Analysis of Radiation Dose around Some Base Stations in Ota and Lagos Environ

Usikalu M.R and Akinyemi M.L
Department of Physics, Covenant University, Ota, Ogun State, Nigeria
Correspondence email: moji.usikalu@covenantuniversity.edu.ng

***Abstract*-- The aim of this work is to investigate radiation dose around some GSM base stations within Ota and Lagos metropolis in Nigeria. This was done using a radiation alert monitor (M4EC) manufactured by S.E. International, Inc., USA. The measurements were carried out on ten different masts cited in some places in Ota Ogun State and Lagos. Measurements were carried out by positioning the radiation meter at five various distances to the masts and the mean value considered. The study showed that there is presence of radiation levels from masts beyond the background radiation levels but is within the permissible limit for public. The radiation dose measured where one mast was erected varied between 0.001 and 0.027 x 10^{-3} mSv/week. The radiation measured from location where two masts were erected varied between 0.001 and 0.039 x 10^{-3} mSv/week. The radiation measured where three masts were erected vaied between 0.001 and 0.050 x 10^{-3} mSv/week. The highest equivalent dose was obtained at 1 m away from the masts where three masts are erected and the radiation went to minimum at 16 m away from the masts. Also, where one mast was erected the highest radiation was measured at 1 m and went to minimum at 6m away from the mast except for BS 3 with the shortest mast 84 ft where minimum radiation was obtained at 8 m from the mast. It can be concluded that radiation dose depends on the number of mast erected in a particular location which implies that the more the number of masts in a location the more the distance should be kept from them. The study showed that the height of the mast plays significant roles in the radiation incurred by people around, in other words, the higher the mast, the safer it is for those around it. Technicians should be advised to desist from crowding a location with too many masts since the higher the number of masts the higher the radiation incurred the mast should be of appropriate height.**

***Index Term*-- Radiation equivalent dose, base stations, masts, radiation meter,**

I. INTRODUCTION

The telecommunications industry is experiencing a robust growth on a global scale. International Telecommunications Union (ITU), an agency of the UN in 2011 estimated that there are 4.1billion mobile subscriptions [1]. Since the introduction of mobile phones in the mid-1980s, the number of mobile phone users has been on the increase and installations of base stations have become common sight around cities. Mobile phones, also known as cellular phones or handsets now form an integral part of modern day telecommunications and are fast becoming a part of social lifestyle. mobile phones are very popular because they allow people to maintain constant and continuous communication without restricting their freedom of movement. Mobile (cellular) telephony is based on two-way radio communication between a portable handset and the nearest base-station. Every base-station serves a cell, varying from hundreds of metres in extent in densely populated areas to kilometres in rural areas, and is connected both to the conventional land-line telephone network and, by tightly focused line-of-sight microwave links, to neighbouring stations. As the user of a mobile phone moves from cell to cell, the call is transferred between base-stations without interruption. The radio communication utilizes microwaves at 900 or 1800 MHz to carry voice information via small modulations of the wave's frequency. A base-station antenna typically radiates 60W and a handset between 1 and 2W (peak). The antenna of a handset radiates equally in all directions but a base-station produces a beam that is much more directional. In addition, the stations have subsidiary beams called side-lobes, into which a small fraction of the emitted power is channeled. A handset that is in operation also has a low-frequency magnetic field associated, not with the emitted microwaves, but with surges of electric current from the battery that are necessary to implement "time division multiple access" (TDMA), the system currently used to increase the number of people who can simultaneously communicate with a base-station. A mobile or cellular phone is a low-power, single-channel, two way radio that contains both a transmitter and a receiver. It emits RF radiation to transmit information to the base station. The radiofrequency (RF) is part of the electromagnetic spectrum includes electromagnetic waves produced by television and radio transmitters (including base stations) and microwaves. The electric and magnetic components that form the electromagnetic wave can be referred to as radiofrequency fields. Mobile phone base stations are also known as base transceiver stations or telecommunications structures. They are low-power, multi-channel two-way radios, antennas, that emit RF radiation, which are normally mounted on either transmission towers or roof-mounted structures. These structures need to be of a certain height in order to have a wider coverage. When you communicate on a mobile phone, you are connected to a nearby base station from where your phone call goes into the regular fixed-line phone system. The two-way communication of mobile phone and the base station emit RF radiation and therefore expose those near them to RF radiation. However, as both the phones and the base stations have low-power (short range) transmitters in them, the RF radiation exposure levels are generally very low [2].

