IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 11, Issue 6, Ver. III (Nov.-Dec .2016), PP 23-29
www.iosrjournals.org

Evaluation and Analysis of Electromagnetic Field Strength in Port-Harcourt and Its Environs Due To Radio Rivers Transmitter

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Abstract: *This paper presents the measurement of Electromagnetic Field Strength of Radio Rivers, which operate at a frequency of 99.1 MHz, in Port Harcourt and its environs with the aid of an automated Band scanner GPS system. The measurements were carried out by taking the Radio station's transmitter as a reference point at the center and selecting 24 measuring point around the transmitter. These points were selected with 1Km spacing taken as the interval between two measuring points, summing up to a total distance of 6Km due EAST, NORTH, WEST and SOUTH of the Radio transmitter respectively. The Received Signal Strength (RSSS) due to the Radio Transmitter were measured at the selected measuring points and the Result obtained was critically analyzed and interpreted with the aid of an attenuation decay curve.Radio Rivers fm Signal was able to travel the distance stated in this paper because of the ground constant of the terrain, reflection of signal from the earth surface, Diffraction by Obstacles and the transmitter parameters (transmitter power, Antenna height and antenna Gain).The signal strength diminishes fairly with distance from the source of electromagnetic waves*

Keywords: *Antenna, Band scanner, Field Strength, Signal, Transmitter.*

I. Introduction

The quantitative measure of the strength of an electric field is known as the electric field strength (intensity) measurement. From electrostatics studies, we can loosely define electric field strength at a point as the force on a unit positive charge at that point and is measured in Newtons per coulomb or volt per meter (Vm^{-1}).A radio wave is an electromagnetic wave which emanates from a radiating source, the radio wave assumes all the properties of a plane wave. The wave-front is the plane which contain the electric (E) and magnetic (H) vectors and is at right angles to the direction of propagation and power flow. Usually, it is convenient to carry out studies in terms of the electric component, E of the wave which is known as the electric field strength of the wave. [1]

This paper present the evaluation and analysis of the measured and calculated Electromagnetic field strength of Radio Rivers FM station at 24 different locations, That is, six locations due EAST, NORTH, WEST and SOUTH of the Radio Transmitter respectively with 1Km interval as shown in figure 1 below using an automated mobile Band Scanner GPS system

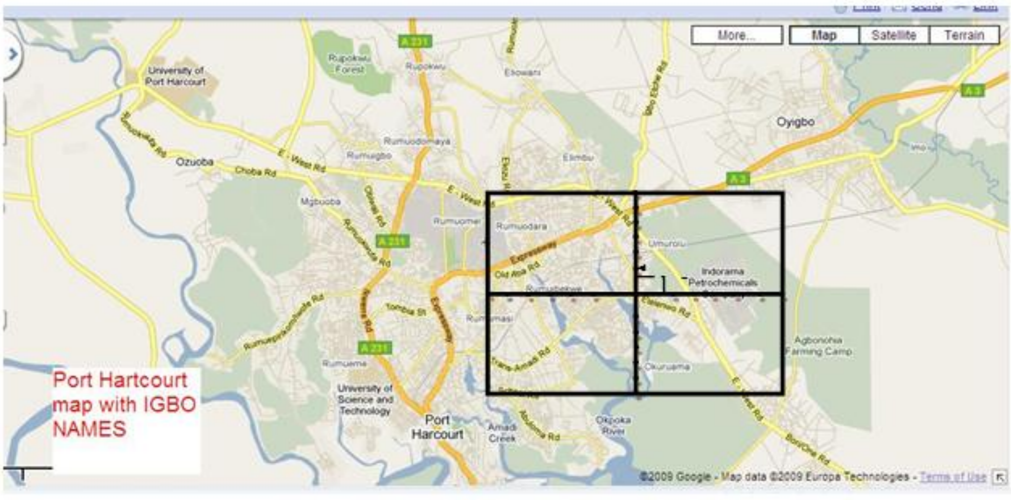

Figure 1: Map of Port-Harcourt showing the location of Radio Rivers Main transmitter

Band Scanner GPS is a tool used to evaluate FM broadcast band and to log station identification parameters such as electromagnetic field strength, bandwidth, received power at a distance and radio data system strength. "Band Scanner GPS" is a Google Earth compatible tool for visualization of selected FM Radio measurements. When running any campaign with the "Band Scanner GPS", results will be saved in a Log file. "Band Scanner GPS" can then convert this file into KMZ format and view the results in Google Earth. The Log file can be exported also as transitional format for future analysis or to keep it in record. The "Band Scanner GPS" can measure RF level, MPX deviation, Left &Right Audio levels, Pilot injection levels and RDS. The system is powered by the USB port of any Windows PC. [2]The result of the measurement is used to plot the attenuation decay graph of the station's transmitting antenna.

