub-urban.

| Distance(km) | Measured Path loss $L_m(d)$ (dB) | Predicted path loss $L_p(d)$ (dBm) | $[L_m(d) - L_p(d)]^2$ |
|---|---|---|---|
| 0.10 | 91 | 94.6300 | 13.1769 |
| 0.20 | 97 | 107.6946 | 114.3745 |
| 0.30 | 115 | 115.3369 | 0.1135 |
| 0.40 | 158 | 120.7592 | 1,386.8772 |
| 0.50 | 137 | 124.9651 | 144.8388 |
| 0.60 | 112 | 128.4015 | 269.0092 |
| 0.70 | 120 | 131.3070 | 127.8483 |
| 0.80 | 123 | 133.8239 | 117.1568 |
| 0.90 | 120 | 136.0439 | 257.4067 |
| 1.00 | 158 | 138.0297 | 398.8129 |

Hence the predicted path loss is evaluated in equation (16) as

$$L_P = 111.45dB + 43.4\log(D) \tag{16}$$

Fig. 7 shows the graphical representation of the comparisons between Hata, Cost-231 and the proposed models for urban regions in Owerri metropolis. At a distance of 0.1km, the path losses were 111.3300 dB, 137.5800 dB and 140.5800 dB for proposed model, Hata model, and Cost 231 model respectively, while at a distance of 1km, the path losses were 143.7298 dB, 172.3698dB and 175.3698dB in that order. Hence, the COST-231 model indicates the highest increase in path loss with distance, followed by the Hata model, and then the proposed model.Fig. 8 is the plot that compared the Hata Model and COST 231 Model with the proposed path loss model for Owerri sub-urban. At a distance of 0.1km, the path losses were 111.4500 dB, 124.8300 dB and 137.2800 dB for proposed model, Hata model, and Cost 231 model respectively, while at a distance of 1km, the path losses were 54.8497dB, 159.6198dB and 172.0698dB in that order. The COST-231 model also indicates the maximum increase in path loss with distance. This is then followed by the Hata model, and the proposed model for Owerri sub-urban.

Fig. 9 compared the proposed models for the studied regions (sub-urban and urban). The graph shows that both models possess similar close-in path losses of 91.75dB and 94.63 at a distance of 100m (0.1Km) for sub-urban and urban regions respectively. However, the path loss exponent for the Owerri suburban is 4.34 while that of Owerri urban is 3.24 indicating that the rate at which path loss for the sub-urban area varies with distance is greater than that experienced in the Owerri urban.It can be seen from all the compared models that while there was clear deviation of the Hata model from the proposed path loss models for Owerri urban and sub-urban; there was however a larger separation between the proposed models and Cost 231 model as represented in Figs. 7 and 8. The slope of the Hata model plot is closer to the proposed model compared to that of Cost 231 model especially for the Owerri sub-urban model; hence, Hata model will best describe the path loss experienced in the Owerri suburban than the Cost 231 model, after the proposed model.