The effects of the radiation from mobile phone and base station can be grouped into two which are; thermal and non thermal effects. The thermal effect is the consequence of microwave energy absorption by the tissue's water content. The amount of heating produced in a living organism depends primarily on the intensity (or power density) of the radiation once it has penetrated the system, on certain electrical properties of the biomatter, and on the efficiency of the body's thermoregulation mechanism. Above a certain intensity of the microwaves, temperature homoeostasis is not maintained, and the effects on health is observed when the temperature rise is approximately 1°C. [3] and [4] reported on thermoregulatory responses, they observed that the deposition of RF energy in the body may not necessarily lead to an increase in temperature. When RF energy deposition and conversion to thermal energy in a biological body exceed its heat dissipation capabilities, an increase in temperature occurs. It has been shown that biological effects, such as the overheating of cells [5], depend on the temperature profile in time. A convenient reference temperature for the heat killing of cells is 43^{o}C, and thus the thermal dose may be expressed in minutes equivalent to heating at 43^{o}C. However, this reference temperature may vary, particularly for different chosen end points, and may be relative to the normal physiological temperature of the tissue [6]. Non-uniform heating, resulting from exposure to RF or microwave radiation, generally referred to as formation of "hot spots" may cause a variety of secondary interactions [7; 8]. Preferential heating of the hypothalamus may affect thermoregulation and elicit aberrant neurophysiological responses even at relatively low power density levels, which are not accompanied by an increase in the whole body temperature. The temperature sensitivity of the thermo-sensitive neurons of the preoptic nucleus of the hypothalamus is such that a temperature increase of only 0.1 °C may result in a 3% increase in the firing rate of such cells [9]. However, relatively large power densities may be required to cause such increase in the temperature. One of the most prominent thermally induced effects where the temperature increases are very small is the microwave hearing effect [10]. Exposure to one pulse of electromagnetic radiation results in a perception of "a click", and exposure to pulsed electromagnetic radiation results in hearing of a buzzing or hissing sound. The threshold of perception depends on radiation frequency, pulse peak power and pulse duration. The mechanism of interaction is as follows: the electromagnetic radiation causes rapid temperature increase which generates thermal expansion pressure in the brain matter which then launches the acoustic wave of pressure that is detected by cochlea. The cochlea microphonic frequency is independent of the MW frequency and the absorption pattern [11].

[12] showed that 24 h of exposure to 935-MHz GSM basic signal at 1or 2 W/Kg did not cause DNA strand breaks in human blood cells. [13] measured DNA single strand breaks in human leukocytes using the comet assay after exposure to various forms of cell phone signals. Cells were exposed at 37±1°C, for 3 or 24 h at average specific absorption rates (SARs) of 1.0-10.0 W/kg. Exposure for either 3 or 24 h did not induce a significant increase in DNA damage in leukocytes. [14] reported that a 2-h exposure to 900-MHz at 0.3 and 1 W/kg did not significantly affect levels of DNA strand breaks in human leukocytes. [15] reported that there is no evidence for the induction of chromosomal aberrations and micronuclei in human blood lymphocytes exposed in vitro for 24 h to 835.62 MHz RF radiation at SARs of 4.4 or 5.0 W/kg. [16] reported no evidence for induction of chromosome aberrations and micronuclei in human blood lymphocytes exposed in vitro for 24 h to 847.74 MHz RF radiation (CDMA) at SARs of 4.9 or 5.5 W/kg.

