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Terrestial VHF / UHF Signal Strength Levels in Eastern Obolo and Ikot Abasi Communities of Akwa Ibom State, Nigeria

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Abstract: *Signal strength levels from Akwa Ibom Broadcasting Corporation (AKBC) television (Channel 45) and Nigerian Television Authority (NTA) channel 12 have been measured with a view to establishing the primary, secondary and fringe service areas of these signals at some locations in Eastern Obolo and Ikot Abasi Local Government Areas of Akwa Ibom State. Eastern Obolo and Ikot Abasi are densely forest zones that empty into the creeks that lead to the Atlantic Ocean in Akwa Ibom State. Propagation of electromagnetic waves in these areas has been quite challenging. CATV was used to measure signals of the TV station in dB, dBµv and dBmv. Signals received from this TV station at different locations of the study area using Radio Frequency Analyser with 24 channels spectrum ranging from 46-870MHz and an outdoor television antenna, 59(L) x 8.5(W) x 11(H) on a 10m pole showed that the signal strength received from VHF channel 45 ranged from 22dBµv to 51dBµv in Ikot Abasi and Eastern Obolo. 31.5dBµv signal was received by more than 55% of the area covered but others, especially the rural communities had signal below this value. In terms of path loss prediction, this closely agreed with Egli model when comparing the standard and calculated path loss. There was a drop in the received signals to about 11dB further in rural areas with thick vegetation. The poor signal received in these areas is not unconnected with the attenuations along the path of propagation from Uyo where the stations are located to these areas. The presence of thick vegetation, the atmosphere and other natural activities have greatly influenced the propagation of the signal. Some of the residents in these rural locations fell within the fringe zone while minority were in the secondary coverage zone as indicated in channel 12. These stations need to do more to boost the signal strength in the rural setting of this study.*

Keyword: *Eastern Obolo, Ikot Abasi, Television Channel, UHF/VHF Signal, Signal propagation.*

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I. Introduction

The television has become an important tool for information dissemination. It's importance in today's modern society cannot be over emphasized which include enhancement of communication and promoting education just to mention a few.

Frequency bands such as VHF (Very High Frequency) and UHF (Ultra High Frequency) bands are assigned to stations for terrestrial broadcasting. As viewers tune to broadcast stations within and outside their localities, what is expected is the television to faithfully reproduce the exact audio and video features transmitted by the broadcasting station's transmitter. The structural content or shape of object, the tonal content or relative brightness, the motion of the object or kinematic content, sound, color or chromatic content and lastly the stereoscopic content also known as perspective should all be intact (Kenedy & David,1999). These contents are direct function of how good the signal is at the point of reception. In other word, they reflect the signal strength at such point. The signals are electromagnetic in nature and as such are subject to natural or man-made phenomena. Factors like the presence of hills, buildings, vegetation and the atmosphere have been found to have great influence on the propagation of this signal in different regions. The areas of reception have been classified into primary, secondary and fringe service area (Ajewole et al,2014), (Oyetunji,2013). Based on environmental influences, the signal may decreases from primary to fringe zone.

When an electric current flows through a conductor, it produces a time-varying electric field which in turn acts as a source of magnetic field. These two fields created can sustain and interact with each other giving rise a special form of energy known as electromagnetic wave (Griffith, 1999). According to Maxwell's equations, both electric and magnetic fields which form the electromagnetic disturbance are sinusoidal functions of time and position, and characterized by frequency and wavelength. These equations and direction of propagation define the basic principle undergirding the operation of electromagnetic wave as a combination of Gauss's law of electric fields, Gauss's law of magnetic fields, Ampere's law and Faraday's law (Griffith, 1999). The equations are as follows:

$$\oint E.dA = Qencl/\epsilon_{\circ} \quad (1)$$

Equation (1) implies that the surface integral of E over any closed surface equals $1/\epsilon$ multiplied by the total charge Q_{encl} , where E is the electric field and A represents the area.

(ii) $\oint B.dA = 0.$ (2)

Equation (2) states that the surface integral of B over any closed surface is zero, where B is the magnetic field.

(iii) $\oint B.dl = \mu_{\circ}(i_{c} + \varepsilon_{\circ}\frac{d\Phi}{dt}E)$ (3)

This is also known as Ampere's law. It implies that both conduction and displacement current act as sources of magnetic field; where $\varepsilon_{\circ}$ is the permittivity of free space, $\mu_{\circ}$ the permeability of free space, and ΦE the electric flux.

(iv) $\oint E.dl = -\frac{d\Phi}{dt}E$ (4)

Equation (4) is Faraday's law and implies that a changing magnetic flux induces an electric field. The Heaviside version of this equation using Laplace transform is shown in Equations (5) to (8) below:

$\nabla.E = 0$ (5)

$\nabla \mathrm{x} \mathrm{E} = -\frac{\partial B}{\partial t}$ (6)

$\nabla.B = 0$ (7)

$\nabla XE = \frac{\mu_{\circ}\epsilon_{\circ}\partial E}{\partial t}$ (8)

Deploying the curl of curl to these equations, we obtain Equations (9) and (10) as presented below:

$\nabla \mathrm{x}(\nabla \mathrm{x} \mathrm{E}) = -\frac{\partial}{\partial t}\nabla \mathrm{x} \mathrm{B} = -\frac{\mu_{\circ}\epsilon_{\circ}\partial^2 E}{\partial t^2}$ (9)

$\nabla \mathrm{x}(\nabla \mathrm{x} \mathrm{B}) = -\frac{\partial}{\partial t}\nabla \mathrm{x} \mathrm{E} = -\frac{\mu_{\circ}\epsilon_{\circ}\partial^2 E}{\partial t^2}$ (10)

Further to the above, applying the vector identity, Equation (11) is derived as:

$\nabla \mathrm{x}(\nabla \mathrm{x} \mathrm{V}) = \nabla.(\nabla.\mathrm{V}) - \nabla^2\mathrm{V}$ (11)

Where **V** is any vector function in space. And Equation (12),

$\nabla^2\mathrm{V} = \nabla.(\nabla.\mathrm{V})$ (12)

Where ∇**V** is a dyadic which when operated on by the divergence operator $\nabla\cdot$ yields a vector. Since

$\nabla.\mathrm{E} = 0$

$\nabla.\mathrm{B} = 0$

Then, the first term on the right in the identity vanishes and the wave equations is obtained as presented below:

$\frac{\partial^2 E}{\partial t^2} - c_{\circ}{}^2.\nabla^2\mathrm{E} = 0$ (13)

$\frac{\partial^2 B}{\partial t^2} - c_{\circ}{}^2.\nabla^2\mathrm{B} = 0$ (14)

Where C in Equation 15:

$c_{\circ} = \frac{1}{\sqrt{\mu_{\circ}\epsilon_{\circ}}} = 2.99792458 \mathrm{~x~} 108 \mathrm{~m/s}$ (15)

is the speed of light in free space.