Radio Rivers (also known as Radio Rivers 2) is the first state-owned FM radio station in Rivers State, and the second FM radio station to be launched in Nigeria. It is run by Rivers State Broadcasting Corporation (RSBC) and its operates on a frequency of 99.1 MHz. from his main transmitter (HT10 FM) located at Elelenwon in Port Harcourt, Nigeria .The studiois located at Degema Street in Port Harcourt from where it transmit RF signal via a 10 watt Studio – Transmitter - Link (STL) using Line of Sight propagation to the main transmitter at Elelenwon.. The STL uses a Yagi-Uda antenna mounted on a mask that is 67feet (20.4 meter) high. The Output of the STL receiver is connected to the station's main transmitter (HT10FM) and the received signal is then re-transmitted with aid of a circularly Polarized antenna to the end user of the signal (Radio Listeners) as shown in Figure 2 below. The Main transmitting antenna has the following characteristics; Operating frequency: 99.10 MHz, Power Output: 10kwatts, Modulation standard: Frequency Modulation, Antenna load impedance: 50 ohms, Polarization of the antenna: circularly Polarized, Antenna location: Elelenwon, Port-Harcourt, Feeder line size: 3.125 Inches, Mast height: 720ft, Transmitter Coordinates:4°49′46″N 7°4′31″E as shown in figure 1 below, Type of cooling of the transmitter: Air cooled (Air conditioning), Power supply of the transmitter: P.H.C.N and Generator as backup.

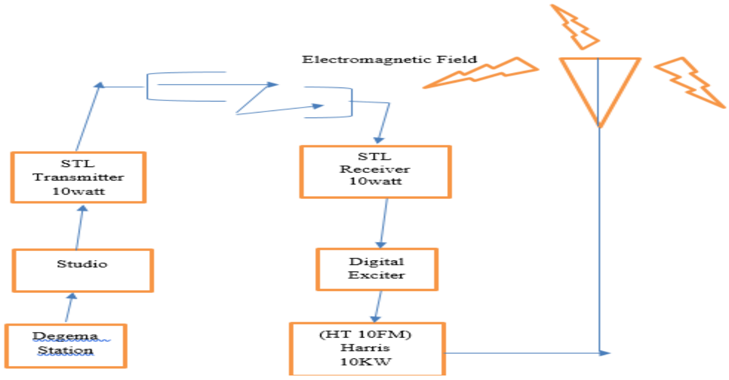

Figure 2: Propagation of Radio Rivers Electromagnetic Waves

Figure 3: Radio Rivers Studio – Transmitter – link (STL) Equipment

II. Electromagnetic Wave Propagation

The magnetic field and electric field oscillations perpendicular to each other or in the direction same as that of the wave propagation is basically known as Electromagnetic waves. The nature of electromagnetic waves is traverse. The speed of propagation of the electromagnetic waves is same as that of velocity of light and is a function of the its frequency and its wavelength as shown in figure 4 below. The scattering of the electromagnetic waves in space is uniform throughout. The propagation of the electromagnetic waves depends upon their properties.[3]