[17] exposed mice to 900 MHz RF at a specific absorption rate (SAR) of 0.09 W/kg for 7 days at 12 h per day. DNA damage in caudal epididymal spermatozoa was assessed by quantitative PCR (QPCR) as well as alkaline and pulsed-field gel electrophoresis post-exposure. Gel electrophoresis revealed no significant change in single or double DNA strand breakage in spermatozoa. However, QPCR revealed statistically significant damage to both the mitochondrial genome ($p < 0.05$) and the nuclear-globin locus ($p < 0.01$). [18] exposed V79 Chinese hamster fibroblast cells to continuous wave 7.7 GHz radiation at power density of 0.5 mW/cm^2 for 15, 30 and 60 min. There was a significantly higher frequency of specific chromosome aberrations such as dicentric and ring chromosomes in irradiated cells. [19] reported increases in DNA strand breaks and micronucleation in lymphocytes obtained from cell phone users. The inconsistent results obtained by the researchers led to this research work to check for the possibility of ionizing radiation dose around the mobile phone base stations. Ten base stations cited in Lagos and Otta, Nigeria were investigated in attempt to find the radiation dose around them and also determine a conducive distance for which residence can be situated. The effect of positioning two or more mast in a location was also investigated by measuring the radiation dose obtained in the vicinity where there are more than one masts.

II. MATERIALS AND METHODS

The radiation dose around base stations which operates using GSM technology, for ten different stations were measured using a radiation alert (M4EC) manufactured by S.E. International, Inc., USA. The radiation meter senses ionizing radiation by means of a GM (Geiger Mueller) tube with a thin mica window. The Monitor 4EC, is optimized to detect low levels four main types of ionizing radiation: alpha, beta, gamma, and x-rays. The meter consists of a halogen-quenched GM tube with mica window of density 1.5 – 2.0 mg/cm^2 and 3500 CPM/mR/hr reference to Cs-137 with accuracy of ±15 %. The measurements was carried out on the ten different masts cited in some places in Ota Ogun State and Lagos. Measurements were carried out by positioning the radiation meter at the various distances to the masts. At each distance, a sample of five measurements were taken and the mean value considered. Measurements of the activity were carried out in units of count per minute (CPM) at various distances to the masks. The activity was converted to dose equivalent rate by a conversion factor of 32240 CPM = 100 mSv/hr as specified by the manufacturers. This was based on the fact that each personnel can be exposed for 8 working hours a day for 6 days a week. The result was then compared with the dose reference of 0.02 mSv/week for protection against ionizing radiation [20].

III. RESULT AND DISCUSSIONS

Table 1 presents the measured radiation dose and standard error from the vicinity where one mast is erected one in Canaanland Ota, two in Ikeja and Oshodi, Lagos. The radiation dose measured where one mast is erected vary between 0.001 and 0.027 x 10^{-3} mSv/week. The radiation measured from all the stations are nearly the same with exception of BS 3 where the mast height is 84 ft and the highest radiation dose is obtained in this station The highest radiation was obtained in BS 3 where mast of height 84 ft. The highest radiation was measured at 1 m from all the masts and went to minimum in the vicinity of one mast 6 m away from the mast, that is, the radiation obtained at 6 m from the mast is the same as the one obtained where there is no mast at all. Also, the case of BS 3 is not the same as other station with one mast the radiation went to the minimum at distance 8 m from the mast at BS 3. This implies that the farther the position from mast the lower the radiation incurred. Also, the higher the height of the mast, the safer it is for people leaving around it. This suggests that erection of mast on the roof top must be checked. Table 2 displays the radiation dose measured with standard error at different positions in the area where two masts are erected in Sango, Ota.

The radiation measured from the three stations vary between 0.001 and 0.039 x 10^{-3} mS/week and the values are nearly the same for all the stations because all the masts are of the same height which implies that height of the mast plays a significant role in safety precaution of mast. The highest radiation was obtained at 1 m (not shown) away from the mast and the radiation went to minimum at 12 m away from the mast. Table 3 presents the results of the measured radiation dose with standard error in the vicinity where three masts are erected one in Yaba and one in Oshodi, Lagos. The radiation measured from the three stations vary between 0.001 and 0.050 x 10^{-3} mS/week and the values are nearly the same for the two stations because the two masts. The highest radiation was obtained at 1 m (not shown) away from the mast and the radiation went to minimum at 16 m away from the mast. This implies that the farther the position from mast the lower the radiation incurred. In order to have clearer comparison of number of masts erected in a vicinity with radiation dose a plot of mean equivalent dose against the stations is shown in Figure 1. BS 1 to BS 5 have a mast each in a location while BS 6 to BS 8 have two mast each at distance 20 ft to each other also BS 9 and BS 10 have three masts erected at 20 ft to one another. Highest radiation was recorded in the location where three masts are erected and the distance to get the minimum radiation possible was farther than where one or two mast(s) are erected. Despite the presence of the radiation from the stations the radiation measured is within the permissible dose limit 0.002 mSv/week for members of the public if certain distances are kept from the masts.

