Journal of Scientific Research & Reports

22(5): 1-10, 2019; Article no.JSRR.46939
ISSN: 2320-0227

Radiation Absorbed Dose Rates from Selected Mobile Phone Base Stations in Ibadan, Oyo State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JSRR/2019/v22i530100
Editor(s):
(1) Dr. Rajkumar Venkatesh Raikar, Department of Civil Engineering, KLE Dr. M. S. Sheshgiri College of Engineering and Technology, Karnataka, India.
Reviewers:
(1) Aleksandra Vasic-Milovanovic, University of Belgrade, Serbia.
(2) F. Cervellati, University of Ferrara, Italy.
Complete Peer review History: http://www.sdiarticle3.com/review-history/46939

Original Research Article

Received 25 November2018
Accepted 01 February 2019
Published 23 March 2019

ABSTRACT

The aim of this study is to measure the radiation dose from Mobile Phone Base Stations relative to human exposure at various locations within Ibadan metropolis, Southwestern Nigeria by measuring the radiation dose at 10 - 100 metres distance away from the randomly selected base stations and compare the results with other studies/recommended exposure limit. A Victoreen radiation survey meter (fluke 451 model) was used to measure the radiation dose. The meter was calibrated with a calibration factor of 1.1 to standardized the values measured with international recommended standards. The average radiation dose reported for the studied area was 9.36, 11.28, 8.73, 10.17, 8.58, 9.80, 7.13, 10.05, 8.14 and 8.81 μSv/hr respectively. The mean value of radiation dose from the study area was 9.21 μSv/hr which is higher than the maximum permissible level of 5.7 μSv/hr recommended by the American Nuclear Society for persons within 0 – 100 m from a mobile phone base station. The values vary according to the distance which shows that the strength of the radiation field is greatest at the source and diminished quickly with distances. Results obtained for the present study showed that radiation emitted at mobile phone base station are at intensities that

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are thousands of times less than intensities that can produce a heating effect. Hence, the assumption from the results obtained for the present study area is that the radiation exposures from mobile phone base stations impose no health hazard as the limits recommended in the guidelines by International Commission of Non-Ionizing Radiation Protection do not appear to have any known adverse consequence on human health.

Keywords: Radiation; absorbed dose rates; mobile phone base stations; Ibadan; Nigeria.

1. INTRODUCTION

Humans in modern society are exposed to an ever increasing dose of radiation generated from the production and supply of electricity, television (TV) sets, a personal computer (PC), radio communication, security devices and most recently mobile phones and their base stations. Though there have been numerous studies on health effects of chronic exposure to the radiation from mobile phone base stations and mobile phones, this is because all living creatures have been and are still being exposed to various degrees of radiation and its fields [1]. Most studies are still at early stages to fully understand the degree of damages caused by these radiation exposures.

In Nigeria, the advent of GSM since 2001 has led to the increased use of Mobile phones and citing of masts/Towers within residential areas. Since the public has raised concern on possible health issues due to radiation from the mobile phone base stations and the mobile handsets. The effect of mobile phones base stations and other wireless communication devices radiation and human health is a subject of interest and study worldwide as a result of an enormous increase in mobile phone base stations and other wireless communication device used throughout the world [2]. Mobile phone use is ubiquitous with an estimated 6.9 billion subscriptions globally and over 150 million subscriptions in Nigeria [3].

World Health Organization in 2011 declared that no adverse health effects have been established with the use of mobile phone and from base stations. Many scientific studies have also investigated possible health effects that could emanate from a mobile phone. These studies are occasionally reviewed by scientific committees to access overall risk. There is an increase in health risk due to high radiation exposure levels from mobile phone base stations [2]. Over the years, an area of concern in telecommunication is the radiation emitted by the fixed infrastructure used in mobile telephony, such as base station and their antennas which provide the link to and from mobile phones. Mobile handset emits radiation continuously into the environment. However, the intensity of the radiation reduces rapidly with distance away from the base of the transmitter because of the power attenuation [4]. The erection of mobile phone base stations in inhabited areas has raised concerns about possible health effects caused by emitted radiation [5]. The area closer to the base antennas installations are prone to overexposure of radiofrequency [6]. Health failure of residents around mobile phone base stations may not be attributed to radiofrequency or electromagnetic field exposures [7]. However, the present belief is that radiofrequency signals employed in mobile phone communication systems are at intensities that can produce such a heating effect [8].