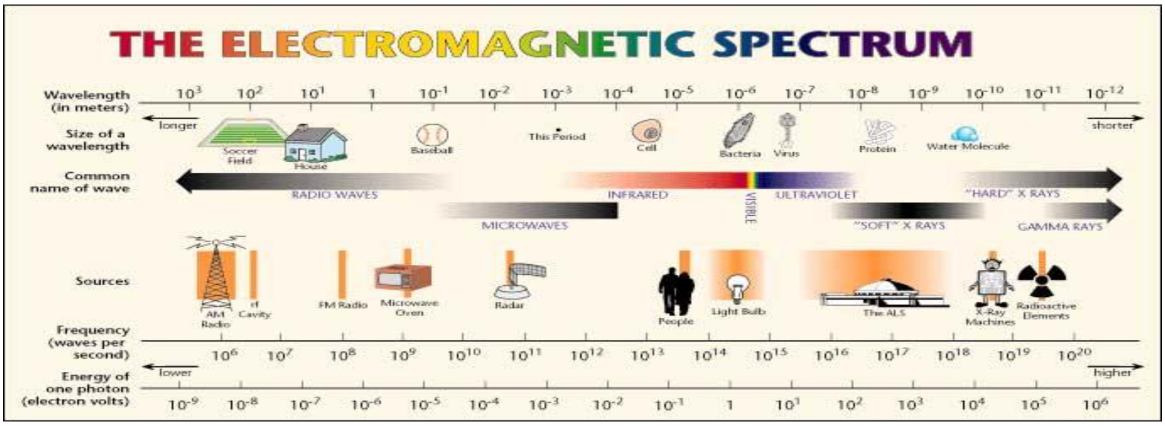

Figure 4: Electromagnetic frequency spectrum

2.1 Ground wave Propagation The propagation of the waves along the surface of the earth is called ground wave propagation. It is also known as surface wave propagation. These waves have the ability to propagate along the surface of earth. These waves bend around the obstacles which come in the path of these waves. Due to this rounding through the obstacles, the intensity of the electromagnetic waves will decrease rapidly. [3]

2.2 Sky wave Propagation The sky waves have frequency range between 2MHz to 30MHz. These radio waves have the ability to pass through earth's atmosphere. The ionosphere of our earth reflects these rays very efficiently. When these rays move along the atmosphere then their movement is from transmitter towards the receiver antenna. This is called as sky wave propagation of the waves. [3]

2.3Wave Propagation in a lossless medium The propagation of waves in a lossless medium explains that, in a lossless medium, certain constants are equal to zero, these constants include; j=current density, σ = conductivity and ρ = chargedensity**.** [4]Thus, $j = \rho = \sigma = \alpha = 0$ (1)

And according to Maxwell's equation,

$$\nabla \times E = -\mu \frac{\partial H}{\partial t} \quad (2)$$

$$\nabla \times H = \varepsilon \frac{\partial E}{\partial t} \quad (3)$$

$$\varepsilon \nabla . E = 0 \quad (4)$$

$$\mu \nabla . H = 0 \quad (5)$$

Where,

$$\nabla = i\frac{\partial}{\partial x} + j\frac{\partial}{\partial y} + k\frac{\partial}{\partial z} \quad (6)$$

Take curl of equation (2) and (3) above;

$$\nabla^2 E = \mu \frac{\partial}{\partial t} \nabla \times H = \mu\varepsilon \frac{\partial^2}{\partial t^2} E \quad (7)$$

Where,

$$\nabla \times \nabla \times H = \nabla(\nabla . E) - \nabla^2$$

And so the wave equation becomes

$$\nabla^2 E - \mu\varepsilon \frac{\partial^2}{\partial t^2} E = 0 \quad (8)$$

Similarly; $\nabla^2 H - \mu\varepsilon \frac{\partial^2}{\partial t^2} H = 0$ (9)

Therefore, for electric field E becomes;

$$\nabla^2 E - \mu_\circ \varepsilon_\circ \frac{\partial^2}{\partial t^2} E = 0 \quad (10)$$

In phasor form;$\frac{\partial}{\partial t^2} = j\omega$

Therefore, equation (10) becomes

$$\nabla^2 E + \omega^2 \mu_\circ \varepsilon_\circ E \quad (11)$$

$$\nabla^2 E + \omega^2 \mu_\circ \varepsilon_\circ E = \nabla^2 E + K^2 E \quad (12)$$

Where,

$K = Propagation\ constant$,and in a lossless medium,

$$K = \omega\sqrt{\mu_\circ \varepsilon_\circ} \quad (13)$$

2.4 Wave in a Conducting Medium Considering a homogeneous lossy medium, [5]

$$j \neq \rho \neq \sigma \neq \alpha \neq 0 \quad (14)$$

The equation (13) becomes $K = \sqrt{\mu_\circ \mu_r \varepsilon_\circ \varepsilon_r}$ And now the propagation constant

$$\gamma = jk_c = \alpha + j\beta \quad (15)$$

2.5. Ground Constants

The relative permittivity and Conductivity Values for different type of ground is shown in figure 1 below [6]

Table 1: Ground Constants

S/No.	Type of Ground	Relative Permittivity	Conductivity $\frac{mho}{meter}$ (Ωm^{-1})
1.	Sea water	80	5
2.	Fresh water	80	0.005
3.	Moist soil	15-30	0.005-0.01
4.	Rocky ground	7	0.001
5.	Dry soil	4	0.001-0.01
6.	3 march	30	0.11
7.	Average soil	15	0.028
8.	Desert	3	0.011

III. Materials and Method

3.1 Measurement Procedure and Equipment: -

The utilized equipment for the electromagnetic field strength measurements include:

- The source antenna and transmitter at Radio Rivers 99.1MHz - This antenna will have a known pattern that can be used to illuminate the test antenna
- The receiver system (Band Scanner GPS) - to determine how much power is received by the test antenna
- A Personal Computer (PC) system - serves as the visual output of the Band Scanner GPS.
- A positioning system - This system is used to rotate the test antenna relative to the source antenna, to measure the distance moved away from the referenced transmitter as a function of angle.
- A module such as a USB cord - To power the receiver system and also serves as a medium or interface for the visual output.

