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Research Article

Occupational Exposure due to RF leakages within GSM Base Station Cabins in Eastern Nigeria

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ABSTRACT: The occupational exposure due to RF radiation leaks inside the base station cabin, when working on the Base station Transceiver (BTS) Radios and TX cables and during active radio communication was measured. A total of number 30 base stations Cabins were studied in the eastern part of Nigeria, using a Broad band TES-90 Electrosmog meter. The maximum instantaneous electric field strength obtained from GSM 1800 radio was 3.72 V/m, 16.56 V/m for GSM 900 radio and 11.29 V/m for the Tx cables. The maximum instantaneous indoor and out power density were 35.47 mW/m^2 and 6.64 mW/m^2 respectively. Also, the average values of the obtained electric field strength from all the cabins are 1.18 ± 1.07 V/m from GSM 1800 radio, 2.33 ± 3.82 V/m from GSM 900 radio and 1.77 ± 2.20 V/m from the Tx cables. The result of this study shows that the values were less than ICNIRP limits for occupational exposure.

Key words: GSM, Base station, Exposure, Radiofrequency

INTRODUCTION

Mobile communication involves transfer of information in form of electromagnetic waves, which comprise of electric and magnetic fields. The use of electromagnetic waves in communication and information technology had existed for a long time in form of radio and television broadcasting, radar and security messaging systems. The widespread use in the Global System of Mobile (GSM) communication is relatively recent but within this short time, it has proved to be of tremendous benefits to the society especially in a developing country like Nigeria where other forms of telephoning exist to a very limited extent.

The GSM communication is a digital mobile phone service consisting of base station antennas which connect with phone handsets via radiofrequency (RF) transmission/reception of electromagnetic waves. The public is generally concerned about the health effects of human exposure to the electromagnetic fields from both the base stations and the hand sets. Exposure from the base station antennas is continuous and whole body to the entire community while exposure from the handsets is intermittent, controllable and mainly to the hand and the head but can be more intense because of the closeness to these two organs.

The greater concern among the public is principally over the proximity of base stations rather than the use of handsets. The apparent unrestrained proliferation of masts and antennas, in some cases with minimal public consultation, has led to suspicion and organized protest, particularly where these facilities have been sited, or have been planned to be sited, near schools, childcare centers, etc. (Hardell et al, 2001; 2005; Ahlbom et al, 2004) Base station masts often represent a visual obtrusion and there have been fears on the engineering of their erection. The sheer number of antennas on a mast shared by several carriers encourages the casual observer to assume that the EMFs can be focused or at least enhanced in particular locations.

It is necessary to first answer the question of whether there is any scientific basis for fear of radiation induced health problem in the use of GSM signals. The radio waves employed in mobile telephony (GSM) are, like visible light and x-rays, electromagnetic waves that consist of both an electric and a magnetic component which vary periodically in time and travel in space with the velocity of light (3×10^8 m/s). The energy E, comprising of electric field and magnetic field components is given by:

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$$E = hf \quad (1)$$

where h is the Planks constant (6.625 x 10^{-34}Js) and *f* is the frequency.

A typical RF meter measures the value electric field strength **E** and converts it into magnetic field strength **H** and the power density ***S***. The meter can measure **E** along different axis, but can also take readings of all the **E**s at the same, time when set to the triaxial mode of operation. Both **E** and **H** are related to power density **S** expressed in Watts per Meter squared (W/m^2) as shown in the equation below,

$$S = EH = \frac{E^2}{377} = 377\Omega H^2 \quad (2)$$

where 377 Ω is the characteristic impedance of free space. Also the specific absorption rate (SAR) is measure of the rate at which energy is absorbed by the human body when exposed to RF electromagnetic field. The unit of SAR is Watt per Kilogram (W/Kg). It can be calculated from **E** using the equation:

$$SAR = \frac{\sigma \left| E_{eq} \right|^2}{\rho_{md}} \quad (3)$$

where σ is the conductivity of the material, $\boldsymbol{E_{eq}}$ electric field strength and ρ_{md} is the mass density of the material. The average power density P (W/m^2) is given by:

$$P = \frac{1}{2} E_o H_o \quad (4)$$

where E_o and H_o are the maximum electric field strength and magnetic field strength respectively. The frequency of variation determines the wave properties and uses.

Higher frequency radiations than RF such as γ-rays and x-ray have energy in the range that can readily ionize atoms and molecules, and produce some damage to biological tissues even at very low intensities. The intensity determines the number of quanta striking the body per second. Each quantum from these higher frequency radiations have a certain probability of ionizing and hence of so damaging biological molecules even at low intensities.

Radiofrequency (RF) which are used in the GSM communication, are in the lower energy part of the electromagnetic spectrum. They are classified as non-ionizing radiation because unlike x-rays and γ-rays, etc, they do not have enough energy to cause ionization in matter. The energy quanta of non-ionizing radiation at the operating frequency of GSM are in the order of few μeV which are extremely small compared with the energy of around 1 eV needed to break the weakest chemical bonds in genetic molecules (DNA).

