Review of Measurement of Exposure of Radio Frequency Field (RF) Radiation from Global System for Mobile Communication (GSM) Masts.

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ABSTRACT

The objective of this study was to make an attempt to answer several questions on the effect of radio frequency (RF) radiated from Global System for Mobile communications (GSM) masts on human health. The measurement of the RF was conducted with an electromagnetic meter at 100m and 200m away from the masts of the major GSM operators in Nigeria; namely, GLO, MTN, and ZAIN. The data obtained was analyzed using correlation and regression analysis. The average amount of power density measured from each GSM masts was 1.87μW/m^2, 2.26 μW/m^2, 1.48 μW/m^2 for 100m and 1.50 μW/m^2, 1.32 μW/m^2, 1.87 μW/m^2 for 200m with the their corresponding values of coefficient of correlation as 0.008, 0.004, 0.27, -0.027, 0.039, and 0.048 for GLO, MTN and ZAIN, respectively. The study revealed that there is almost zero correlation ranging between $0 \leq r \leq 1$ with only one result correlating negatively between the range of $-1 \leq r \leq 0$ while the regression analysis shows that the two parameters (RF and human health) are independent of each other. Finally, based on this study, we can say that radiation from GSM masts has no significant effect on human health.

(Keywords: human health, radiation, radio frequency, correlation coefficient, regression coefficient, GSM masts)

INTRODUCTION

GSM is one of the fastest growing and most demanding telecommunication applications in the world today. It presents a continuously increasing telephone subscription base around world. Nigeria is one of the largest users of GSM equipment (mobile unit) in Africa, with over 50% of the total population in Nigeria depending on the GSM as the easiest, most available, and cheapest means of communication (ZAIN, 2005).

Since the introduction of mobile phones in Nigeria, the health implications of RF radiation from the GSM masts has been a subject of great debate and concern among the Nigerian citizens. Some interested groups opine that radiation from GSM masts is dangerous to health and some believed that human health shares an exposure relationship to RF fields. Some believed that exposure to radiation from GSM masts for long periods could cause different diseases like cancer, destruction of reproductive organs, congenital anomalies, epilepsy, and persistent headaches. In Nigeria some of GSM base stations are planted right in residential areas.

Some groups believe that exposure to RF has effect on areas of the body like eyes and testes, which are particularly vulnerable to RF heating because of the relative lack of available blood flow to dissipate the excessive heat load (Hyland, 2000 and CESL, 2006). At relatively low levels of exposure to RF radiation, that is, levels lower than those that would produce significant heating; the evidence for harmful biological effects is ambiguous and unproven. Such effects have sometimes been referred to as “non thermal” effects. It is generally agreed that further research is needed to determine the effects and their possible relevance, if any, to human health (Kelly, 2005; Krzysztof, 2002; and Zsolt, 2006).

Some investigation carried out on the effects of RF indicates that there may be risk of RF radiation to pregnant women fetuses. RF radiation may continuously react with the developing embryo, increasing cells. When pregnant women either use mobile phones or when illuminated with RF radiation, the developing child can become affected and developmental malformation may occur. RF radiation may also affect the human brain which is the most vulnerable organ to the NIEMR (RFR). Some of the known effects are neurological

effects, increase in ODC (ornithine decarboxylase) activity, effects on enzymes and free radicals decreasing the brain metabolism CCESL, 2006; Thomas, 2007; and Persson, 1997). Although some groups like the Mobile Manufacturer Forum (MMF), which manufactures mobile equipment, and GSM operators across the world insist that there are no discernible effects from the RF radiated from GSM masts (ICNIRP, 2008).

Therefore to confirm whether there is scientific evidence or not to suggest that the low power emission levels are inimical to human health; the authors have undertaken this research project. This work aimed at investigating the relationship between exposures of radio frequency radiation from GSM masts and human health, mathematically (correlation and regression analysis). Our work does not put into consideration on the laboratory experiments needed to check these associations.

MATERIALS AND METHODS

The materials/instruments used in the study are measuring tape, a stop watch, and an electromagnetic meter. The electromagnetic meter has the following accessories: 2 Kytes data memory, audible pulse ticker, audio warning alert, dosage expose chart, multi–function keypad, large digital LCD display, reliable battery, m/µW units, wide temperature range (-40 to 70^0C), Alpha/Beta/Gamma radiation detector, and USB 2.0 data transfer port. In this work the electromagnetic meter was calibrated to take measurements in µW/m^2.