Radiofrequency (RF) which are used in mobile phone communication is in the lower energy part of the EM 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 the matter. The energy quanta of non-ionizing radiation of the operating frequency of mobile phones are in the order of few μeV which is extremely small compared to the energy of around 1eV needed to break the weakest chemical bonds in the genetic molecules (DNA) [9]. Non-ionizing EMR is therefore believed to be of very low intensities, although it can be damaging through heat producing at high intensities [10]. It is well established, however, that non-ionizing radiations have the ability to penetrate the human body and heat up the tissue with the main effect of raising the temperature in the exposed tissue [11]. At low intensity, the homeostatic (thermo-regulations) ability of the body can effectively cope with the heat produced. A homeostatic ability can breakdown at very high intensities.

When radiation is absorbed in a living system, it initiates a complex series of reactions which sooner or later may become manifest as an alteration in the normal functioning of the system. The damage takes the form of changes in the

construction and functioning of a cell. In the human body, these changes manifest themselves as clinical symptoms, such as radiation sickness, cataracts, or in the long term, cancer [12]. Radiation may damage the cell when it delivers extra energy to it, because the energy may be used to destroy parts or functions of the cell. For example, as a result of irradiation, chromosomes or DNA molecules may break. The break may occur either by direct collision with incoming fast particles or as the result of chemical activity initiated by the radiation. The effects of radiation on the human body are thus the result of damage to individual cells which may react in different ways. Another effect of irradiation may be damage to the DNA molecules that carry the genetic code which may manifest in the descendants of an organism. The exposure of radiation in recent time is thousands of times higher than before the proliferation of mobile phone base station [13]. In Nigeria, the inhabitants have expressed concern over living or working near a cell phone tower because of likely health risks [14]. It is, therefore, necessary to assess whether or not there is health effect due to exposure of EMF from Mobile Phone Base Stations and provide guidelines on horizontal safety distance of the house/structure from base stations.

Thus, the aim of the study is to measure the level of radiation dose Mobile Phone Base Stations in various locations within Ibadan metropolis. The study was limited to Ibadan, capital of Oyo state, Southwestern Nigeria due to the peculiarity of their population (the third most populous city in Nigeria after Lagos and Kano) and spatial distribution of base stations (about 90% of base stations are in close proximity with human living quarters).

2. MATERIALS AND METHODS

2.1 Description of the Study Area

This study was carried out in Ibadan, the capital of Oyo state, Nigeria. Ibadan was selected as a study area due to the population density and spatial distribution of mobile phone base stations in the city. Invariably, about 90% of the base stations are in close proximity to human living quarters. Ibadan is the most populous city of Oyo state and it is Nigeria's largest city by geographical area with urban density 464.71/km^2 and population density 2,551.5/sq.mi. Ibadan is situated at 7.3775°N latitude, 3.9470°E longitude. Its elevation is 273 meters' height, that is equal to 896 feet. The estimated population of Ibadan is over 3 million [15].

2.2 Measurement and Methods

2.2.1 Sampling selection/techniques

A total of ten (10) base stations within Ibadan metropolis were considered for the study. The measurement in the study was the radiation dose. The Radiation Survey meter was used to

Fig. 1. Map of Nigeria (indicating Ibadan, the study area)

measure the radiation dose at different distances to the base station and the coordinates of each base station and points of measurements were marked out a with Global positioning system (GPS). A global positioning system (GPS) is a device that receives signals for the purpose of determining the correct location of an object on the earth surface. GPS devices provide information about latitude, longitude and elevation (altitude) of a location. Hence, coordinates of the base stations under study in Ibadan were obtained with the aid of a handheld global positioning system (GPS). The radiation dose was measured at distance such as 10 m, 20 m, 30 m, 40 m 50 m, 60 m, 70 m, 80 m, 90 m, and 100 m away respectively from 10 selected mobile phone base stations in Ibadan to check the radiation exposure within such distances.