TABLE III
Radiation Parameters Measured with Citing of Three Mast at Different Distances

Station Name	No of masts	Height of masts (ft)	Distance from masts (m)	Activity (CPM)	Dose Equivalent (mSv/week)
BS 9	3	90.0	2.00	87.0 ± 0.25	0.045
			4.00	72.0 ± 0.30	0.037
			6.00	60.0 ± 0.20	0.031
			8.00	43.0 ± 0.15	0.022
			10.00	26.0 ± 0.20	0.013
			12.00	13.0 ± 0.10	0.007
			14.00	4.0 ± 0.10	0.002
			16.00	2.0 ± 0.00	0.001
BS 10	3	90.0	2.00	95.0 ± 0.20	0.050
			4.00	72.0 ± 0.10	0.037
			6.00	60.0 ± 0.30	0.031
			8.00	44.0 ± 0.25	0.023
			10.00	28.0 ± 0.10	0.014
			12.00	14.0 ± 0.20	0.007
			14.00	3.0 ± 0.10	0.002
			16.00	2.0 ± 0.00	0.001

TABLE I
Radiation Parameters Measured with Citing of Mast at Different Distances

Station Name	No of masts	Height of masts (ft)	Distance from masts (m)	Activity (CPM)	Dose Equivalent (mSv/week)
BS 1	1	90.0	1.00	40.0 ± 0.15	0.020
			2.00	34.0 ± 0.20	0.018
			3.00	27.0 ± 0.18	0.014
			4.00	17.0 ± 0.25	0.009
			5.00	4.0 ± 0.10	0.002
			6.00	2.0 ± 0.00	0.001
BS 2	1	90.0	1.00	46.0 ± 0.10	0.024
			2.00	39.0 ± 0.25	0.020
			3.00	31.0 ± 0.15	0.016
			4.00	17.0 ± 0.30	0.009
			5.00	4.0 ± 0.15	0.002
			6.00	2.0 ± 0.00	0.001
BS 3	1	84.0	1.00	53.0 ± 0.25	0.027
			2.00	43.0 ± 0.10	0.022
			3.00	34.0 ± 0.25	0.018
			4.00	23.0 ± 0.20	0.012
			5.00	15.0 ± 0.15	0.008
			6.00	9.0 ± 0.10	0.005
			8.00	2.0 ± 0.00	0.001
BS 4	1	90.0	1.00	35.0 ± 0.15	0.018
			2.00	24.0 ± 0.20	0.012
			3.00	20.0 ± 0.25	0.010
			4.00	15.0 ± 0.10	0.008
			5.00	6.0 ± 0.10	0.003
			6.00	2.0 ± 0.00	0.001
BS 5	1	90.0	1.00	39.0 ± 0.20	0.020
			2.00	28.0 ± 0.15	0.014
			3.00	20.0 ± 0.15	0.010
			4.00	13.0 ± 0.20	0.007
			5.00	5.0 ± 0.10	0.003
			6.00	2.0 ± 0.00	0.001

TABLE II
Radiation Parameters Measured with Citing of Two Mast at Different Distances

Station Name	No of masts	Height of masts (ft)	Distance from masts (m)	Activity (CPM)	Dose Equivalent (mSv/week)
BS 6	2	90.0	2.00	76.0 ± 0.30	0.039
			4.00	50.0 ± 0.20	0.025
			6.00	40.0 ± 0.15	0.020
			8.00	26.0 ± 0.10	0.010
			10.00	9.0 ± 0.20	0.004
			12.00	2.0 ± 0.00	0.001
BS 7	2	90.0	2.00	75.0 ± 0.20	0.039
			4.00	60.0 ± 0.15	0.031
			6.00	47.0 ± 0.10	0.024
			8.00	23.0 ± 0.15	0.012
			10.00	4.0 ± 0.10	0.002
			12.00	2.0 ± 0.00	0.001
BS 8	2	90.0	2.00	76.0 ± 0.25	0.039
			4.00	55.0 ± 0.10	0.030
			6.00	43.0 ± 0.10	0.022
			8.00	22.0 ± 0.15	0.011
			10.00	5.0 ± 0.10	0.003
			12.00	2.0 ± 0.00	0.001