The three GSM operator (GLO, MTN and ZAIN) antennas have general electrical properties: gain (unity 3dBi), connector (multi–type option), VSWR (2:1), bandwidth (broad band), impedance (50 ohms), H-plane beam width (omni directional), E-plane beam width (100 degree), polarization (vertical), mounting (double side tape), and mechanical properties such as antenna cover (polyurethane), operational temperature (-20^0C to +60^0C), and storage temperature (-30^0C to +75^0C).

Method of Data Collection

The data was collected from the three major GSM operator masts. The entire masts were located at "Unguwar Lokowa/Barama Ward" Mubi, North Adamawa State of Nigeria. The GSM masts are depicted in Figures 8, 9, and 10.

This area was chosen because most of the tertiary's institution and secondary schools in Mubi are located in this area, for example Adamawa State University, Federal Polytechnic, College of Health, former College of Agriculture, Government Technical College, Government Secondary School, Mundra, IPS, and many others. Students spend most of their time within this area and some of the GSM masts are planted near these institutions and students hostels. For each of these masts the measurements were taken at 100m and 200m every 10 minutes for an hour in front, back, and sides of the masts with the electromagnetic meter placed at 1.5m height to receive the GSM RF.

Method of Data Analysis

The data obtained was analyzed using correlation and regression analysis to determine the coefficient of correlation and regression between the exposures of GSM RF to human health and the period of exposure with the view to establish whether exposure of GSM RF has relationship with human health. Equations (1) and (2) present how to determine the coefficient of correlation and the regression.

$$r = \frac{\sum XY - \frac{\left(\sum X\right)\left(\sum Y\right)}{N}}{\sqrt{\left(\sum X^2 - \frac{\left(\sum X\right)^2}{N}\right)\left(\sum Y^2 - \frac{\left(\sum Y\right)^2}{N}\right)}} \quad \textbf{(1)}$$

Where, r = coefficient of correlation
X = Average amount of the radiation measured
Y = Period of exposure to GSM RF radiation
n = Is the number of terms (Ezeowu, 1990)

$$y = a + bx \quad \textbf{(2)}$$

Where, a and b are given by the following expressions:

$$a = \overline{Y} - b\overline{X} \quad \textbf{(3)}$$

$$b = \frac{\sum_{i=0}^{N-1}\left(X_i - \overline{X}\right)\left(Y_i - \overline{Y}\right)}{\sum_{i=0}^{N-1}\left(X_i - \overline{X}\right)^2} \quad \textbf{(4)}$$

Where, $\overline{X}$ and $\overline{Y}$ are the mean of X and Y, respectively (Alan, 1990). The results were further analyzed using correlation and regression graph.

RESULTS AND DISCUSSION

All GSM Operators' antennae were made to radiate 900/1800MHz; they have the following specifications GLO, MTN, and ZAIN have down link frequency of 1820–1835MHz, 1835–1850MHz, and 1850– 1865MHz and uplink frequency of 1725 – 1740MHz, 1740 – 1755MHz, and 1756–1770MHz, respectively. The measured results are presented in Tables 1 – 6.

Table 1: Radiation from GLO masts at 100m.

Y (min)	X1 (µW/m2)	X2 (µW/m2)	X3 (µW/m2)	X4 (µW/m2)
10	0.45	0.41	0.30	0.27
20	0.40	0.40	0.25	0.21
30	0.21	0.40	0.20	0.21
40	0.40	0.45	0.40	0.20
50	0.45	0.40	0.40	0.20
50	0.40	0.30	0.30	0.25
210	2.31	2.36	1.87	1.34

Y = Time taken during the measurement in minutes
X_1 = Amount of radiation measured in front of the Antenna
X_2 = Amount of radiation measured at the back of the Antenna
X_3 = Amount of radiation measured at side 1 of the Antenna
X_4 = Amount of radiation measured at side 2 of the Antenna.
X = Average amount of radiation measured across the all sides of the Antenna.
X_4 = Amount of radiation measured at side 2 of the Antenna. (Field Survey, 2009)

Table 2: Radiation from GLO masts at 200m.