Each of these radiations has both frequency and wavelength range called bands, and are expressed below [7]: **Radio Waves**: 10 cm to 10 km wavelength; **Microwaves**: 1 mm to 1 m wavelength. **(1 GHz = 10^9 Hz); P band**: 0.3 - 1 GHz (30 - 100 cm); **L band**: 1 - 2 GHz (15 - 30 cm); **S band**: 2 - 4 GHz (7.5 - 15 cm); **C band**: 4 - 8 GHz (3.8 - 7.5 cm); **X band**: 8 - 12.5 GHz (2.4 - 3.8 cm); **Ku band**: 12.5 - 18 GHz (1.7 - 2.4 cm); **K band**: 18 - 26.5 GHz (1.1 - 1.7 cm); **Ka band**: 26.5 - 40 GHz (0.75 - 1.1 cm); **Infrared**: 0.7 to 300 µm wavelength; **Near Infrared (NIR)**: 0.7 to 1.5 µm; **Short Wavelength Infrared (SWIR)**: 1.5 to 3 µm; **Mid Wavelength Infrared (MWIR)**: 3 to 8 µm; **Long Wavelength Infrared (LWIR)**: 8 to 15 µm; **Far Infrared (FIR)**: longer than 15 µm; **Visible Light**: It ranges from about 400 nm (violet) to about 700 nm (red);**Red**: 610 - 700 nm; **Orange**: 590 - 610 nm; **Yellow**: 570 - 590 nm; **Green**: 500 - 570 nm; **Blue**: 450 - 500 nm; **Indigo**: 430 - 450 nm; **Violet**: 400 - 430 nm; **Ultraviolet**: 3 to 400 nm; **X-Rays and Gamma Rays;** Nakanishi (2013) indicated that there are other approaches that have the ability to track the passage of electromagnetic waves (Lee, 1982).

The radial electric field surrounding such electron is given by the Equation (16) below:

$Er = \frac{1}{4\pi\varepsilon_0} * \frac{e}{r^2}$ (16)

The condition stated by Equation (16) holds only for a stationary electron; but changes when such an electron is moving. Example: a current-carrying wire. The moving electron which produces current is also responsible for the magnetic field around it.

According to Griffiths (1999), any new field (electromagnetic radiation) produced by an accelerating electron depends on the acceleration of the electron and the reciprocal of the distance of the electron from the nucleus. This theory is illustrated in Equation (17) below:

$E_{\theta} = e * \frac{1}{4\pi\varepsilon_0} * \frac{\ddot{r}\sin\theta}{c^2 r}$ (17)

where E_θ is the pulse of electromagnetic radiation, e is the electronic charge, r is the acceleration, c is the speed of light, r the distance from the nucleus, and the angle between the changing fields. The amount of radiation leaving the system also depends of the length of the current-carrying conductor and the wavelength of the current flowing through it. Based on this, electromagnetic radiation can be described as an energy that is transmitted in form of electromagnetic wave either through space or a material medium.

Attenuation of Electromagnetic radiations

This is one of the major setbacks in the propagation of electromagnetic waves when it leaves its source. Electromagnetic waves get attenuated as they travel outwardly. Attenuation can be referred to as a reduction in the intensity of propagated electromagnetic waves. Attenuation of electromagnetic radiation in space obeys the inverse-square law which indicates that power density reduces fairly rapidly with distance from the source. This means that signal attenuation, is proportional to the square of the distance travelled by the wave Kenedy & David, 1999). The attenuation of field intensity is given by Equation (18):

$$\alpha_E = \frac{\sqrt{\frac{30P_t}{r_1}}}{\sqrt{\frac{30P_t}{r_2}}} = 20log\frac{r_1}{r_2} \qquad (18)$$

where α_E is the field intensity attenuation, P_t the transmitted power, r_1 and r_2 are distances from the source of electromagnetic waves with r_2 greater than r_1. This implies that at a distance of 2r from the source of the electromagnetic waves, the field intensity drops by 6dB.

Statement of the Problem

Propagation loss has been established to be inevitable as the distance between the transmitting antenna and the receiving antenna increases. Researchers have also indicated the probable cause of the loss to be from natural or manmade phenomena such as forest, hills, mountains, equipment, etc. Audio signal quality can deteriorate without much impact on the received signal as well as message.

However, visual signals are highly sensitive to fluctuations, and therefore easily noticed to the discomfort of the viewer. This research study is therefore focused on the UHF/VHF visual signal distortion levels experienced by subscribers at Eastern Obolo and Ikot Abasi Council Areas. The study carried out measurements and analyses of signal strength levels from (UHF and VHF) transmitted from Akwa Ibom Broadcasting Corporation (AKBC) channel 45 television and Nigerian Television Authority ,channel 12 propagating signals to these study locations. This is with a view to establish the primary, secondary and fringe service areas of these signals at different strategic locations, and topographical influences on the delivered signal strength levels in these locations.

II. Theoretical Review

Propagating signals undergo modulation processes; such as amplitude, Frequency and phase modulation. The general form of an amplitude modulated wave is presented in Equation 27:

$$f(t) = Asin(2\pi f_c t) + Am/2[sin2\pi(f_c + f_m)t + \emptyset) + [sin2\pi(f_c - f_m)t - \emptyset)$$

(27)

Where $A$and f_c are the carrier amplitude and frequency, respectively. m is the modulation index, f_m and $\emptyset$ are the frequency and phase of the baseband signal respectively. From the above equation, the modulation has three components which are the carrier wave and the two sidebands with frequencies above and below the carrier frequency (Grifiths, 1999). Frequency modulation (FM), is an alternative to AM, in order to achieve a radio transmission with much resistant to noise. It is a form of angle modulation in which the frequency of the carrier signal is varied by modulating the baseband signal while its amplitude and phase remain constant. The general form of an instantaneous frequency modulated wave is given by in Equation 28.

$$f = f_c(1 + kv_m cosw_m t) \qquad (28)$$

Where f_c = carrier frequency, k = proportionality constant, $v_m cos$ = instantaneous modulating voltage. The modulation index of an FM signal is given in Equation 29: $m = \frac{\Delta f}{f_m}$

(29)

Where Δf is the maximum deviation of the instantaneous frequency, and f_m ,is the maximum frequency of the modulating signal.

Phase modulation PM is another form of angle modulation besides FM where the phase of the carrier signal is varied by the modulating signal. In phase modulation, the variation in the carrier phase is proportional to the baseband signal, while its amplitude and frequency are constant during the process. The general form of a phase modulating wave is given as $v = A_c sin(w_c t + m_{(t)} + \emptyset_c)$ (30)

Where A_c and w_c are the amplitude and angular of the carrier signal respectively, $m_{(t)}$ is the modulating signal and $\emptyset_c$ is the phase of the carrier signal being modulated.

Griffiths presented an efficient realization of a filtered multi-tone (FMT) modulation system and its orthogonal design. FMT modulation was seen as a Discrete Fourier Transform (DFT) modulated filter bank (FB). It generalized the popular orthogonal frequency division multiplexing (OFDM) scheme by deploying frequency continued sub channel pulses. They considered the design of an orthogonal FMT system and exploited the third realization which allowed simplifying the orthogonal FB design and obtained a block diagonal system matrix with independent sub blocks. Griffiths modified a Michelson interferometer to produce a wide-band FM signal having a center frequency of 80MHz. According to him, assembling many radio stations in the same vehicle or network of radios is likely to induce self-interference. They analyzed the influence of an Adjacent Channel Interference (ACI) and white Gaussian noise of FM communication, and established an ACI model of FM communication system and this enabled them to evaluate the influence of ACI interference which they realized by computing the distortion of the speech signal demodulated. Also in 2007, McCue examined the problem of radio-frequency interference (RFI) between radars using linear-FM pulses. According to him, in most of the scenarios he considered, the RFI remain the same as if the FM were not present while in other cases it became very easy to evaluate the peak response of an un-weighted receiver by mere calculation. He finally generated expressions for the RFI and showed that if one knows the peak of the response, the effect of the weighting can as well be approximated by some simple expressions. Kenedy & David (1999) discovered a low profile polarized cavity-backed antennas using substrate integrated waveguide (SIW) techniques. According to the research, SIW and half-mode (HMSIW) techniques in antenna designs allows for low-profile cavity-backed structure using low-cost standard printed circuit board process. They used two single fed low-profile cavity-backed antennas and an antenna array for circular polarization to achieve their results. Griffiths both proposed a low cost printed dipole antenna as a perfect feed for prime focus reflectors. The dipoles were arranged such that their arms were oppositely placed in a dielectric substrate which is fed by a microstrip line. After this, they realized an impedance bandwidth of 16.5% with 2.5 dielectric constant substrate and an overall dimension of 60 x 60 x1.58 mm^3 at 3GHz. The bandwidth of any antenna refers to the angle between half power point(3dB) and the maximum power point in the radiation lope. He used a 7x7 rectangular ring unit metal surface and a single-feed, circular polarized rectangular slotted patch antenna to enhance bandwidth. They realized after simulation that while using the metal surface that the bandwidth of the circular polarized antenna increased seven times that of a normal antenna.

