

Preliminary Studies of Radiofrequency Radiation Emitted from Mobile Phone and its Health Implications

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ABSTRACT

The research work aimed to study the Radiofrequency radiation emitted from mobile phone and its health implications. The experiment was carried out in the dark room (research room) of Physics Department Modibbo Adama University(MAU), Yola where the light meter sensor was used to obtain the intensities of the radiation coming from the surface of the mobile phone at normal and while ringing, at morning, afternoon and at night. The results obtained shows that 2G SIM card of MTN gave the highest intensity for both normal condition and while ringing at 0 cm, 0.7031 Wm⁻² and for 3G is 0.6715 Wm⁻² at 0 cm and 4G is 0.6004 Wm⁻² at 0 cm, when mobile phone was ringing, the intensities for 2G, 3G and 4G at 0 cm are 0.81765 Wm⁻², 0.7505 Wm⁻² and 0.7268 Wm⁻² respectively, for morning reading. The highest value for the half distance is 79.67 cm and the lowest value obtained showed 0.0168 cm. The lowest absorption coefficient is 0.0163 Wm⁻² cm⁻¹ and the highest value is 0.0283 Wm⁻² cm⁻¹. The highest value of peak intensity is 0.5469 Wm⁻² and the lowest is 0.5180 Wm⁻². Whereas the results of afternoon and night followed the same pattern. The result obtained in this work is higher than the result obtained in Ojuh and Isobana (2015). The result is also higher than that of the recommended value by the International Commission on Non-ionizing radiation protection (ICNIRP). The effects that this may cause includes blood brain barrier, eye pain and weakness, and brain tumor.

1. Introduction

In physics, Radiation is the emission or transmission of energy in the form of waves or particles through a space or medium. Also, Radiation can be described as energy or particles from a source that travel through space or mediums. Light, heat, and the microwaves used for wireless communication are all forms of radiation. Radiation includes particles and electromagnetic waves that are emitted by some materials and carry energy given by

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

The term RF (radiofrequency) refers to the parts of the electromagnetic spectrum that can be readily used for radio communications purposes and which lie below the infrared region. Specifically, for this document, frequencies in the range of 100 kHz to 300 GHz. Frequency bands within this range have been named more formally by the International Telecommunications Union (ITU).

Bands, together with the ranges of frequencies commonly used for various applications, including those for telecommunications, in medicine, and for industry. Human exposure to RF fields may arise from their deliberate use for example, as part of the global telecommunications networks or adventitiously, as part of industrial and other processes utilising RF energy. The term radio wave is used to denote a radiofrequency electromagnetic field that is transmitted from a source for communications purposes, while the term microwave can be used to refer to RF fields with frequencies between 300 MHz and 300 GHz. The significant of this research it that, it will assist the individual/relevant bodies to know the health implications of the radiofrequency radiation that is emitting from GSM smart phone. The contribution of this work is that, individuals and government can use the result for awareness.

2. Literature review

Alanko *et al.* (2007) considered exposure of workers to radiofrequency fields and was assessed in two

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medium-sized antenna towers. The towers had transmitting antennas from different network (mobile phone networks, radio and digital TV sub-stations and amateur radio. It was found that, the levels of radiofrequency fields measured close to the ladders of the towers were below ICNIRP. In Asiegbu *et al.* (2011), the results obtained for the assessment of radiofrequency power density distribution around GSM and broadcast antenna masts in Lagos City, Nigeria varied between 0.29 and 302.40 mWm⁻² from the studied based stations. The result was very low when compared with the standard of ICNIRP and IEEE/ANSI which are 12000 mWm⁻² and 5700 mWm⁻². It was concluded that power densities of the RF radiation from telecommunication transmitting/receiving antennae were far below international standard limits. The measured values are not likely capable of inducing significant hazardous health effects among the people that are at least 6 m away from the antennae.