Y(min)	X_1	X_2	X_3	X_4	X
10	0.25	0.20	0.20	0.40	0.26
20	0.20	0.10	0.20	0.20	0.18
30	0.20	0.10	0.30	0.32	0.23
40	0.40	0.20	0.31	0.31	0.31
50	0.30	0.40	0.32	0.27	0.32
60	0.20	0.10	0.21	0.28	0.20
210	1.55	1.10	1.51	1.78	1.50

(Field Survey, 2009)

Table 3: Radiation from MTN masts at 100m.

Y (min)	X1 (µW/m2)	X2 (µW/m2)	X3 (µW/m2)	X4 (µW/m2)
10	0.60	0.40	0.40	0.40
20	0.20	0.40	0.30	0.40
30	0.40	0.30	0.30	0.30
40	0.50	0.35	0.40	0.20
50	0.40	0.30	0.30	0.60
50	0.45	0.30	0.40	0.40
210	2.55	2.05	2.10	2.30

(Field Survey, 2009)

Table 4: Radiation from MTN masts at 200m.

Y (min)	X1 (µW/m2)	X2 (µW/m2)	X3 (µW/m2)	X4 (µW/m2)
10	0.25	0.19	0.19	0.20
20	0.21	0.25	0.25	0.30
30	0.30	0.25	0.25	0.20
40	0.30	0.15	0.20	0.20
50	0.27	0.10	0.19	0.21
50	0.25	0.15	0.18	0.24
210	1.60	1.09	1.26	1.35

(Field Survey, 2009)

Table 5: Radiation from ZAIN masts at 100m.

Y (min)	X1 (µW/m2)	X2 (µW/m2)	X3 (µW/m2)	X4 (µW/m2)
10	0.25	0.11	0.20	0.26
20	0.27	0.20	0.25	0.21
30	0.25	0.25	0.30	0.20
40	0.20	0.20	0.25	0.22
50	0.49	0.20	0.30	0.22
50	0.30	0.25	0.28	0.25
210	1.76	1.21	1.58	1.36

(Field Survey, 2009)

Table 6: Radiation from ZAIN masts at 200m.

Y (min)	X1 (µW/m2)	X2 (µW/m2)	X3 (µW/m2)	X4 (µW/m2)
10	0.20	0.20	0.20	0.40
20	0.30	0.30	0.20	0.20
30	0.40	0.20	0.20	0.30
40	0.40	0.30	0.40	0.38
50	0.50	0.30	0.40	0.38
50	0.40	0.20	0.40	0.32
210	2.20	1.50	1.80	2.00

(Field Survey, 2009)

Point–to–Point microwave antennas (masts) transmit and receive microwave signals across relatively short distances from a few tenths of a kilometer to 48Km or more (Kelly, 2005). These antennae are usually circular in shape and are normally found mounted on a supporting tower as depicted in Figures 8, 9, and 10, they are always place at a considerable height to provide clear and unobstructed line of sight (LOS) path between both ends of a transmission path or link.

These antennas have a variety of uses, such as transmitting voice and data message and serving as link between broadcast or cable TV studios and transmitting antennas. The RF signal from these masts travel in a directed beam from a transmitting antenna to a receiving antenna, and dispersion of microwave energy outside of the relatively narrow beam is minimal and this antenna transmit usually very low power levels, usually on the order of a few watts or less.

The measurements were taken at ground level (1.5m above sea level). The average amounts of radiation measured in this study were 1.87μW/m^2, for GLO, 2.26μW/m^2 for MTN, and 1.48μW/m^2 for ZAIN at 100m and 1.50μW/m^2 for GLO, 1.32μW/m^2 for MTN, and 1.37μW/m^2 for ZAIN at 200m in 210min each.

These measurements show that ground level power densities due to microwave directional antenna are normally a thousand times below recommended safety link (Thomas, 2007).

In addition a recent research carried in July, (2009) on the review of the evidence on biological effects, epidemiological and health consequences concerning exposure to high frequency electromagnetic fields (100kHz – 300GHz) was conducted by ICNIRP standing committees in cooperation with its consulting members. It covers all scientific aspect relevant in this area which includes numerical dosimetry, measurements, biological laboratory investigation *in vitro* and *in vivo* as well as epidemiological findings.

One of their main conclusions of the review was that "results of epidemiological studies to date give no consistent or convincing evidence of a causal relation between RF exposure and any adverse health effect" (ICNIRP, 2009).

Moreover as added margin of safety, microwave towers shown in Figures 8, 9, and 10 are inaccessible to the general public because of its considerable height.