The intensity or power of transmitted signal from a transmitting station received by an antenna at a different location is referred to as the electric field strength. Electric field strength are measured in dB millivolt per metre (dBmV/m) or dB microvolt per metre (dBuV/m). In 1998, Werner and Emders researched on an alternative means of calibration of electric field sensor which will enable a smooth computation of coupling errors which was not dealt with by previous methods of calibration like the use of closed transverse electromagnetic (TEM) wave. The new method involves the superposition of radiated and guided wave, and this presented an easy assessment of the coupling factor, a key index for computation of electric field strength, calibrations of sensors and antennas. Ajayi (2005) used ground conductivity to predict the field strength for medium frequency transmitter in Ondo state, Nigeria. He measured ground conductivity using electrical resistivity method that is Wenner arrangement of electrodes and obtained the average ground conductivity for different soil types he used. The values were 3.02 ± 0.29mS/m. He then used these values with other propagation models to establish suitable propagation curves for that radio station, thus predicting the field strength at different locations all over the geographical coverage of the transmitter.

Pathloss and models:

The intensity of radio wave leaving a transmitting station is found to differ in value at some locations away from the transmitter. This means that not all the intensity or signal strength that is transmitted by a station is being received at measured distances from the transmitter. Some percentages are lost in the propagation path. This drop in signal power as the radio wave propagates through space is known as path loss. A lot of factors are responsible for this phenomenon such as poor terrain and environment like the rural, sub-urban or urban areas, presence of hills, mountains, foliage etc and transmitter-antenna distance. Other factors include the height and location of antennas, diffractions and absorption of the electromagnetic waves. Path loss models on the other hand are experimented mathematical expressions used when illustrating radio wave propagation as a function of frequency, distance and some conditions. There are different models in existence for different conditions of the atmosphere, terrain, paths, obstructions, etc. The models for outdoor attenuations include:

(i) Weissberger's modified exponential model. It is a radio wave propagation model for predicting path loss by foliage. It has a frequency range of 230MHz to 95GHz with foliage depth of 400m. It is a reviewed ITU (International Telecommunication Union) model for Exponential Decay (MED) created in 1982, [8].

Weissberger's model is formally expressed as :

$$L = \begin{cases} 1.33 f^{0.284} d^{0.586}, & \text{if } 14 < d \leq 400 \\ 0.45 f^{0.284} d, & \text{if } 0 < d \leq 14 \end{cases} \qquad (31)$$

Where L = the loss due to foliage in decibel (dB); F = the transmission frequency gigahertz (GHz); d = the depth of foliage along the path in meters

(ii) Early ITU model. It is also a radio propagation model for predicting loss due to foliage and was adopted in late 1986 (M. Gudmunson, (1991). It has no specified frequency range and no foliage depth and it is expressed as: $L = 0.2 f^{0.3} d^{0.6}$ (32)

where f and d are defined as above; and L = path loss in dB, F = transmission frequency in megahertz (MHz), d = depth of the foliage

(iii) Egli Model: This is a model sourced from UHF and VHF television transmissions data in several large cities and suitable for cellular communication on irregular terrain. It predicts the path loss for outdoor line-of-sight transmissions and expressed as follows (Egli, 1957):

$$P_{R50} = 0.668 G_R \, G_m \left[\frac{h_B h_m}{d^2}\right]^2 \left[\frac{40}{f}\right]^2 P_T \qquad (33)$$

where P_{R50} = 50^{th} percentile receive power (W); P_T = Transmit Power (W); G_B = 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) .

(iv) ITU terrain model: This provides a method to predict the medium path loss for a telecommunication link and its prediction is based on the height of the path blockage [9].It is applicable on any terrain and expressed as follows:

$A = 10 - 20C_{N(37)}$; $C_N = h/Fi$; $h = h_L - h_o$; $F_1 = 17.3\sqrt{\frac{d_1 d_2}{fd}}$ (34)

A = Additional loss (in excess of free – space loss) due to diffraction (dB); C_N = Normalized terrain clearance; h = The height difference (negative in the case that the LOS path in completely obscured) (m); h_L = Height of the line-of-sight link (m); h_o = Height of the obstruction (m); F_1 = Radius of the First Fresnel zone (m); d_1 = Distance of obstruction from one terminal (m); d_2= Distance of obstruction from the other terminal (m); f = Frequency of transmission (GHz); d = Distance from transmitter to receiver (km).

(v) Young Model: It is an appropriate model for predicting path loss in cellular communications in large cities with tall structures. It has a frequency range of 150 MHz to 3700MHz and it is expressed as presented in Equation 35 (Seybold, 2005):

$$L = G_B \, G_m \left(\frac{h_B \, h_m}{d^2}\right)^2 \beta \qquad (35)$$

L = path loss in (dB); G_B = gain of base transmitter (dB); G_m = gain of mobile transmitter (dB; h_B = height of base station antenna (m); h_m = height of mobile station antenna (m); d = line distance (Km); β = clutter factor.

(vi) Okumura model: This is used mostly in the cities where there are many urban structures, but not many tall blocking structures. It has a frequency range of 150-1920MHz, a base station antenna height between 30m and 1000m and link distance between 1Km and 100km (Seybold, 2005).

It is expressed as presented in Equation 36:

$$L = L_{FSL} + A_{mu} - H_{MG} - H_{BG} - \sum k \ \text{correection} \qquad (36)$$

Where L = The medium path loss (dB); L_{FSL} = The free space loss (dB); A_{mu} = Medium Attenuation (dB); H_{GM} = Mobile station antenna height gain factor. H_{BG} = Base station antenna height gain factor; $K_{correction}$ = Correction factor gain (such as type of environment, water, surfaces, isolated obstacle etc.

(vii) Hata model for Urban areas: It is also referred as Okumura-Hata model and widely used radio frequency propagation model for predicting the behaviour of cellular transmissions in built up areas. It has a frequency range of 150-1500MHz with mobile antenna height of 1-10m, base station antenna height 30-200m and link distance 1-10km. *It incorporates both suburban and open areas [10]*.It is formulated as presented in Equation 37:

$$Lu = 69.55 + 26.16 \log_{10} f - 1.82 \log_{10}$$

$h_B – C_h + [44.9 - 6.55 \log_{10} h_B] \log_{10} d$ (37)

for small or medium sized city

$$C_H = 0.8 + (1.1 \log_{10} f – 0.7) h_m – 1.56 \log_{10} f \quad (38)$$

and large cities

$$C_H = \begin{cases} 8.29 [\log_{10} (1.54 h_m)]^2 - 1.1, & \text{if } 150 \le f \le 200 \\ 3.2 [\log_{10} (11.75 h_m)]^2 - 4.97, & \text{if } 200 < f \le 1500 \end{cases} \quad (39)$$

L_u = Path loss in urban areas (dB); h_B = Height of base station antenna (m);

h_m = Height of mobile station antenna (m); f = Frequency of transmission (MHz); C_H = Antenna height correction factor; d = Distance between the base and mobile stations (Km).