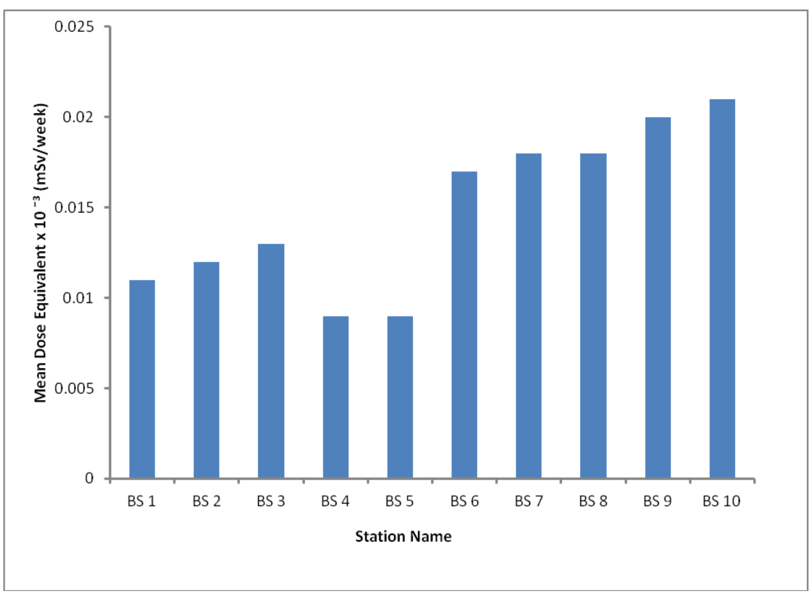

Fig. 1. Mean Dose Equivalent Associated with the Masts

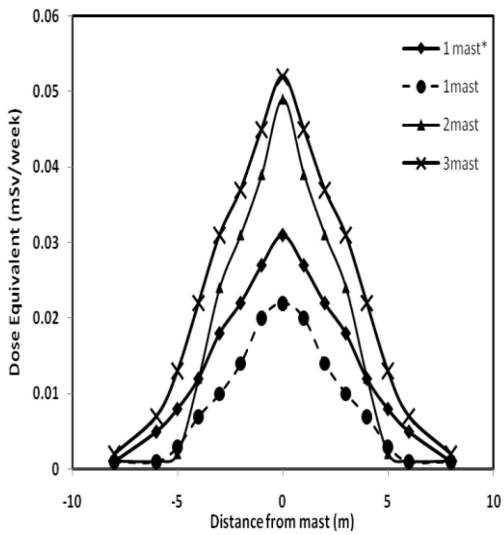

Fig. 2. Mean Dose Equivalent Associated with Distances from the Masts

CONCLUSIONS

This study has confirmed the presence of radiation levels from masts beyond the background radiation levels. The highest equivalent dose 0.050 x 10^{-3} mSv/week was obtained at 2 m away from the masts where three masts are erected and lowest equivalent dose 0.0010 x 10^{-3} mSv/week from the location with just one mast. It can be concluded that radiation dose depends on the number of mast erected in a particular location. The height of the mast equally plays significant roles in the radiation incurred by people around, in other words, the higher the mast, the safer it is for those around it. In order to avoid the potential risks, here are a few simple steps that can be taken to help minimize exposure to radiation. Since time is a key factor in how much exposure a person receives, the shorter the time you spend in a radiation area, the smaller the radiation exposure. Keep distance away from mast at least 20 m and the technicians should be advised to desist from crowding a location with too many masts since the higher the number of masts the higher the radiation incurred. The mast also should be of appropriate height. Further work can be done by measuring the alpha and beta emission around the base stations in order to correlate it with dose measured here.

REFERENCES

[1] Tryhorn Chris (2009). Nice talking to you ... mobile phone use passes milestone. The guardian Tuesday 3rd March 2009 http://www.guardian.co.uk/technology/2009/mar/03/mobile-phones

[2] Hyland G. J (2000). Physics and biology of mobile telephony Lancet (356): 1833-1836

[3] Bowman, H.D. (1981). Heat transfer and thermal dosimetry. *Journal of Microwave Power* **16**: 121-133.