Significant exposure from these masts could only occur in the unlikely event that an individual has to stand directly in front of the antenna and very close to the antenna for a long period of time. The analysis of the correlation results are shown in Figures 1, 2, 3.

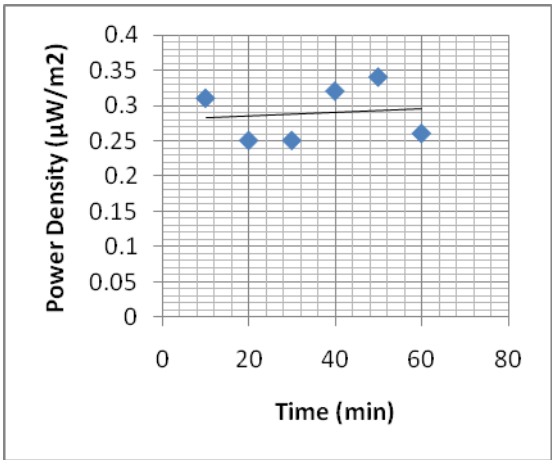

Figure 1: Correlation between RF and Human Health for GLO at 100 and 200m.

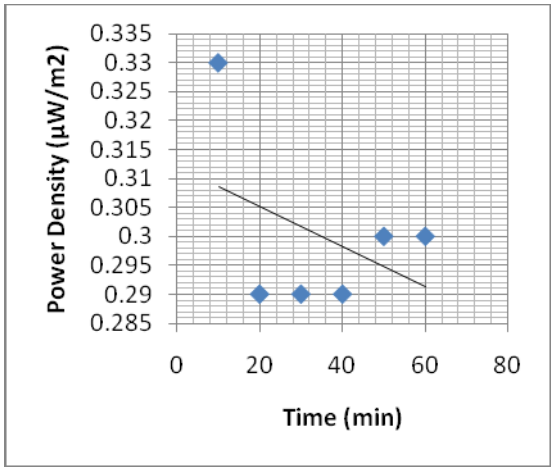

Figure 2: Correlation between RF and Human Health for MTN at 100 and 200m.

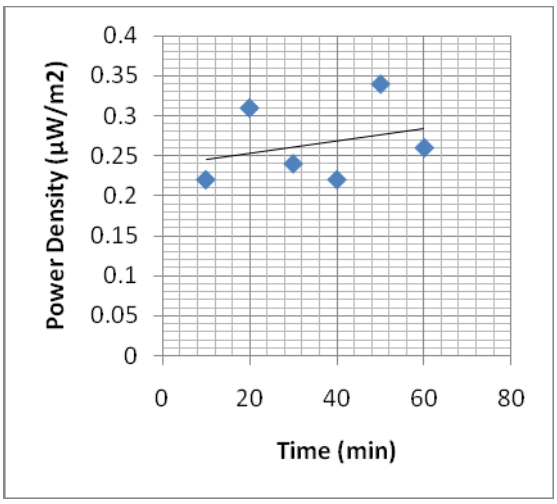

Figure 3: Correlation between RF and Human Health for ZAIN at 100 and 200m.

Generally, Figures 1, 2, and 3 show that there is an insignificant, negative, scattered correlation between exposure of RF radiation, human health and long period of time, with coefficient of correlation of 0.008, 0.004, 0.27, -0.0027, 0.039, and 0.048 while regression analysis shows that the relation between GSM RF and Human health are almost independent of each other as depicted in Figures 4, 5 and 6. The coefficient a = -0.03 and b=11.4 with line of best fit as y = -0.03 + 11.4x which are further analyze in Figures 4, 5, and 6.

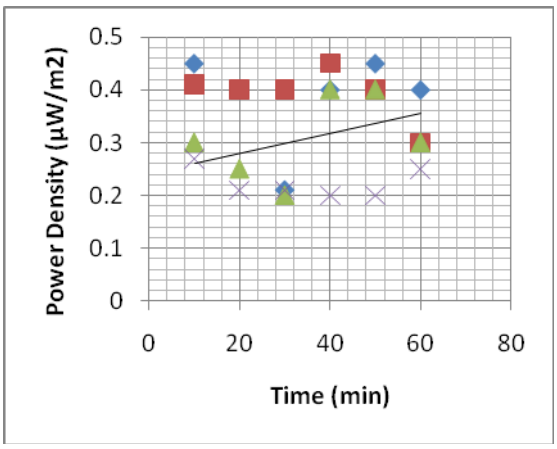

Figure 4: Regression graph between RF & Human Health for ZAIN at 100 and 200m.