(viii) Hata model for open areas is presented in Equation 40 [11]:

$$L_o = L_u - 4.78 (\log_{10} f)^2 + 18.53 \log_{10} f - 40.94 \quad (40)$$

Where L_o = Path loss in open area (dB); L_u = Path loss in urban areas for small sized city (dB); f = Frequency of transmission (MHz).

(ix) COST231 Extension to Hata Model: A model that is widely used for predicting path loss in mobile wireless system is the COST-231 Hata model (ogbulezie,2013). The COST-231 Hata model is designed to be used in the frequency band from 500 MHz to 2000 MHz. It also contains corrections for urban, suburban and rural (flat) environments. Although its frequency range is outside that of the measurements, its simplicity and the availability of correction factors has seen it widely used for path loss prediction at this frequency band (Mardeni & Kwan,2010). The basic equation for path loss in dB is :

$$L = 46.3 + 33.9 \log f - 13.82 \log h_B - a(h_R) + [44.9 - 6.55 \log h_B] log d + c$$

(41)

For suburban or rural environments:

$$(h_R) = (1.1 \log f - 0.7)\, h_R - (1.56 \log f - 0.8) \quad (42)$$

$$c = \begin{cases} 0dB, \ formediumcitiesandsuburbanareas \\ 3dB, \ formetropolitanareas \end{cases}$$

Where, L = Median path loss. Unit: decibel (dB); f = Frequency of Transmission. Unit: megahertz (MHz); h_B = Base station antenna effective height. Unit: meter (m).

d = Link distance. Unit: Kilometer (km); h_R = Mobile station antenna effective height. Unit: meter (m); $a(h_R)$ = Mobile station antenna height correction factor as described in the Hata model for urban areas.

Nadir et al (2009) presents an investigation on the characteristics of radio propagation, by measurement, at the small town of rural area in Purwokerto Central Java Indonesia. Their results were used to evaluate the accuracy of Okumura Hata and Lee prediction models and to determine the necessary adjustments to these models in order to improve their accuracies. He radiated a 20dBm signal at 1467MHz by an omni directional antenna with 5.2dB gain. His propagation measurements showed that the received signal strength decreases with distance at the rate of 2.34dB, while its mean values fall between 10 and 15dB below free space prediction with standard deviation of 6.5dB. Comparing these propagation measurements with Okumura- Hata and Lee prediction models for open area classifications, they discovered that they were in agreement for area coverage of 3 to 10Km. Also, Okumura-Hata and Lee models gave less path loss prediction for smaller coverage area but propose higher values for larger distances.

Similarly, in Ondo State, the relationship between the line of sight and signal strength of an Ultra High Frequency (UHF) television signals was investigated. The Propagation curves for the signal along different routes were plotted and regression analysis was used to determine the exponential models which can be used to calculate signal strength for a given line of sight at the designated routes in the state (Okey and Raji, 2014)

According to Faruk,et al. (2009), Path loss exponent is one of the important parameters in all distance path loss models (log-normal); once it is known for an environment, coverage planning and propagation analysis could be done easily. In their work, log-normal propagation path loss model was used to characterize the path loss parameters in the VHF and UHF frequencies for Ilorin City of Kwara State, Nigeria. Results indicated that the path loss exponent varies from 1.4 to 4.94 with an average value of 2.80. The work further investigated the behaviour of the TV signals in the same environment in terms of standard deviation and building penetration loss. It is concluded that the standard deviation for Ilorin city is 7.35 dB, the average penetration loss is 11.49 dB and the path loss intercept at 1 km at 203.25 MHz and 583.25 MHz is 107.56 dB.

A research in South-Eastern Nigeria by Nwalozie et al (2014), showed that Hata and other empirical models didn't predict the path loss. Instead using the log-normal, the outdoor path loss model for Aba urban was obtained as

$$Lp\,(d) = 75 + 31 \log (D) \quad (43)$$

where D is the ratio of the test distance (d_i) to the reference distance (d_0)

And 75dB is the path loss at the reference distance using the free-space model.

GSM signals operating on the frequencies of 900 MHz and 1800 MHz, which are the two frequencies used by mobile operators in Nigeria, were investigated in Enugu and Portharcourt. The mean square errors (μ_e) ranged from 0.8 dB to 5.04 dB for Okumura Hata at 900 MHz. For COST 231 Hata lied between $1 \leq \mu \leq 15$ dB which is universally accepted .(Ogbulezie et al, 2013)

Measurement results of signal strength in UHF band obtained in Idanre Town of Ondo State Nigeria are presented and compared with the results predicted by using the propagation models. A modified COST231-Hata radiowave propagation model was developed and implemented with Matlab GUI (Graphical User Interface) for simulation. The model developed has 93.8% accuracy (Oluwole et al, 2013)

Obstacle effect on radio waves propagation

The free space earlier mention for wave propagation does not really exist, though it serves as a guide for simple computation of signal strength and path loss. Ideally there are obstacles in signal path which greatly influence the predictability of signal strength along any route. These obstacle include buildings, vegetations (foliage) hills,

The density of foliage and the heights of trees that are not uniformly distributed in a forested environment cause variation in the signal reception at different points. The research carried out in Ondo state on the effect of hills on UHF signal propagation showed a marked difference when measurements were taken at two different environments, one with without hills and the other with hills. The field strength decreases rapidly in region with hills (Oluwole et al, 2013).

Also, a study by Ajewole et al, 2014, on the effects of rain on the coverage areas of Ondo State Radio/television Corporation (OSRC) UHF Television signals transmitted on Channel 23(487.25MHz) and Channel 25(503.25MHz) in Ondo State revealed that the early part of the dry season recorded the highest signal strength of 75.0% coverage followed by the onset of raining season at a value of 72.5%. The peak of the raining season recorded the lowest electric field signal strength and coverage of 67.45%.

Furthermore, to understand the degree of interaction, signal strength measurements of the 93.1MHz frequency modulated Radio located at Federal University of Technology, Akure, Nigeria. The long rice irregular terrain model was used and the losses along the paths were determined. This was compared with the path loss predicted by the irregular terrain model and this was highly correlated. The result offered useful data for developing the contour map of the propagation loss which was developed for the station. It was concluded that with the irregular terrain model predictions can be used for accurate spectrum management in Nigeria (Oyetunyi,2013).

III. Materials And Methods

Study Area

This research was carried out in Akwa Ibom State, Nigeria. **Akwa Ibom** is a state in Nigeria. It is located in the coastal southern part of the country, lying between latitudes 4°32′N and 5°33′N, and longitudes 7°25′E and 8°25′E. The state is located in the South-South geopolitical zone, and is bordered on the east by Cross River State, on the west by Rivers State and Abia State, and on the south by the Atlantic Ocean and the southernmost tip of Cross River State. **Akwa Ibom's** 6,900 sq Km land area is located between Cross River, Abia, and Rivers on the sandy coastal plain of the Gulf of Guinea. It is bordered on the south by the Atlantic Ocean which stretches from Ikot Abasi to Oron. A sprawling volume of water seemingly kissing the skyline from flank to flank.