According to Maheep (2015), the effect of mobile phone Radiation on human health is the interesting subject as a result of the enormous increase of mobile phone use throughout the world. Special attention has been drawn to the biological effects of electromagnetic field (EMF) in general, particularly on human nervous system. It is estimated that currently six Billion people worldwide using mobile phones. Digital cellular phones using the GSM system transmits information in Burst of microwaves (electromagnetic waves ranging in frequency from 300 MHz to 300 GHz). As mobile phone and other wireless gadgets are held closer to the body, especially near the brain, these devices are potentially the most dangerous source of electromagnetic radiation that the average person is exposed to. This has given rise to an increasing concern for any unknown effects that may be potentially detrimental to human health. Antennas of modern mobile telephones are located close to the head and the radiations from the base stations are distributed all over the areas around it. There is now an added worry, if these radiations are casino genic or tumour promote or have any other health implications. The amount of the power which sent from a base stations could vary from cell phone to another one even within the same area, depending on the interfering from obstacles such as building and trees. Although cell phone was designed to operate at power level below a threshold for unknown thermal effects, radiofrequency Radiation could produce other kind's effects, called biological effects (Ashraf 2014). For GSM phones and base stations, a 0.58 mS pulse is transmitted, every 4.6 mS, resulting in pulse modulation at a frequency of 217 Hz; pulsing also occurs at 8.34 Hz and at certain other frequencies because of changes in the pattern of bursts produced. For TETRA handsets and mobile terminals, the main pulse frequency is 17.6 Hz. (Ashraf, 2016).

Power density(S). equals the electric field strength (E) multiplied by the magnetic field strength (H);

$$\mathbf{S} = \mathbf{E} \times \mathbf{H} \quad (2)$$

Power density decreases with increasing distance from the source because the waves spread out as they travel. In free space, power density in the far field follows the inverse square law (S is proportional to 1/d², where d is the distance from the source).

$$S \propto \frac{1}{d^2} \quad (3)$$

When categorise human exposure, it is important to account consistently for the signal characteristics of particular communication systems when summing them together in the context of a chosen exposure metric. This involves considering whether the waveform is continuous or intermittent and whether the way information was carried affects important aspects of the signal (Foster and Repacholi, 2004).

As mentioned earlier, RF sources give rise to electric and magnetic fields and these fields in turn can induce currents or raise temperature inside the human body. It is therefore important to assess the strength of the fields in order to protect the body from harmful effects. The physical quantities (E and H, and to some extent the induced current) can be directly measured outside the body, while the dosimeters quantities (induced current density or rise in temperature) are mainly assessed by indirect means inside the body. Here the methods used to measure electric and magnetic fields outside the human body are explained. Dosimetry quantities are critically assessed There is no single method to evaluate the electric and magnetic field components of an RF source. This is because the type and characteristics of different sources vary greatly.

In addition, the magnitude and direction of E and H vary throughout space and over time. Other factors affecting the measurements of electric and magnetic field strengths are: the frequency and power of the source, the modulation of the signal, the propagation and fading of the signal, the radiation pattern and direction of propagation, the polarisation of the field, and the physical environment. Measurement approaches also differ when the exposure is considered in the near-field or far-field regions. For all the factors mentioned above, it is important to follow a standard protocol for assessing the electromagnetic field strengths, in particular when the purpose of the assessment is to

demonstrate compliance with exposure guidelines. To achieve harmonisation, technical standards are provided by international standardisation bodies such as the International Electro Technical Commission (IEC), the European Committee for Electro Technical Standardisation (CENELEC) and the Institute of Electrical and Electronic Engineers (IEEE). As for all electromagnetic radiation, high frequency electromagnetic fields carry energy. When the body is exposed to radio waves, some of the energy is absorbed from the waves, a direct effect which leads to heating of the body tissues (World Health Organization, 1993). Contact with a radio antenna or metallic conductor placed in an RF field can lead in some circumstances to electric shock or burn, indirect effects that result from current flow in the body tissues (Chatterjee *et al.*, 1986). Shock is related to electro stimulation of tissues and burn occurs due to intense and rapid localised heating. At frequencies below 100 kHz, the physical quantity identifiable with most biological effects is the electric field strength in tissue, which is related to the current density. However, at the higher (RF) frequencies considered here, the rate at which the body is heated is a more appropriate measure to assess the exposure. The absorption of energy from radio waves causes molecules to vibrate, which in turn leads to heating of body tissues. This heating is governed by a quantity known as the specific energy absorption rate (SAR), with units of watt per kilogram (Wkg^{-1}). The SAR is derived from the square of the (instantaneous) electric field strength, E , in tissue where σ and ρ are the conductivity (in Siemens per metre, Sm^{-1}) and the density (kgm^{-3}), respectively, of the tissue of interest.

The SAR provides a measure of the power absorbed from the radiation per kilogram of body tissue. It is a measure of the energy absorption inside the body and is often used as a proxy for the amount of heating or temperature rise in the body. The SAR provides the link between exposure to an external RF field, whose strength is quantified in terms of power density, and temperature rise inside the body. The SAR cannot be measured easily in a living human and is usually estimated from simulations using experimental or computer-based models of the human body.