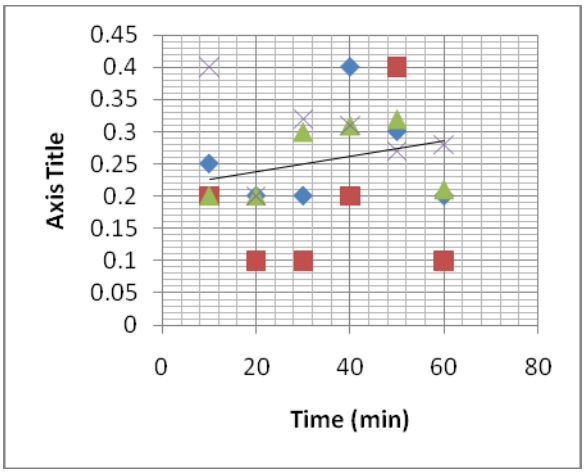

Figure 5: Regression graph between RF and Human Health for MTN at 100 and 200m.

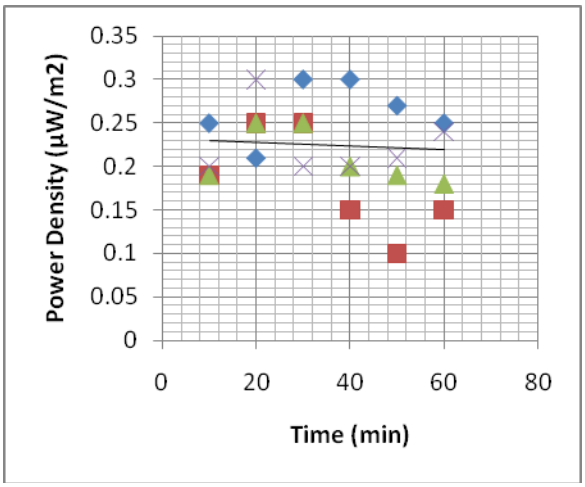

Figure 6: Regression graph between RF and Human Health for ZAIN at 100 and 200m.

The measurements also shows that at 1000m (1Km) the radiation disappears completely meaning at that point no amount of radiation can be detected (Zero radiation). Figure 7 below shows frequency spectrum that indicated GSM frequency position, which means that RF radiated from GSM masts is within the safety range in (MHz) far lower than medical x – ray (THz) use in the Nigerian Hospitals.

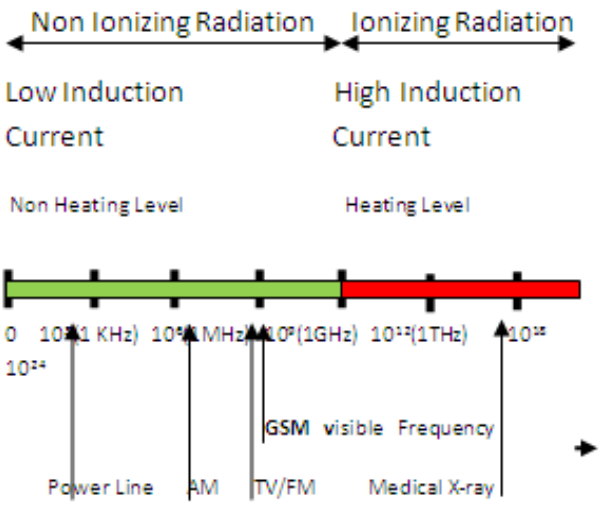

Figure 7: Non Ionizing and Ionizing radiation spectrum (V-Mobile, 2004).

Figure 8: ZAIN Masts

Figure 9: MTN Masts

Figure 10: GLO Masts.

CONCLUSION

The purpose of this study was to offer insight into the great debate among Nigerian citizen that RF of GSM masts has a measurable and correlated effect on human health. The measurements were carried out carefully with precision and the results obtained established that GSM RF has no correlation or effect on human health because the low power emission does not have sufficient ionization energy to damage the cells of the human body. On the other hand it is worthy to say that this work is a preliminary study that used a mathematical approach to established the relationship between RF radiation with human health. This study has deficiency to prove biologically that exposure to RF radiation has association with human health. Therefore it is recommended for further studies which may require multi-disciplinary research groups to ensure more definitive results

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