Eastern Obolo is located in the Niger Delta fringe between Imo and Qua Iboe Rivers estuaries and lies between latitudes 4° 28` and 4° 53` and longitudes 7° 50` and 7° 55` East. It is bounded in the North by Mkpat Enin Local Government Area, North East by Onna,West by Ikot Abasi, South East by Ibeno Local Government Area and in the South by the Atlantic Ocean. **Ikot Abasi**, also called Opobo, formerly Egwanga, port town, **Akwa Ibom state**, southern Nigeria. The town lies near the mouth of the Imo (Opobo) River. Situated at a break in the mangrove swamps and rain forest of the eastern Niger River delta, it served in the 19th century as a collecting point for slaves. It is located in the south west corner of Akwa Ibom State, Nigeria. It is bounded by Oruk Anam Local Government Area in the north, Mkpat Enin and Eastern Obolo Local Government Areas in the east and the Atlantic Ocean in the south. The Imo River forms the natural boundary in the west separating it from Rivers State.

The study areas have a tropical-humid weather with wet and dry season. It also has an average temperature ranging between 15^0C – 30^0C; with an annual rainfall between 1300 – 3000mm. Million hectares of land in Eastern Obolo and Ikot Abasi are vast mangrove and swamp forest. The distinct environmental characteristics between these two residential locations made it a challenging location to propagate electromagnetic waves; and therefore recipe for this study.

Digital cable Television Analyzer (CATV)

It is radio frequency analyzer, with 24 channels spectrum, ranging between 46-870MHz (model: RO.VE.R.-'DLM3-T'). It has a video display screen and corresponding output sound to capture signals from terrestrial radio stations and television stations. CATV measures signal of both radio and TV in dB, dBμV and dBmV. The equipment works perfectly with 12V supply, either from an external battery, or from other available grid supply; and it's capable of powering the pre-amplifier of an antenna system for maximum reception. Figure 1 shows the field strength meter in its operational form displaying a monitored TV channel.

Fig. 1: Field strength meter(CATV)

Receiving antenna

An outside television antenna of dimension 59(L) x 8.5(W) x 11(H) cm on a pole of about 7m, was used to receive the signal at different locations across the state. Its frequency range spans from 40-860MHz, from channel 1 to channel 69. The antenna has both VHF and UHF gain of 20 $\pm$ 3dB, with an impedance of 75Ω and a noise coefficient less than 3dB. The operational power of this antenna is 3W with an output level of 145dB.

Global positioning system

GPS 72H from Garmin was used to measure the distance from the transmitting antennas to different measuring locations in the state as well as their elevations above sea level.

Measurement procedure

Measurements were carried out in Eastern Obolo and Ikot Abasi Local Government Areas in the state along accessible route . Field or signal strength at various locations were examined both at the UHF and VHF bands, with special attention given to some reliefs along the measuring route. At each location, the signal strength of various stations alongside the elevation above sea level were measured. Measurements of the signal strength were measured first at premises of the stations; also referred to as the near field signal, before subsequent measurements at other locations.

IV. Results

Eastern Obolo Local Government Area.

Figure 2, is the plot of signal strength levels from Channel 45 against distance , Figure 3 is plot of signal strength from Channel 12 against distance, Figure 4 is plot of path loss in Channel 12 against distance, Figure 5 is plot of calculated path loss and other models in channel 45 against distance all in Eastern Obolo Local Government Area.

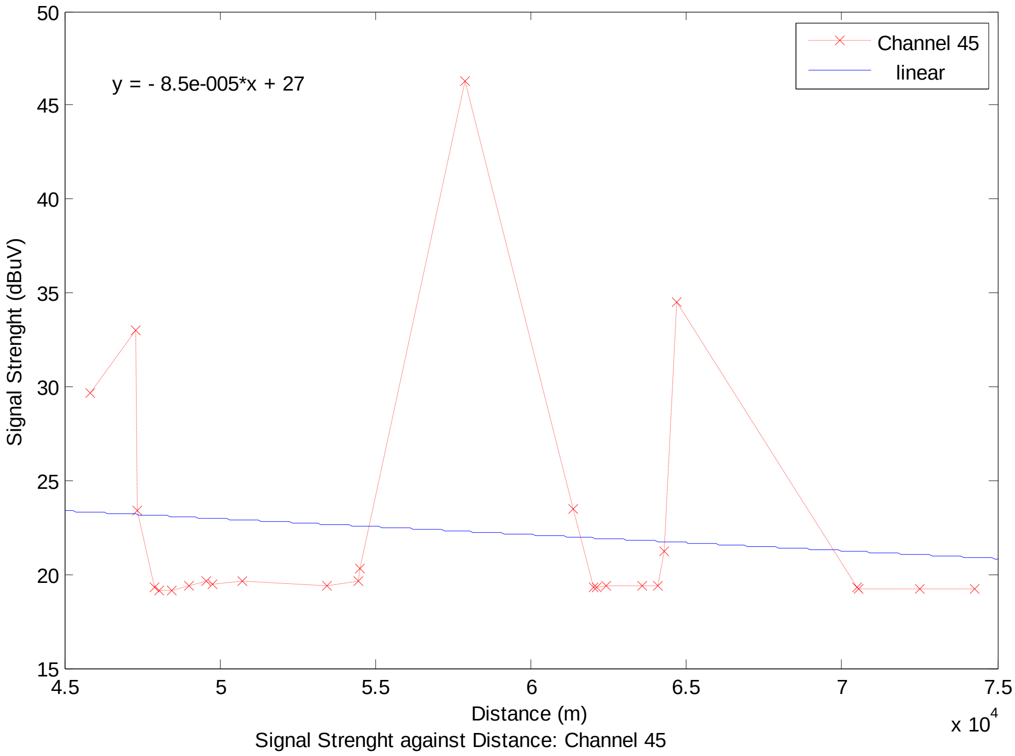

Fig. 2: Plot of signal strength from channel 45 against distance at Eastern Obolo

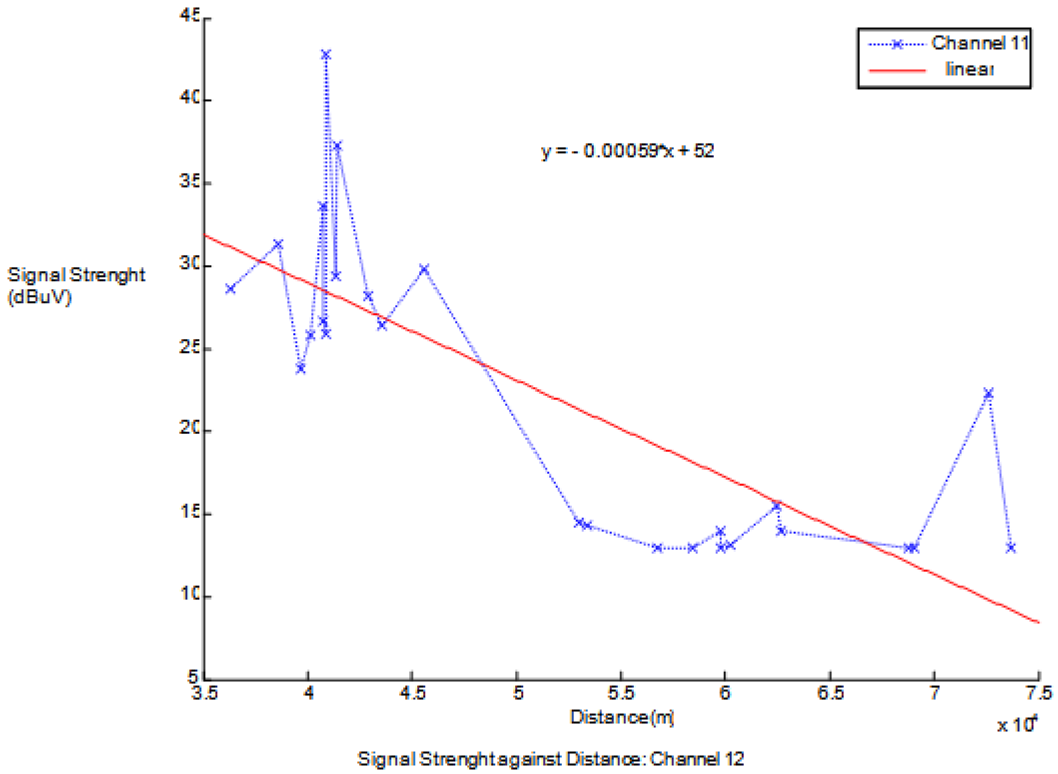

Fig. 3: Plot of signal strength from channel 12 against distance at Eastern Obolo