According to Vijayalaxmi *et al.* (2008), the potential of in vitro and /or in vivo exposure of radio-frequency (R.F) radiation to damage the genetic material in mammalian somatic cells was examined. Their result indicates that, the difference between RF- radiation exposure was small with few exceptions, at certain RF radiation exposure conditions, there were statistically significant increases in genotoxicity for some end points, the mean indices for chromosomal aberrations and micronuclei in RF-radiation –exposed and sham-/unexposed controls were within the spontaneous levels as reported in the historical database.

In the research carried-out by Akintowa *et al.* (2009), on ‘the hazard of non-ionizing radiation from telecommunication mast on exposed community were assessed and result indicates that, the hazard profile showed majority (62%) having different symptoms with headache being the most frequent (51.6%), similar to other established findings. There is significant synergistic relationship between high voltage cable and telecom mast on the health effect. (Jama, 2000), worked on handheld cellular telephone use and risk of brain cancer, from their results they have concluded that, their data suggest that use of handheld cellular telephones is not associated with the risk of brain cancer, and stated it clear that further studies are highly needed to account for longer induction periods, most especially for slow-growing tumour with neuronal features.

(Khurana Vini, 2008), work suggested that, there are currently enough evidence and technology available to warrant taking immediate steps to reduce exposure of consumers to cell-phone-related electromagnetic radiation.

3. Materials and Method

3.1 Materials

The materials used are EI 200k Digital light meter, Meter rule, Three different of Network of 2G, 3G and 4G respectively and Tecno smartphone (camon 12)

3.1.1 EI200k Digital Light Meter and Specification

The echo logistic el200k is a digital light meter for evaluating lighting at work places and at home. It provides reliable light level reading from 1 to 200,000 lux. The light meter has a sensor that measure the light falling on it and provide the user with a measurable IL luminance reading. The specification of EI200K Digital light meter are as follows; Measurement range: 1 to 200,000 lux (0.1 to 18581fc) , Accuracy: 4% (0.1-10,000 lux), 10% above 10,000 lux , Resolution: 1 lux /0.1 fc, Sampling time: 500mS, operating temperature: 32 to 122 F (0 to 50 °C) operating humidity: 10 to 90% RH, Storage temperature 14 to 140 F (-10 to 60 °C), storage humidity: 10 to 75% RH, Size: 9.5 × 2.5 × 1.5 (240 mm × 65 mm × 38 mm), detachable sensor with 3 ft/1 m cable, Weight: 10.6 oz (300 g) and batteries included.

3.1.2 Meter Rule

A meter rule is a device which is used to measure the length of different objects. A meter rule of length 1m is equal to 100 centimetres (cm). On meter rule each centimetre meter is divided further into 10 divisions which are called millimetres (mm). So, a meter rule can measure up to 1 mm as smallest reading.

3.2 Method

The GSM smart phone radiation is detected using the digital light meter that contains a sensor which sense the radiation and displays, it on the LED screen, and the meter rule is used by taking the measurement or varying the distance between the GSM smart phone and the digital light meter. The three (3) different sim cards was exchanged or swapped in the GSM smart phone to take their readings.

3.2.1 Method of Data Analysis

The research made use of tables and graphs to analyse the radiofrequency radiation that GSM smart phone emits. The table was also used to present detailed implementations schedule for the radiofrequency radiation that smart phones emits.

4. Result and Discussion

Table 1: 2g Morning reading at normal condition

S/N	D(cm)	INTENSITY IN (LUX)	INTENSITY IN (Wm^{-2})	LOG I
1	0	89	0.7031	-0.1530
2	5	42.5	0.33575	-0.4740
3	10	25	0.1975	-0.7044
4	15	15.5	0.12245	-0.9120
5	20	11	0.0869	-1.0610
6	25	8	0.0632	-1.1993
7	30	6	0.0474	-1.3242
8	35	4.5	0.0355	-1.4498
9	40	4	0.0316	-1.5003
10	45	3	0.0237	-1.6253
11	50	2	0.0158	-1.8013
12	55	1.5	0.01185	-1.9263
13	60	1	0.0079	-2.1024
14	65	1	0.0079	-2.1024
15	70	0	0	0
16	75	0	0	0