Non-ionizing electromagnetic radiation is therefore believed to be harmless at very low intensities, although it can be damaging through heat production at high intensities. The radiofrequency though non-ionizing can penetrate exposed tissues and could cause appreciable thermal biological effects especially at high intensity. This heating effect is as a result of the force produced by the electric field on charged objects, such as the mobile ions present in the body. This force causes the ions to move, resulting in electric currents against the electrical resistance of the material in which the currents are flowing. Consequently, body temperature tends to rise but normal flow of blood immediately removes excess heat accumulation at any point in the body to stabilize the temperature. At very high intensity RF radiation, however, the heat removal system may not be sufficient to balance heat production thereby causing damage. The present belief is that RF signals employed in GSM communication are at intensities that are thousands of times less than intensities that can produce such heating effect (Inskip et al, 2001; Lonn et al, 2004; 2005)

The introduction of Global System of Mobile Communication (GSM) is over a decade in Nigeria, and there has been a continuous boom in the telecommunication industry since the reception of up to 4 GSM networks in the country. Many base stations has been sited to accommodate the spontaneously increasing demands of the user of mobile phones, especially now that the 3G technology has been introduced to facilitate high speed messaging and internet connection. GSM 900 and GSM 1800 band are mostly used in many part of the world including Africa. GSM generates burst of microwave radiations, between of which power fall to zero and at a burst repetition frequency rate of 1.74 KHz, which is 217 Hz per time slot (Hyland, 2003). Reported signs of associated radiation health risk to RF depend on the duration of exposure, the distance from antenna and the antenna characteristics (Roosli et al, 2003). In areas closer to the base station antenna installations not accessible to the general public, RF or general maintenance work sometimes has to be performed while the antennas are active to avoid loss of communication (VanWyk et al, 2005). In this condition, over exposure of the RF worker may be possible. This present study is therefore aimed at estimating the level of occupational exposure of RF workers to RF radiation leaks from base inside the base station cabin, especially when working on the Base station Transceiver (BTS) Radio and TX cable during active radio communication.

MATERIALS AND METHODS

Measurement sites

This study was carried out in major commercial cities in two states in eastern part of Nigeria. The cities are Asaba in Delta state and Abakaliki in Ebonyi state. A total of number 30 base stations cabins were covered within the two cities. Only the base stations that belong to one of the GSM service providers were studied in both cities considering the fact that the same type of telecommunication equipments were used in the setting up of the base stations, and both towns are in the same region overseen by same technical supervisory staff who ensures the proper functioning of the equipments. Measurements were taken at the centre of the cabin while outdoor measurements were made within 10 m radius from the mast.

Power level meter used in the study

An Electrosmog meter by TES Electrical Electronic Corporation USA (model TES-92 serial No 006P 9V-090200180) was used for the measurement. The meter is a broadband device for monitoring high-frequency radiation in the range from 50 MHz to 3.5 GHz. It is a non-directional digital 3-axis (isotropic) radio frequency (RF) processing meter, potable and low cost RF. It is an effective meter for digital RF signals and equally very sensitive: 20 mV/m to 108 V/m (equivalent to power density: 0.1 nanoWatt/cm^2 to 3 milliWatt/cm^2). The absolute error at 1 V/m and 50 MHz is ± 1.0dB. The frequency response of the sensor taking into account the typical calibration factor is ±1.0 dB (50 MHz to 1.9 GHz) and ±2.4dB (1.9 GHz to 3.5 GHz) while the typical isotropic deviation is ±1.0 dB for frequency greater than 50MHz. The overload limit is 10.61 mW/cm^2. The sensitive range of the meter effectively covers 800 to 960 MHz and 1800 to 2100 MHz, the frequency bands in which the mobile phone transmitters operate. Due to the isotropic characteristic of the field probe, the unknown direction of maximum field and the unknown polarization are not important. In this case, the measurement is taken as the signal sum in any given location at the communication base stations.

Some assumptions in the study

All the Base station Transceivers (BTS) were made by Motorola, model SW1134B with most of the GSM 1800 radio being SVLG9153A model while GSM 900 model was SVLF9150B. It is assumed that very close to these radios (about 2.5 cm to the components) the RF radiation frequency of the GSM signal will dominate, therefore measurements at this distance were taken on GSM 1800 radio and GSM 900 radio. It is also assumed that at this short distance, measurements are taken in the near field of the leak sources which are the radio and the Tx cables. Only electric field strength **E** measurements were in this study since at the near field, the **E** and **H** fields are incoherent which makes the power density an inappropriate quantity to use in expressing exposure at such a distance (ICNIRP 1998).

RESULTS AND DISCUSSION

The results obtained from CAB 1 to CAB 30 are shown in Table 1. The maximum instantaneous electric field strength E from GSM 1800 radio is 3.72 V/m in CAB 9, from GSM 900 radio 16.56 V/m in CAB 18 and from the Tx cables 11.29 V/m also in CAB 18. The maximum instantaneous indoor and out power density are 35.47 mW/m^2 (in CAB 18) and 6.64 mW/m^2 (outside CAB 20). Also, the average values of the obtained electric field strength from all the cabins are 1.18 V/m from GSM 1800 radio, 2.33 V/m from GSM 900 radio and 1.77 V/m from the Tx cables; this can be found in tables 2 with the minimum obtained values inclusive.