3.2 Selection of Data Points On The Map Taking Radio Rivers' transmitter as the reference point, the electromagnetic field strength of the signal transmitted by it was measured, at 24 locations, and comparing the strength of the signals, at the different locations. The first four points of measurement was taken at a radius distance of 1Km away from the transmitter. Similarly, the second four points of measurement was taken at a radius distance of 1Km away from the first points of measurements i.e. 2Km radius distance away from the Station's transmitter, the third four points of measurements, was taken at a radius distance of 1Km away from the second points of measurements i.e. 3Km radius distance away from the station's transmitter, the fourth four points of measurements, was taken at a radius distance of 1Km away from the third points of measurements i.e. 4Km radius distance away from the station's transmitter, the fifth four points of measurements, was taken at a radius distance of 1Km away from the fourth points of measurements i.e. 5Km radius distance away from the station's transmitter and the last four points of measurements, was taken at a radius distance of 1Km away from the fifth points of measurements i.e. 6Km radius distance away from the station's transmitter. A diagrammatic description is shown in figure 3 below. A horizontal line was drawn passing through Radio Rivers 99.10MHz Elelenwon Station, which was assumed to be the center of the town. All other lines were drawn on the map using 90^o spacing thus, six measurement positions were 90^o to the vertical line due North, the next six measurement positions were 180^o to the horizontal line due East, the next six measurement positions were 270^o to the vertical line due south and the last six measurement positions was $360^o$to the horizontal line due west. The figure below shows the schematic diagram of the points of measurements.

The global positioning system antenna was connected to the receiver system, after which the receiver system was connected to the personal computer on which the Deva Broadcast Ltd Software was launched for the sake of viewing the output of various data such as, Distance, electromagnetic field strength, spectrum analysis and Radio Data System analysis. The source antenna was used to illuminate the antenna under test with a plane wave from 90^odirection due EAST, NORTH, WEST and SOUTH of Radio Rivers' transmitting antenna, since the polarization and antenna gain (for the fields radiated toward the test antenna) of the source antenna are known. The test antenna was rotated using the test antenna's global positioning system (Band Scanner). So that in this manner, the magnitude of the radiation pattern of the test antenna can be determined. The coordinate system of choice for the radiation pattern is spherical coordinates.

3.3Presentation of Data

Table 2, Table 3, Table 4 and Table 5 shows the Electric Field Strength measured in Port Harcourt at the location, Time and date Stated below.

Table 2: Measurements Carried Out Due East Of The Transmitter

S/N	Location	Distance From Transmitter (Meters)	Voltage (μV)	Time (PM)	Received Power (KW)	EMF Strength Measured (nV/m)	Date
1.	Elelenwon Bus stop	1010	52.1	2:25	10	0.5158	11-08-2016
2.	Rumuamadi Bus stop	2016	52.0	2:46	10	0.2579	11-08-2016
3.	St Mark's Church	3031	50.7	3:07	10	0.1673	11-08-2016
4.	Railway	4040	51.2	3:28	10	0.1267	11-08-2016
5.	Stark Petrol Station	5045	49.2	3:49	10	0.0975	11-08-2016
6.	Oil Mill Market	6053	49.8	4:00	10	0.0823	11-08-2016

Table 3 Measurements Carried Out Due North Of The Transmitter

S/N	Location	Distance From Transmitter (Meters)	Voltage (μV)	Time (PM)	Received Power (KW)	EMF Strength Measured (nV/m)	Date
1.	Eliminigwe Estate	1006	50.8	4:12	10	0.5049	11-08-2016
2.	Eliminigwe Bridge	2009	51.1	4:22	10	0.2544	11-08-2016
3.	Chealsea Petrolstation	3018	50.3	4:32	10	0.1667	11-08-2016
4.	YKC Petrol Station	4022	51.8	4:40	10	0.1288	11-08-2016
5.	Total Petrol Station	5029	52.0	4:49	10	0.1034	11-08-2016
6.	Transamadi Bus Stop	6032	51.2	5:02	10	0.0849	11-08-2016