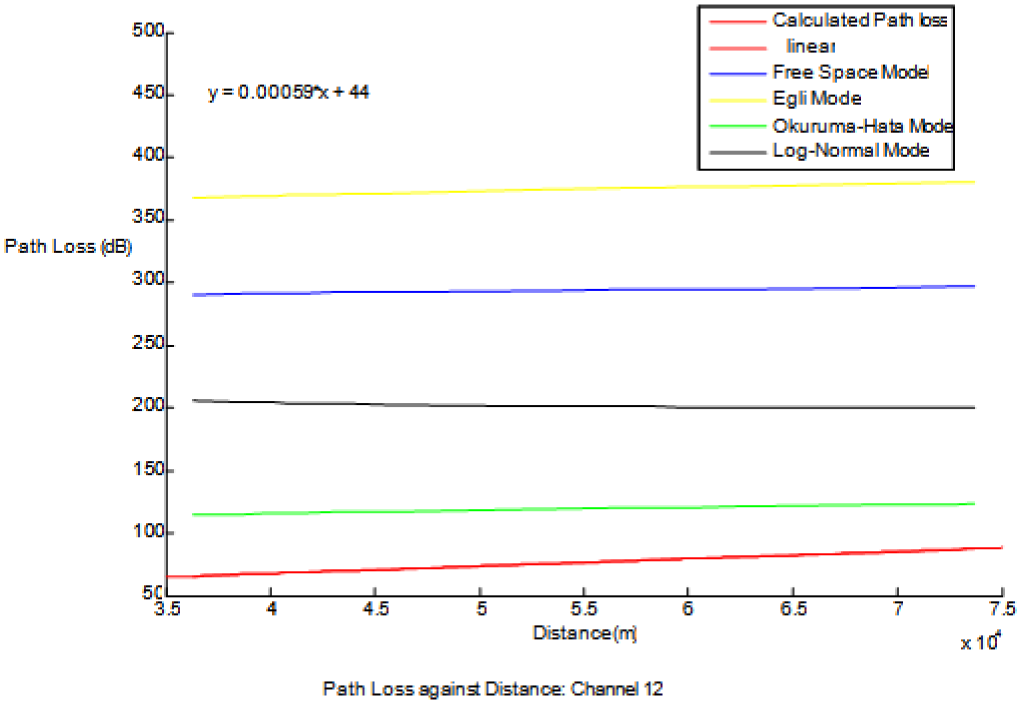

Fig. 4: Plot of calculated path loss and other models in channel 12 against distance at Eastern Obolo

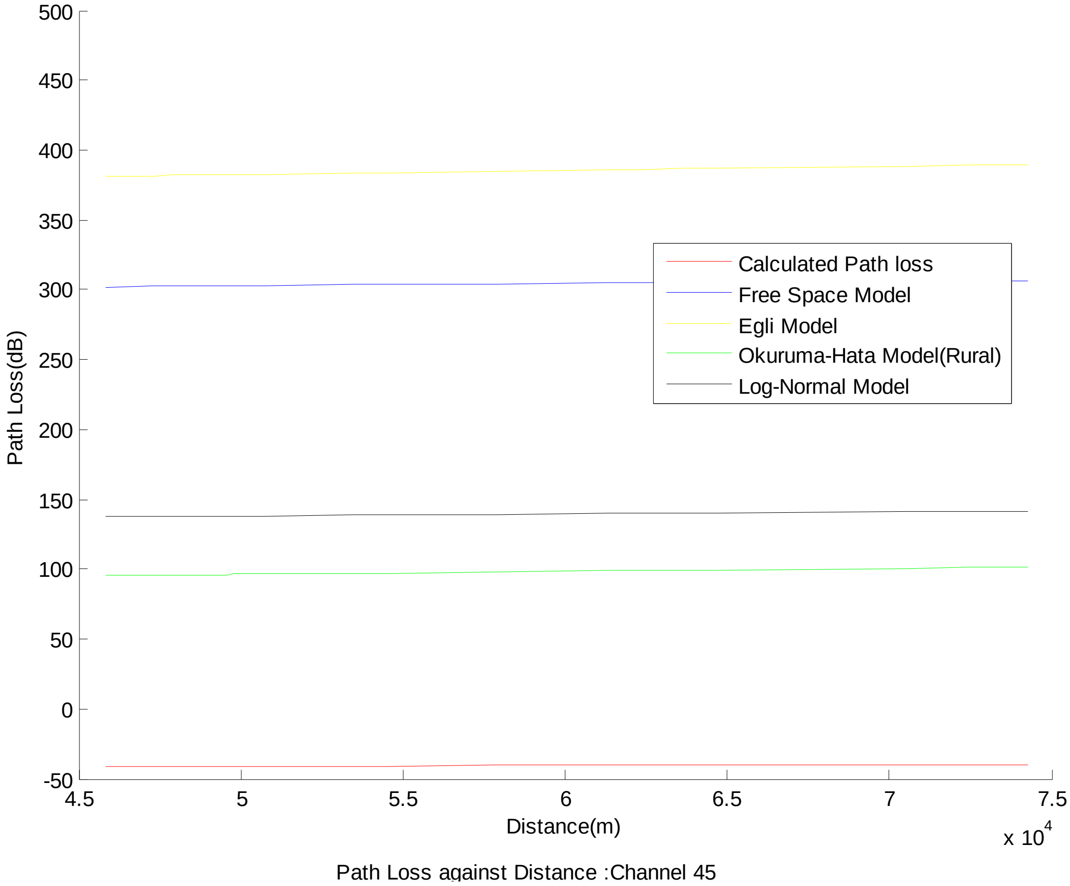

Fig. 5: Plot of calculated path loss and other models in channel 45 againstdistance at Eastern Obolo

Ikot Abasi Local Government Area

Fig. 6 is Plot of signal strength from channel 12 against distance , Fig. 7 is Plot of calculated path loss in channel 12 against distance , Fig. 8 is Plot of calculated path loss and other models in channel 12 against distance , Fig. 9 is Plot of signal strength from channel 45 against distance , Fig. 10 is Plot of calculated path loss in channel 45 against distance , Fig. 11 is Plot of calculated path loss and other models in channel 45 against distance, all in Uta-Ewa in Ikot Abasi Local Government Area