Table 2 shows the obtained values of the maximum, minimum and the average specific absorption rate (SAR) from GSM 1800 radio, GSM 900 radio and Tx cables; also presented is the maximum, minimum and the average that of Indoor and outdoor power density.

From the results, the obtained average and maximum electric field strength E are below the recommended values shown in Table 1. Also the obtained indoor and outdoor power densities are lower than the recommended values. GSM 900 radio tends to produce more E strength than GSM 1800 radio in most cabins, with its maximum value of 16.56 V/m in CAB 18. This is due to fact that GSM 900 is mostly used in a densely populated area or an urban centre where you find more phone users, which is true for the study locations. In most base stations where GSM 1800 radio was used in the study locations, it was meant to serve some inner villages which are not too far from the base station; of which the population of such nearby village may be sparsely distributed.

Therefore E strength from GSM 1800 radio in most of the cabins was lower than that of the GSM 900 radio. Where we have the high E value from GSM 1800 in some of the cabins, the rate at which calls are made through the radio is higher than that of GSM 900. There are up to 6 Tx cables from GSM 1800 and mounted side by side in Cabins, and this contributes to the E strength. The indoor power density is higher than the outdoor in most of the base stations.

Table 1. The electric field strength E from the GSM radios with the indoor and outdoor values of Power Density.

Cabin No.	GSM 1800	GSM 900 E	Tx Cables E	Indoor Power	Outdoor Power
CAB 1	0.49	1.60	2.63	1113.40	1271.87
CAB 2	1.95	4.39	2.60	4012.67	442.87
CAB 3	0.83	0.24	0.33	207.87	60.87
CAB 4	1.46	2.02	2.26	1111.00	23.13
CAB 5	1.10	1.24	2.07	3475.33	1583.00
CAB 6	0.50	1.39	0.49	54.33	3.70
CAB 7	0.12	0.35	0.02	335.85	1.37
CAB 8	0.04	0.08	0.02	0.50	205.53
CAB 9	3.72	1.94	3.65	25260.00	249.90
CAB 10	0.09	0.16	0.19	18.53	397.03
CAB 11	0.32	0.15	0.33	284.30	299.47
CAB 12	1.40	1.99	1.21	3512.00	820.77
CAB 13	0.66	1.32	2.35	1738.77	4.33
CAB 14	0.51	0.45	0.36	955.27	371.37
CAB 15	0.26	0.18	0.27	126.10	925.60
CAB 16	3.10	6.88	5.01	17943.33	13.13
CAB 17	No radio	1.83	1.24	663.43	13.13
CAB 18	3.19	16.56	11.29	35472.67	72.90
CAB 19	none	3.67	3.81	4763.67	116.93
CAB 20	none	0.54	1.97	594.77	6640.67
CAB 21	2.18	2.00	1.90	2092.70	493.20
CAB 22	0.80	0.59	1.40	877.87	2.50
CAB 23	1.30	1.74	1.38	2655.33	743.90
CAB 24	No radio	0.60	1.40	1384.00	4.43
CAB 25	1.14	0.51	1.25	33.60	257.35
CAB 26	No radio	13.85	0.02	0.23	1.37
CAB 27	No radio	0.42	0.44	19.77	482.06
CAB 28	0.04	0.10	0.07	1.60	140.27
CAB 29	0.77	0.50	0.72	289.30	12.77
CAB 30	2.46	2.55	2.37	4461.00	30.00
Mean	1.18 ± 1.07	2.33 ± 3.82	1.77 ± 2.20	3781.97 ± 0.89	522.85 ± 1223.01

Table 2. Obtained maximum, minimum and average specific absorption rate (SAR) values, in and out of the base station cabin

	GSM 1800 SAR (mW/Kg)	GSM 900 SAR (mW/Kg)	Tx Cables SAR (mW/Kg)	Indoor SAR (mW/Kg)	Outdoor SAR (mW/Kg)
Max	15.50	204.08	4.72	14.97	2.80
Min	0.00	0.00	0.01	0.00	0.00
Avg	2.66	14.19	1.05	1.60	0.22

It was observed that where the outdoor power was higher than that of the indoor, we have either E strength of GSM 900 radio or that of the Tx cable to be higher than the others. This may be due to a higher level of radiating power of from GSM 900 radio than that of the GSM 1800, or it may be due to angle of tilt of the GSM 900 antenna on the mast in which some of the radiation beam falls close to base station.

The maximum and average electric field strength and specific absorption rate (SAR) from the GSM 1800 and GSM 900 radios, with the level of indoor and outdoor exposure from all the studied base station cabins in the eastern part of Nigeria were less than the international commission on non-ionising radiation (ICNIRP) limits for occupational exposure.

This indicates that workers which spend time inside and outside the surroundings of these base station cabins, in this area of country may not be at risk of health hazards due to exposure to RF radiation from the GSM radios and their Tx cables.

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