[4] International Non-Ionizing Radiation Committee of the Radiation Protection Association (1985). Review of concepts, quantities, units, and terminologies for non-ionizing radiation protection. *Health Physics* **49**:1329-1362.

[5] Sapareto, S.A. and Devey, W.C. (1984). Thermal dose determination cancer therapy. *International Journal of Radiation*: oncology-biology-physics **10:** 787-800.

[6] Lau, M.P. (1979). Induced thermal resistance in the mouse ear. The relationship between heating time and temperature. *International Journal of Radiation Biology* **35**:481-185.

[7] Michaelson, S. M. (1977). Microwave and radiofrequeney radiation. World Health Organization, Document ICP/CEP 803.

[8] Baranski, S., Czerski, P. (1976). Biological effects of microwave radiation. Stroudsburg, Pa.: Dowden, Hutchinson & Ross, Inc

[9] Cleary, S.F. (1980). Microwave cataractogenesis. *Proceedings of the Institute of Electrical and Electronics Engineers*, **68:** 49-55.

[10] Guy, A.W., Chou, C.K., and Lin, J.C. (1975). Microwave-induced acoustic effects in mammalian auditory systems and physical material. *Annals of the New York Academy of Science*, **247:** 194-215.

[11] Lin, J. C. (1977). On microwave-induced hearing sensation. *IEEE* Trans. MIT-**25**, 605-613

[12] Stronati, L., Testa, A., Moquet, J., Edwards, A., Cordelli, E., Villani, P., Marino, C., Fresegna, A.M., Appolloni, M. and Lloyd, D. (2006). 935 MHz cellular phone radiation. An in vitro study of genotoxicity in human lymphocytes. *Int J Radiat Biol.* **82(5):** 339-346.

[13] Tice, R.R., Hook, G.G., Donner, M., McRee, D.I. and Guy A.W. (2002). Genotoxicity of radiofrequency signals. I. Investigation of DNA damage and micronuclei induction in cultured human blood cells. *Bioelectromagnetics* **23:** 113-126.

[14] Zeni, O., Romano, M., Perrotta, A., Lioi, M.B., Barbieri, R., d'Ambrosio, G., Massa, R. and Scarfi, M.R. (2005). Evaluation of genotoxic effects in human peripheral blood leukocytes following an acute in vitro exposure to 900 MHz radiofrequency fields. *Bioelectromagnetics* **26(4):** 258-265.

[15] Vijayalaxmi, M., Leal, B.Z., Meltz, M.L., Pickard, W.F., Bisht. K.S., Roti J.L. and Straube, W.L. and Moros E.G.(2001b). Cytogenetic Studies in Human Blood Lymphocytes Exposed In Vitro to Radiofrequency Radiation at a Cellular Telephone Frequency (835.62 MHz, FDMA). *Radiat Res* **155(1):**113-121.

[16] Vijayalaxmi, M., Bisht, K.S., Pickard, W.F., Meltz, M.L. and Roti, J.L. Moros EG. (2001c). Chromosome damage and micronucleus formation in human blood lymphocytes exposed in vitro to radiofrequency radiation at a cellular telephone frequency (847.74 MHz, CDMA). *Radiat Res* **156(4):**430-432.

[17] Aitken, R.J., Bennetts L.E., Sawyer D, Wiklendt A.M. and King, B.V.(2005). Impact of radio frequency electromagnetic radiation on DNA integrity in the male germline. *Inter J Androl* **28**:171-179.

[18] Garaj-Vrhovac, V., Horvat, D., Koren, Z.(1991). The relationship between colony-forming ability, chromosome aberrations and incidence of micronuclei in V79 Chinese hamster cells exposed to microwave radiation. *Mutat Res* **263(3):**143-149.

[19] Gandhi, G. and Anita (2005). Genetic damage in mobile phone users: some preliminary findings. *Ind J Hum Genet* **11(2):** 99-104.

[20] International Commission on Radiological Protection (ICRP, 1991). Recommendations of the International Commission on Radiological Protection. Annals of the ICRP 194 (46).