Table 4: Measurements Carried Out Due West Of The Transmitter

S/N	Location	Distance From Transmitter (Meters)	Voltage (μV)	Time (PM)	Received Power (KW)	EMF Strength Measured (nV/m)	Date
1.	Sand Fill Junction	1009	42.3	5:12	10	0.4192	11-08-2016
2.	Old RefineryRoad	2032	41.4	5:24	10	0.2037	11-08-2016
3.	NNPC Estate	3040	48.3	5:30	10	0.1589	11-08-2016
4.	ECOBank	4046	45.4	5:36	10	0.1122	11-08-2016
5.	CIENT LTD	5048	53.6	5:40	10	0.1062	11-08-2016
6.	Refinery Junction	6063	52.8	5:46	10	0.0871	11-08-2016

Table 5: Measurements Carried Out Due South Of The Transmitter

S/N	Location	Distance From Transmitter (Meters)	Voltage (μV)	Time (PM)	Received Power (KW)	EMF Strength Measured (nV/m)	Date
1.	Ekwu Elijiji	1006	46.8	6:02	10	0.4652	11-08-2016
2.	NNPC Station	2015	48.5	6:10	10	0.2407	11-08-2016
3.	26,Odani Rd	3018	51.7	6:16	10	0.1713	11-08-2016
4.	Range 86 Odani Road	4020	52.4	6: 22	10	0.1303	11-08-2016
5.	Range 87 Odani Road	5021	48.4	6:28	10	0.0964	11-08-2016
6.	Range 88 Odani Road	6026	49.5	6:36	10	0.08214	11-08-2016

IV. Results and Discussion

The results obtained from the field strength values during each 1Km interval of measurement, at EAST, WEST, NORTH and SOUTH was ploted against the diatance as shown in figure 5 to figure 8 below. The attenuation decay curve shows that Radio Rivers transmitting antenna is not practicallyisotropic. The Signal was able to travel the distance stated in this paper because of the transmitter parameters (transmitter power, Antenna height and antenna Gain).The signal strength diminishes fairly with distance from the source of electromagnetic waves.. The results obtained are due to the topography, the earth conductivity and resistivity, the relative permittivity of the area understudied and the power of the transmitter at a given time and space

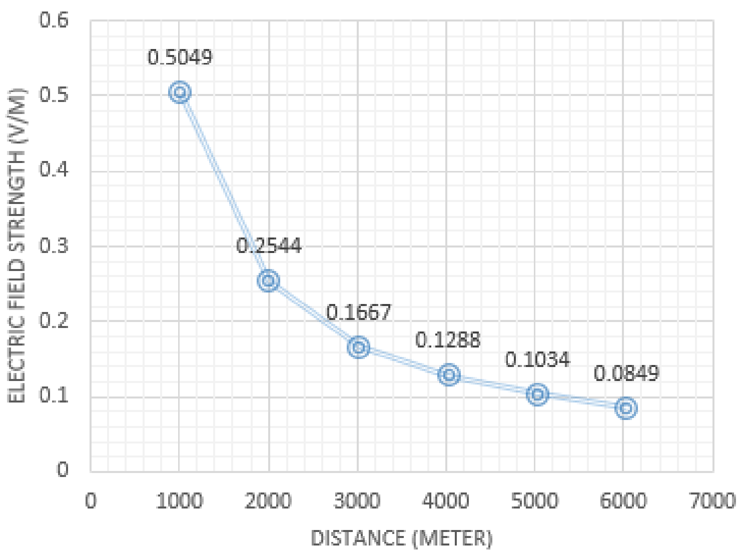

Figure 5: Graph of EMF strength against Distance (Due East)