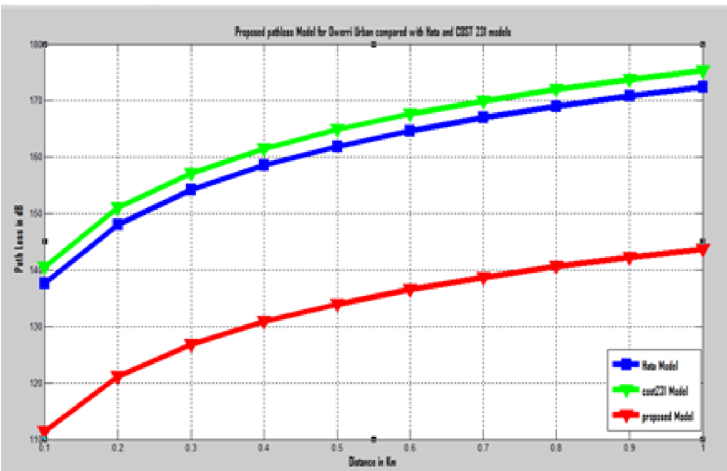


**Fig. 7:** Comparison of Hata Model, COST 231 Model, and Proposed Model for Owerri urban.

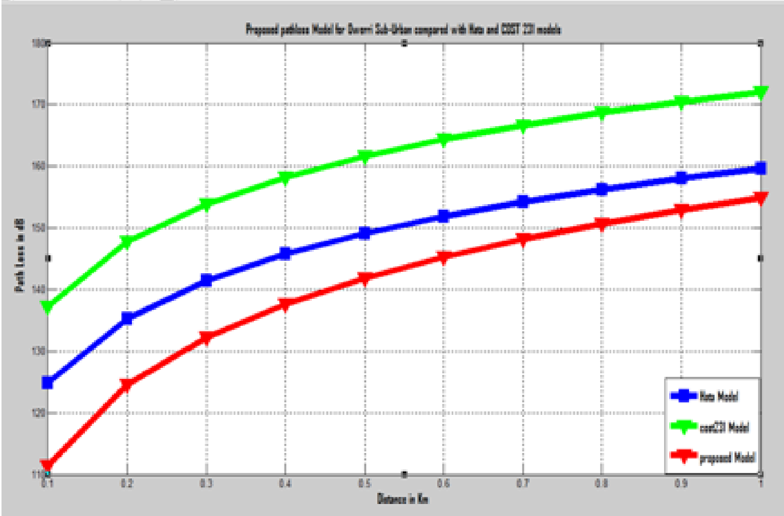


**Fig .8:** Comparison of Hata Model, COST 231 Model, and Proposed Model for Owerri sub-urban

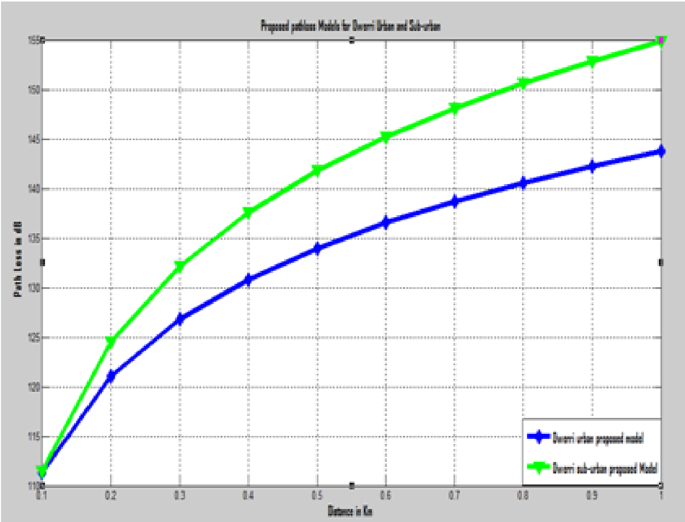


**Fig. 9:** Comparison of the proposed models for Owerri urban and sub-urban.

## VI. Conclusion

In this article, a drive test was carried out within Owerri metropolis categorized into urban and sub-urban regions. Experimental observations showed that there were much signal losses in the sub-urban region comprising Owerri-Obinze road and FUTO community than the Owerri urban region which comprises Wethedral road, Nekede road, Royce road, Tetlow road Government house, Akanchawa new road, World Bank road and new Owerri road. The results obtained along these routes in Owerri metropolis were used to compute the path loss exponents as 3.24 and 4.34 for Owerri urban and sub-urban, standard deviations that exist between the measured and predicted path losses as 19.58 and 16.82 and the mean squared error of 1.96 and 1.68 for Owerri urban and sub-urban regions respectively. These parameters were used to develop suitable path loss models for Owerri urban and sub-urban. Thereafter, the proposed models were compared with Hata model and COST 231 model. From all indications, these classical models did over-estimate the path losses within the Owerri urban and sub-urban environments. Thus, the proposed models are best suited for the environment under study followed by Hata model.

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