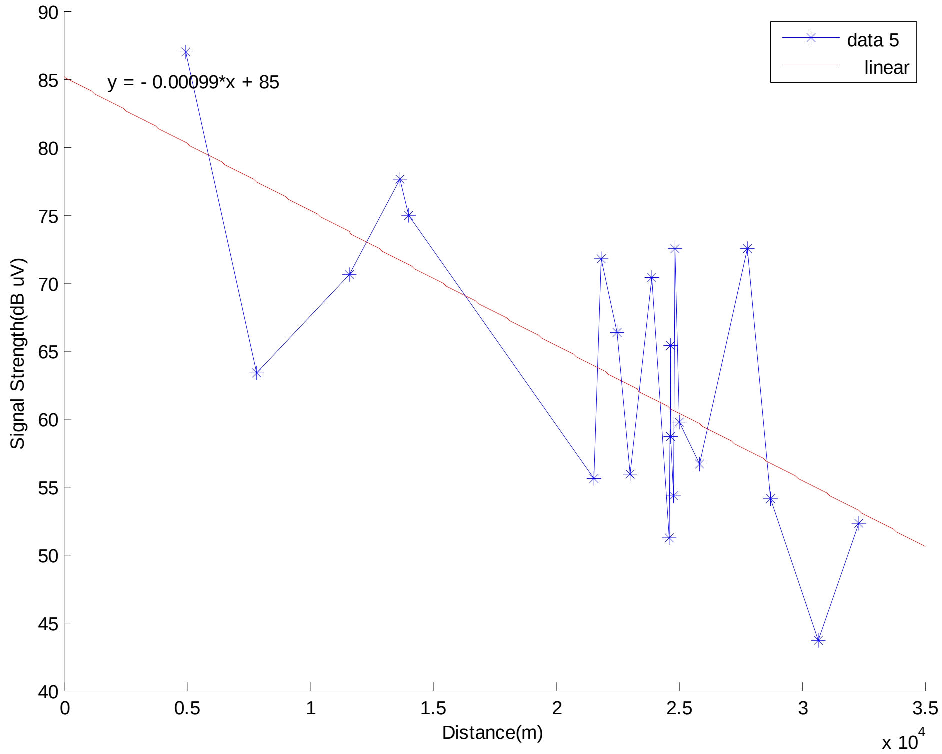

Fig. 6: Plot of signal strength from channel 12 against distance at Uta Ewa

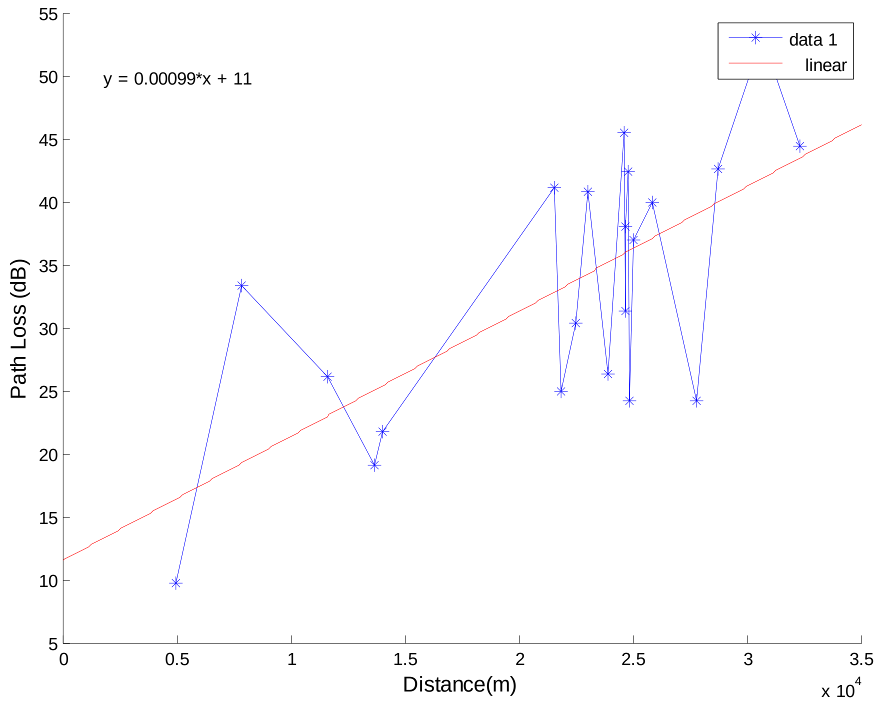

Fig. 7: Plot of calculated path loss in channel 12 against distance at Uta Ewa

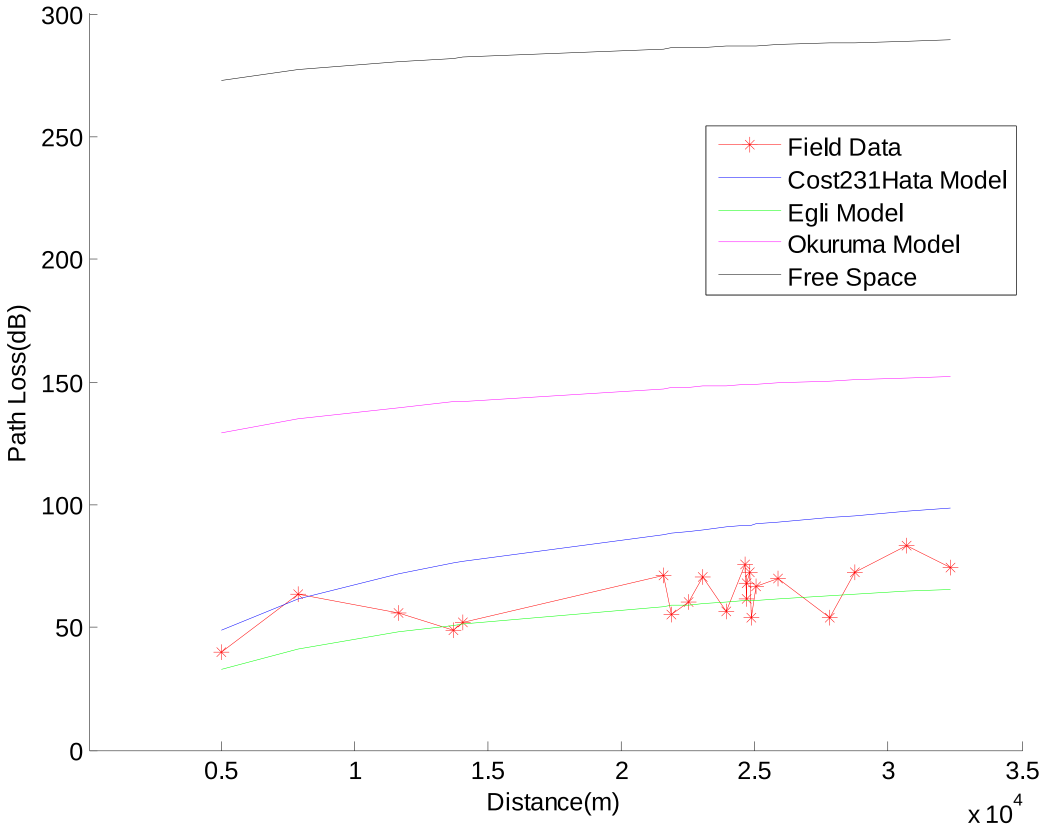

Fig. 8: Plot of calculated path loss and other models in channel 12 againstdistance at Uta Ewa