2.2.2 Overview of the radiation survey meter

The radiation survey meter used was Victoreen Radiation Survey Meter (Fluke 451 model). The meter was calibrated with a calibration factor of 1.1 to standardized the values measured with international standards. The radiation dose measured were in micro Sievert per hour (μSv/hr). A micro Sievert per hour (μSv/hr) is the SI derived unit of radiation absorbed dose rate. The Sievert (Sv) is the SI derived unit of equivalent radiation dose, effective dose, and committed dose. 1 Sievert is the energy absorbed by one kilogram of biological tissue, which has the same effect as one gray of the absorbed dose of gamma radiation. Therefore, the Sievert can be expressed in terms of other SI units as:

$$1\ Sv = 1\ J/kg \quad (1)$$

$$1\ J/kg{\cdot}s = 1\ Sv/s = 3.6 * 10^{7}\ \mu Sv/hr \quad (2)$$

The Fluke 451 model used is an ion chamber radiation survey meter which features a pressurized ionization chamber, providing enhanced sensitivity (μR resolution) and improved energy response to measure radiation rate and dose from x-ray and gamma sources. Originally designed to measure leakage and scatter around diagnostic x-ray and radiation therapy suites, the 451P's radiation measurements surveying capabilities make it well-suited for a wide range of end users, including x-ray manufacturers, government agencies, state inspectors, biomedical technicians, and maintenance technicians for airport baggage scanners.

The ion chamber detector allows for fast response time to radiation from leakage, scatter beams and pinholes. Additionally, the low noise ionization chamber bias supply provides for fast background settling time. The digital display features an analog bar graph, 2.5-digit digital readout, low battery and freeze (peak hold) mode indicators, and an automatic backlight function. User controls consist of an ON/OFF button and a MODE button. The case is constructed of lightweight, high strength materials and is sealed against moisture. The RS-232 interface can be connected directly to a computer for use with the Excel add-in for Windows (451EXL), enhancing the functionality of the instrument. This software allows for data retrieval, user parameter selection and provides a virtual instrument display with audible (requires sound card) and visual alarm indication.

Fig. 2. Radiation Survey Meter (Fluke 451 model)

2.2.3 Radiation dose from mobile phone base station

Radiation dose is a measure of the amount of exposure to radiation. The energy from a mobile phone base station antenna, like that of other telecommunication antennas, is directed toward the horizon (parallel to the ground), with some downward scatter. Base station antennas use higher power levels than other types of land-mobile antennas, but much lower levels than those from radio and television broadcast stations. The amount of energy decreases rapidly as the distance from the antenna increases. As a result, the level of exposure to radiation at ground level is very low compared to the level close to the antenna. Public exposure to radiation from mobile phone base station antennas is negligible for several reasons. The radiation levels are relatively low, the antennas

are mounted high above ground level, and the signals are transmitted intermittently, rather than constantly.

3. RESULTS AND DISCUSSION

The radiation dose from various mobile phone base station in Ibadan, Oyo State, Nigeria was measured and was tabulated in Tables 1-10. The maximum average radiation dose was reported for MPSB-2 and the lowest was reported for MPSB-7. The average radiation dose from the base stations were 9.36, 11.28, 8.73, 10.17, 8.58, 9.80, 7.13, 10.05, 8.14 and 8.81 μSv/hr at the sampling locations within Ibadan, Southwestern Nigeria.

Table 1. Radiation Dose from MPBS (SP 1)

S/N	Distance	Radiation Dose	Base Station Location (GPS)	
	(m)	μSv/hr	Northing	Easting
1	10	18.23	0596147	0813597
2	20	16.06	0596142	0813603
3	30	13.45	0596138	0813607
4	40	10.23	0596134	0813612
5	50	9.64	0596129	0813616
6	60	9.52	0596125	0813620
7	70	6.08	0596123	0813622
8	80	5.19	0596122	0813625
9	90	3.92	0596120	0813629
10	100	1.26	0596115	0813633
	Average	9.36		
	Range	1.26 -18.23		

Table 2. Radiation Dose from MPBS (SP 2)

S/N	Distance	Radiation Dose	Base Station Location (GPS)	
	(m)	μSv/hr	Northing	Easting
1	10	16.83	0594928	0815061
2	20	15.07	0594925	0815056
3	30	14.96	0594921	0815058
4	40	14.85	0594917	0815057
5	50	14.52	0594912	0815056
6	60	12.63	0594905	0815054
7	70	10.45	0594902	0815052
8	80	6.23	0594897	0815051
9	90	5.07	0594891	0815049
10	100	2.15	0594886	0815047
	Average	11.28		
	Range	2.15 -16.83		

Table 3. Radiation Dose from MPBS (SP 3)