Table 2: 2g Morning reading at ringing condition

S/N	D(cm)	INTENSITY IN (LUX)	INTENSITY IN (Wm^{-2})	LOG I
1	0	103.5	0.81765	-0.0874
2	5	50.5	0.39895	-0.3991
3	10	26	0.2054	-0.6874
4	15	17	0.1342	-0.8722
5	20	11.5	0.09085	-1.0417
6	25	7.5	0.05925	-1.2273
7	30	6.5	0.05135	-1.2895
8	35	5	0.0395	-1.4034
9	40	4	0.0316	-1.5003

10	45	3	0.0237	-1.6253
11	50	2	0.0158	-1.8013
12	55	1.5	0.01185	-1.9263
13	60	1	0.0079	-2.1024
14	65	1	0.0079	-2.1024
15	70	1	0.0079	-2.1024
16	75	0	0	0

Table 3: 2g Afternoon reading at normal condition

S/N	D(cm)	INTENSITY IN (LUX)	INTENSITY IN (Wm^{-2})	LOG I
1	0	76	0.6004	-0.2216
2	5	46.5	0.36735	-0.4350
3	10	26.5	0.20935	-0.6792
4	15	16.5	0.13035	-0.8849
5	20	11.5	0.9085	-0.0420
6	25	9	0.0711	-1.1481
7	30	5.5	0.04345	-1.3620
8	35	4.5	0.03555	-1.4492
9	40	3	0.0237	-1.6253
10	45	2	0.0158	-1.8013
11	50	2	0.0158	-1.8013
12	55	1	0.0079	-2.1023
13	60	1	0.0079	-2.1023
14	65	1	0.0079	-2.1023
15	70	0.5	0.00395	-2.4034
16	75	0	0	0

Table 4: 2g Afternoon reading at ringing condition

S/N	D(cm)	INTENSITY IN (LUX)	INTENSITY IN (Wm^{-2})	LOG I
1	0	78.5	0.62015	-0.2075
2	5	53.5	0.42265	-0.3740
3	10	32	0.2528	-0.5972
4	15	18.5	0.14615	-0.8352
5	20	13	0.1027	-0.9884
6	25	9.5	0.07505	-1.1246
7	30	7	0.0553	-1.2573
8	35	5	0.0395	-1.4034
9	40	4	0.0316	-1.5003
10	45	3	0.0237	-1.6253
11	50	2	0.0158	-1.8013

12	55	2	0.0158	-1.8013
13	60	1	0.0079	-2.1024
14	65	1	0.0079	-2.1024
15	70	1	0.0079	-2.1024
16	75	0	0	0

Table 5: 2g Night reading at normal condition

S/N	D(cm)	INTENSITY IN(LUX)	INTENSITY IN (Wm ⁻²)	LOG I
1	0	81	0.6399	-0.1939
2	5	45	0.3555	-0.4492
3	10	27.5	0.21725	-0.6630
4	15	16	0.1264	-0.8983
5	20	12	0.0948	-1.0232
6	25	9	0.0711	-1.1481
7	30	6.5	0.05135	-1.2895
8	35	4.5	0.03555	-1.4492
9	40	3.5	0.02765	-1.5583
10	45	2.5	0.01975	-1.7044
11	50	2	0.0158	-1.8013
12	55	2	0.0158	-1.8013
13	60	1	0.0079	-2.1024
14	65	1	0.0079	-2.1024
15	70	1	0.0079	-2.1024
16	75	0	0	0

Table 6: 2g Night reading at ringing condition

S/N	D(cm)	INTENSITY IN (LUX)	INTENSITY IN (Wm ⁻²)	LOG I
1	0	85	0.6715	-0.1730
2	5	51	0.4029	-0.3948
3	10	29.5	0.23305	-0.6326
4	15	18.5	0.14615	-0.8352
5	20	12.5	0.09875	-1.0055
6	25	8.5	0.06715	-1.1730
7	30	6.5	0.05135	-1.2895
8	35	5	0.0395	-1.4034
9	40	3.5	0.02765	-1.5583
10	45	3	0.0237	-1.6253
11	50	2	0.0158	-1.8013
12	55	1.5	0.01185	-1.9263
13	60	1	0.0079	-2.1024
14	65	1	0.0079	-2.1024
15	70	0	0	0