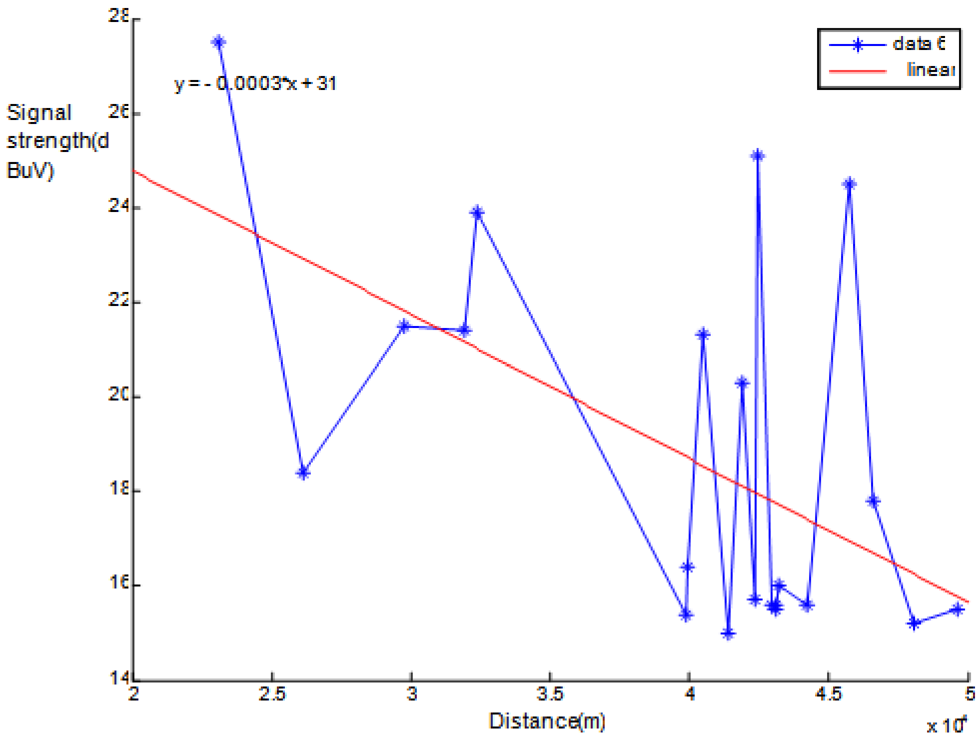

Fig. 9: Plot of signal strength from channel 45 against distance at Uta Ewa

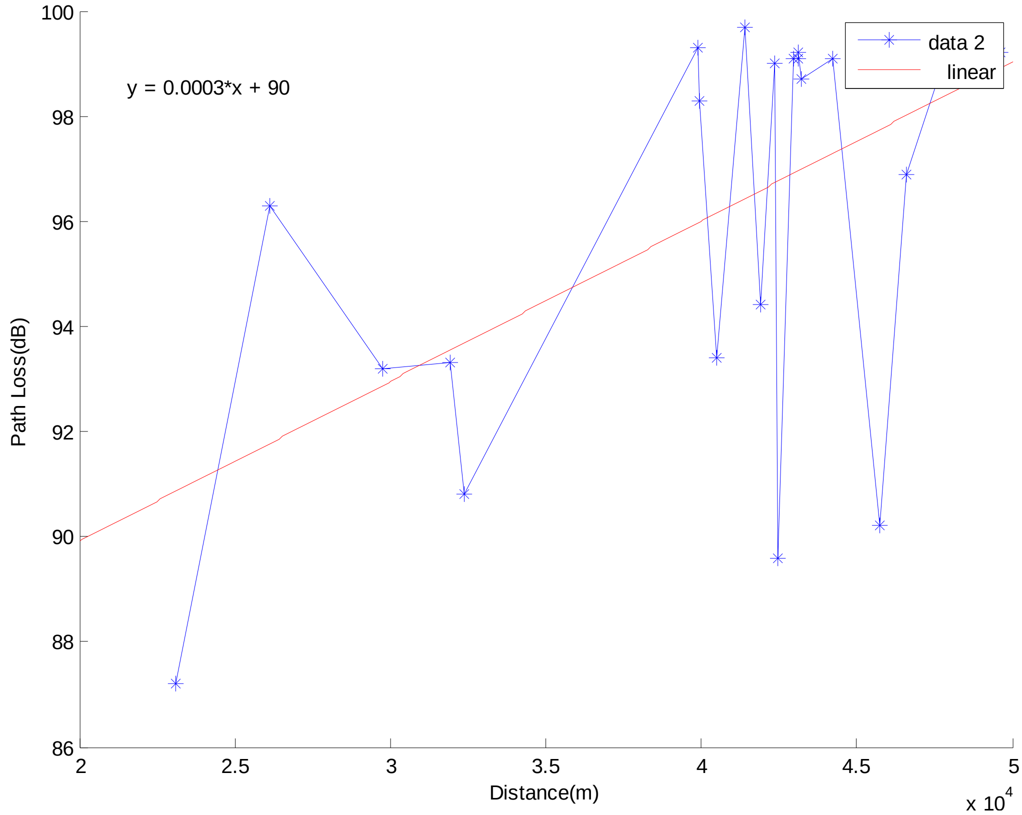

Fig. 10: Plot of calculated path loss in channel 45 against distance at Uta Ewa

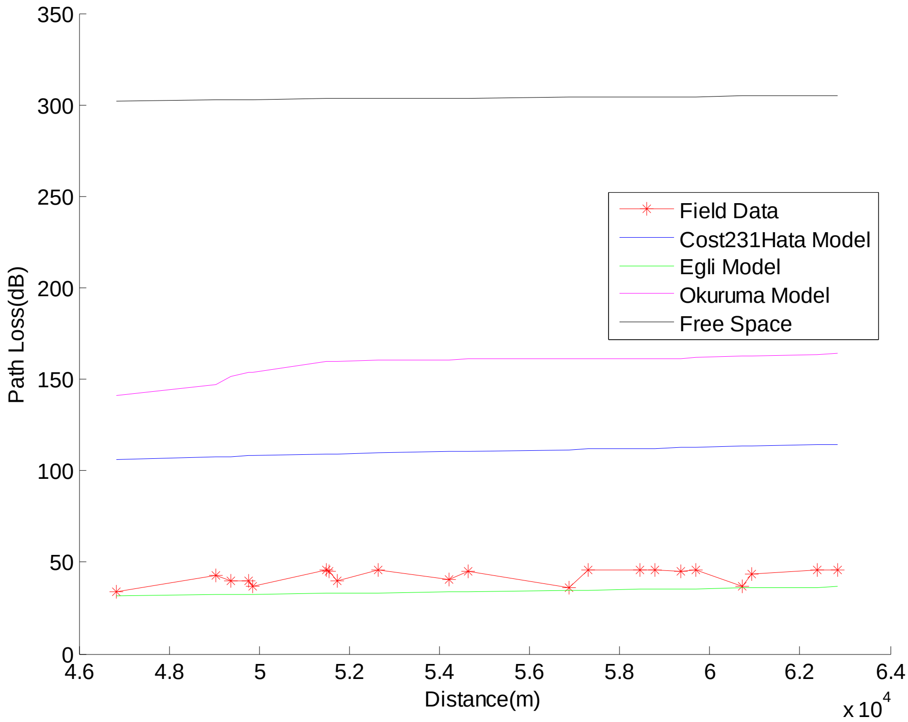

Fig. 11: Plot of calculated path loss and other models in channel 45 against distance at Uta Ewa

V. Conclusion

The thick vegetation in Eastern Obolo and Ikot Abasi, made some of the areas become skip zones for signals. Channel 12 signal, that was previously received up to 75dBμV in neibouring Mkpat Enin local council, drastically dropped to a range of 35-22dBμV in Eastern Obolo locations. None of the standard path loss models agreed with calculated path loss in Eastern Obolo. Besides, empirical records showed that Channel 12 signals completely faded out in this area.

Signals from Channels 12 was completely lost in this area; though the field strength meter recorded up to 13dBμV and 22dBμV for channel 12 and 45 respectively. These signal strength was not high enough to deliver signal to any TV-set in these locations.

These broadcasting stations, especially channel 12 both at UHF and VHF channels need to do more to cover up to at least 95% of the state catchment area. Remedial measures such as installing Repeater stations at different locations as signal booster is strongly recommended.

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