S/N	Distance	Radiation Dose	Base Station Location (GPS)	
	(m)	μSv/hr	Northing	Easting
1	10	16.43	0594742	0815186
2	20	13.09	0594740	0815191
3	30	10.94	0594738	0815194
4	40	10.78	0594735	0815197
5	50	9.13	0594733	0815202
6	60	6.82	0594730	0815207
7	70	6.15	0594728	0815212
8	80	5.43	0594726	0815214
9	90	5.06	0594724	0815221
10	100	3.48	0594721	0815225
	Average	8.73		
	Range	3.48-16.43		

Table 4. Radiation Dose from MPBS (SP 4)

S/N	Distance	Radiation Dose	Base Station Location (GPS)	
	(m)	μSv/hr	Northing	Easting
1	10	18.25	0595014	0814278
2	20	14.96	0595011	0814283
3	30	14.74	0595007	0814285
4	40	14.52	0595003	0814288
5	50	9.33	0595000	0814291
6	60	9.33	0595996	0814294
7	70	8.39	0595992	0814296
8	80	5.60	0595987	0814298
9	90	4.68	0595986	0814301
10	100	1.93	0595983	0814305
	Average	10.17		
	Range	1.93-18.25		

Table 5. Radiation Dose from MPBS (SP 5)

S/N	Distance	Radiation Dose	Base Station Location (GPS)	
	(m)	μSv/hr	Northing	Easting
1	10	13.37	0595633	0813788
2	20	11.60	0595636	0813790
3	30	11.32	0595641	0813793
4	40	10.93	0595644	0813795
5	50	10.16	0595647	0813798
6	60	8.91	0595651	0813801
7	70	8.35	0595656	0813802
8	80	4.63	0595658	0813805
9	90	4.18	0595662	0813806
10	100	2.34	0595665	0813811
	Average	8.58		
	Range	2.34-13.37		

Table 6. Radiation Dose from MPBS (SP 6)

S/N	Distance	Radiation Dose	Base Station Location (GPS)	
	(m)	μSv/hr	Northing	Easting
1	10	14.93	0596036	0813816
2	20	14.08	0596035	0813813
3	30	13.82	0596034	0813808
4	40	13.77	0596034	0813803
5	50	13.09	0596037	0813799
6	60	7.54	0596040	0813796
7	70	7.16	0596043	0813793
8	80	5.22	0596048	0813792
9	90	5.08	0596053	0813788
10	100	3.26	0596055	0813786
	Average	9.80		
	Range	3.26-14.93		

The mean value of radiation dose from the study area was 9.21 μSv/hr which is higher than the maximum permissible level of 5.7 μSv/hr recommended by the American Nuclear Society. The intensity of radiation dose from the mobile phone base station decreases as the distance of measurement increases (see Table 11) implying that to have minimum dose exposure within the studied area, all residential homes and business outlets sited closer to the mobile phone base

stations up to 200 m away needs to be relocated for health safety purposes. This may be a difficult consideration for the nature and population of Ibadan. However, considering the long term health effect of the people could serve as a motivation for the residential relocations. The values reported for the present study were higher than the average values of radiation dose reported for Mubi North Adamawa Nigeria which were 1.87, 2.26 and 1.48 μSv/h at 100 m for mobile phone base station respectively [16]. The radiation dose value measured in the study varies in agreement with the fact that the strength of the radiation field is greatest at the source and diminished quickly with distance.

Table 7. Radiation Dose from MPBS (SP 7)

S/N	Distance	Radiation Dose	Base Station Location (GPS)	
	(m)	μSv/hr	Northing	Easting
1	10	12.76	0596052	0813841
2	20	12.68	0596056	0813844
3	30	10.34	0596060	0813846
4	40	8.91	0596063	0813849
5	50	8.36	0596068	0813852
6	60	6.41	0596071	0813857
7	70	4.03	0596073	0813860
8	80	3.48	0596078	0813863
9	90	3.09	0596080	0813866
10	100	1.26	0596085	0813870
	Average	7.13		
	Range	1.26-12.76		

Table 8. Radiation Dose from MPBS (SP 8)