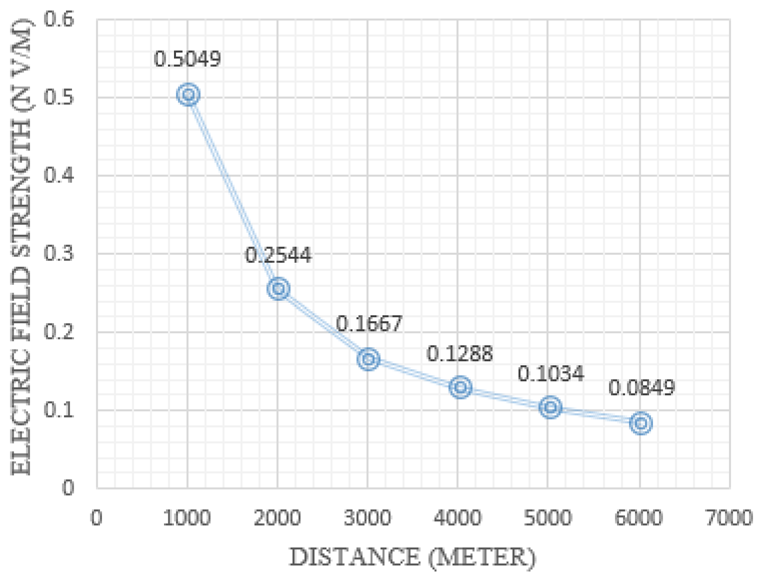

Figure 6: Graph of EMF against Distance (Due North)

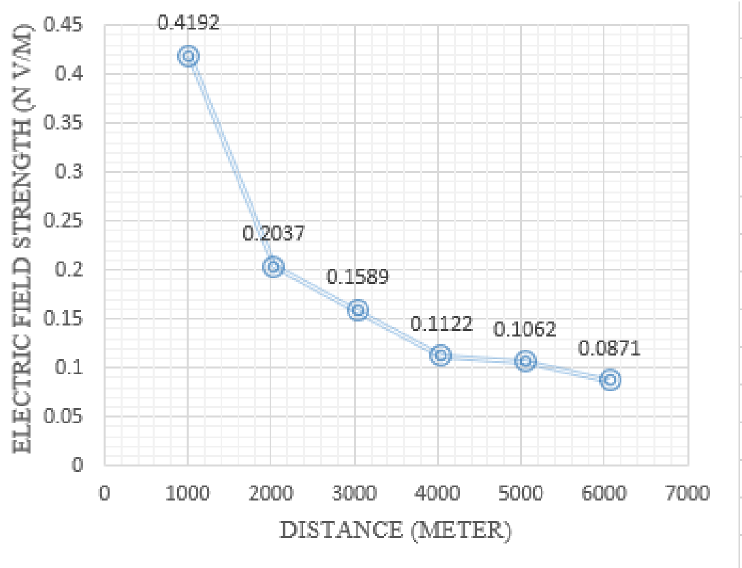

Figure 7: Graph of EMF against Distance (Due West)

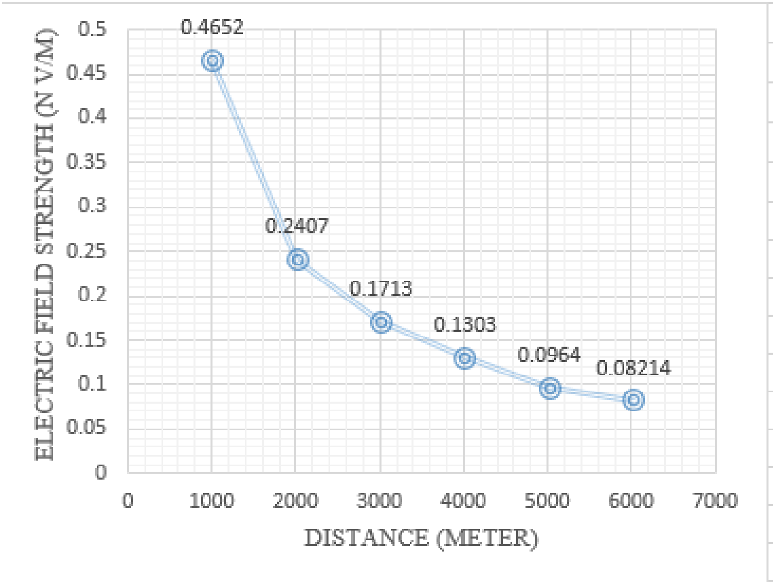

Figure 8: Graph of EMF against Distance (Due South)

V. Conclusion

Radio Rivers fm Signal was able to travel the distance stated in this paper because ofthe earth conductivity and resistivity, the relative permittivity of the area understudied, Diffraction by Obstacles and the transmitter parameters (transmitter power, Antenna height and antenna Gain).The signal strength diminishes fairly with distance from the source of electromagnetic waves. It is recommended that the height of the transmitting antenna could be made electrically longer so as to increase the gain of the antenna and hence the Electric Field Strength of the electromagnetic wave radiated from the antenna. This can be achieved by increasing the series inductance of the antenna by adding a loading ceil to it and also by increasing the shunt capacitance of the antenna by top loading it with a metal conductor.

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