S/N	Distance	Radiation Dose	Base Station Location (GPS)	
	(m)	μSv/hr	Northing	Easting
1	10	15.63	0596810	0812277
2	20	14.08	0596807	0812275
3	30	13.86	0596806	0812272
4	40	13.31	0596805	0812271
5	50	12.98	0596803	0812269
6	60	10.04	0596801	0812267
7	70	8.43	0596800	0812266
8	80	4.86	0596798	0812264
9	90	4.22	0596797	0812263
10	100	3.04	0596796	0812261
	Average	10.05		
	Range	3.04-15.63		

Table 9. Radiation Dose from MPBS (SP 9)

S/N	Distance	Radiation Dose	Base Station Location (GPS)	
	(m)	μSv/hr	Northing	Easting
1	10	12.98	0596864	0812198
2	20	12.76	0596863	0812200
3	30	12.21	0596860	0812202
4	40	11.88	0596857	0812204
5	50	11.55	0596854	0812208
6	60	8.43	0596852	0812212
7	70	6.27	0596850	0812214
8	80	3.11	0596848	0812216
9	90	1.45	0596845	0812218
10	100	0.72	0596842	0812222
	Average	8.14		
	Range	0.72-12.98		

Table 10. Radiation Dose from MPBS (SP 10)

S/N	Distance	Radiation Dose	Base Station Location (GPS)	
	(m)	µSv/hr	Northing	Easting
1	10	15.57	0596813	0812101
2	20	13.64	0596817	0812100
3	30	13.31	0596821	0812099
4	40	12.65	0596825	0812099
5	50	12.21	0596827	0812096
6	60	7.74	0596832	0812095
7	70	4.88	0596835	0812093
8	80	3.46	0596739	0812089
9	90	3.01	0596741	0812087
10	100	1.63	0596742	0812082
	Average	8.81		
	Range	1.63-15.57		

**MPBS (Mobile Phone Base Station)* **SP (Sampling Point)*

The values reported were also higher than 0.3 µSv/hr reported for radiation dose during the day at Yalvac, Turkey [17], the present values were also higher than 0.50 µSv/hr reported for Public Health of England [18]. The mean value from the study was higher than reported values of 0.29 µSv/hr [19] but was lower than the values of 50 µSv/hr reported by Farai and Ayinmode [20]. The assumption from the result is that the radiation exposures from MPBS impose no health hazard as the limits recommended in the guidelines by International Commission on Non-Ionizing Radiation Protection (ICNIRP) do not appear to have any known adverse consequence on human health.

However, the continuous exposure of the human body to radiation has reported causing weakness of immune system [12] and such disturbances increase the probability of causing diseases. Generally, the variations of radiation dose with distance from mobile phone base stations were observed to obey inverse square law i.e. intensity diminishes quickly with distance from the tower. The observation was in agreement with other international and national studies. Therefore, it is presuming that mobile phone base stations could constitute any potential health hazard to the public. The devices should be operated in accordance with established safety standard to avoid any adverse health effect.

The values reported for this present study showed that all mean radiation dose from various locations ranged between 7.13 µSv/hr at sampling point 7 to 11.28 µSv/hr at sampling point 2 of the sampling points respectively. All values reported were higher than the recommended average value of 0.71 µSv/hr and a maximum value of 5.7 µSv/hr given by the American Nuclear Society for Mobile Phone Base Stations. However, the values reported are not high enough to cause a heating effect on people living close to the base stations.

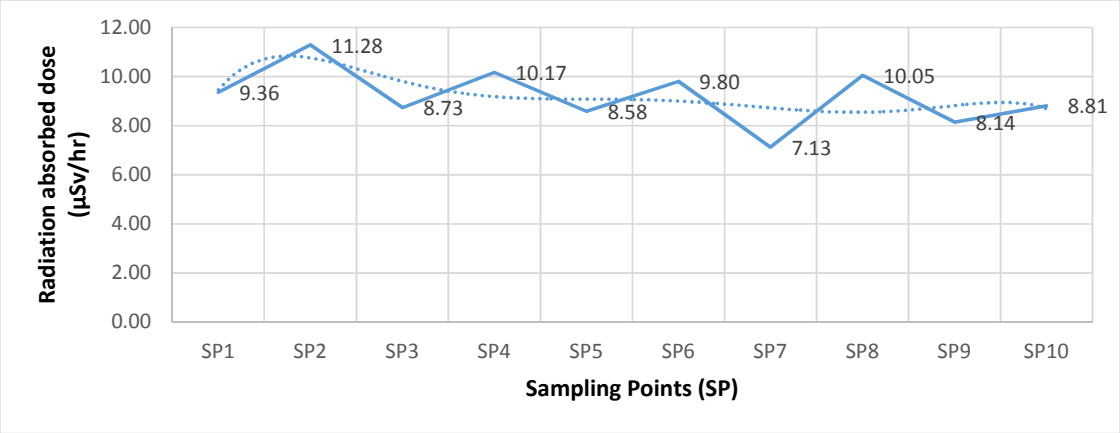

Fig. 3. Mean radiation absorbed doses from sampling points 1- 10 in the study area.

Table 11. Radiation from all sampling locations

Distance	Radiation Dose (μSv/hr)										
(m)	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10	Mean Dose
10	18.23	16.83	16.43	18.25	13.37	14.93	12.76	15.63	12.98	15.57	15.50
20	16.06	15.07	13.09	14.96	11.6	14.08	12.68	14.08	12.76	13.64	13.81
30	13.45	14.96	10.94	14.74	11.32	13.82	10.34	13.86	12.21	13.31	12.90
40	10.23	14.85	10.78	14.52	10.93	13.77	8.91	13.31	11.88	12.65	12.18
50	9.64	14.52	9.13	9.33	10.16	13.09	8.36	12.98	11.55	12.21	11.10
60	9.52	12.63	6.82	9.33	8.91	7.54	6.41	10.04	8.43	7.74	8.74
70	6.08	10.45	6.15	8.39	8.35	7.16	4.03	8.43	6.27	4.88	7.02
80	5.19	6.23	5.43	5.6	4.63	5.22	3.48	4.86	3.11	3.46	4.72
90	3.92	5.07	5.06	4.68	4.18	5.08	3.09	4.22	1.45	3.01	3.98
100	1.26	2.15	3.48	1.93	2.34	3.26	1.26	3.04	0.72	1.63	2.11

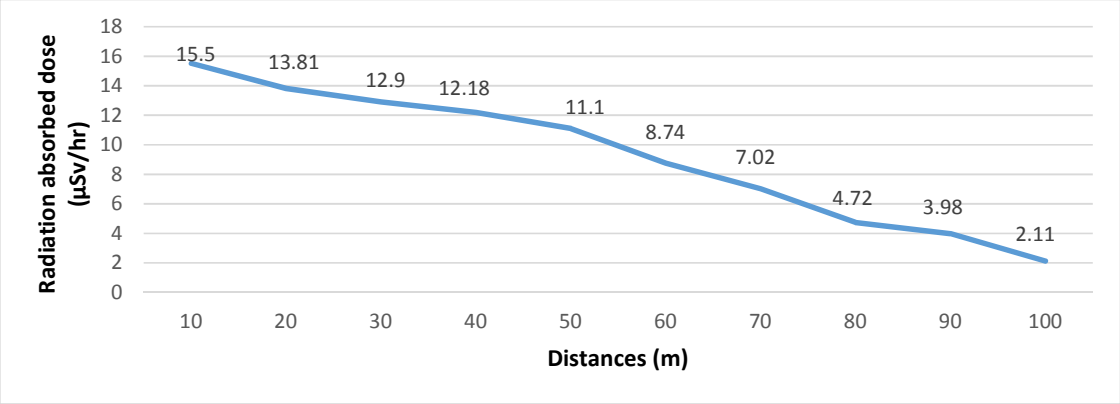

Fig. 4. Mean radiation absorbed doses with respect to distances from the mobile phone base stations

Table 11 shows that values of radiation dose measured at mobile phone base stations were similar and that the amount of radiation decreases rapidly as distance from the mobile phone base station increases.

4. CONCLUSION

The study has provided data on the radiation dose from Mobile Phone Base Stations in Ibadan, Oyo state, Southwestern Nigeria. The results showed that the maximum radiation dose in Ibadan is 16.94 μSv/hr and the mean radiation dose 13.53 μSv/hr for all locations understudied. The result from the study indicated that exposure of people to radiofrequency radiation from mobile phone base station in Ibadan is higher than the average and maximum values recommended by the American Nuclear Society but far less than the levels recommended by International Guidelines for Protection against Established Health Effects (ICNIRP reference level). However, the effect of exposure to low radiations from base stations can only be heating effect of the body tissues. Therefore, the inhabitants of the study area should not raise any anxiety on the health impact due to the radiation exposure from mobile phone base stations.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/46939