16

75

0

0

0

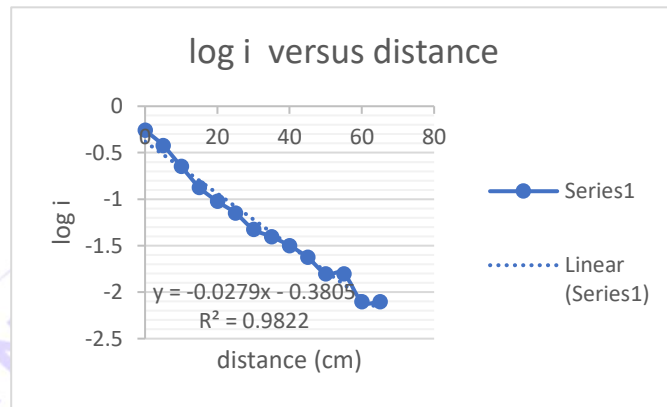


Figure 1: A graph of log I against distance D(cm)

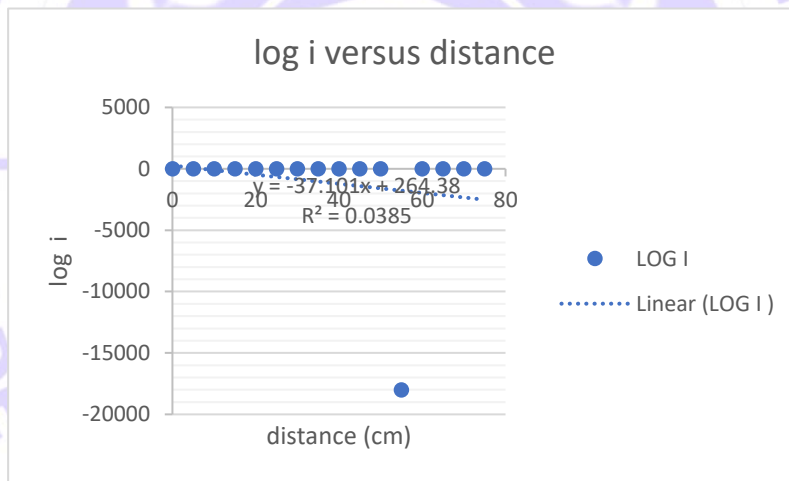


Figure 2: A graph of log I against distance D(cm)

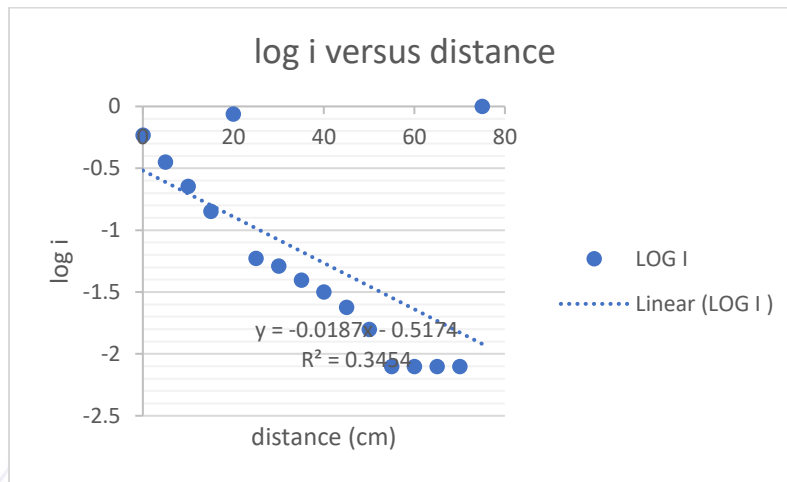


Figure 3: A graph of log I against distance D(cm)

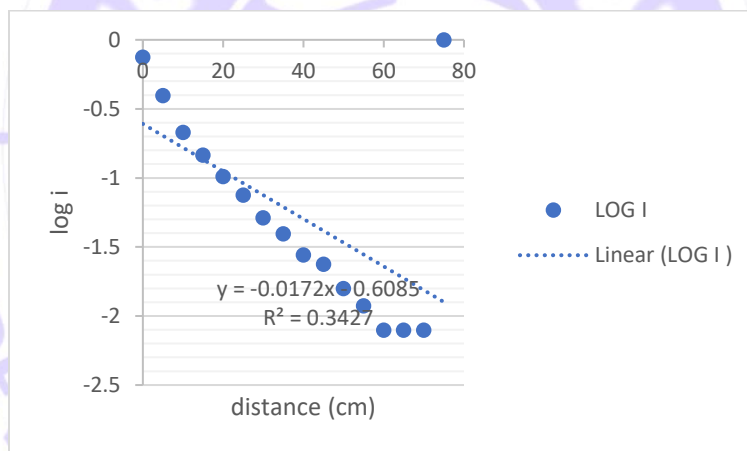


Figure 4: A graph of log I against distance D(cm)

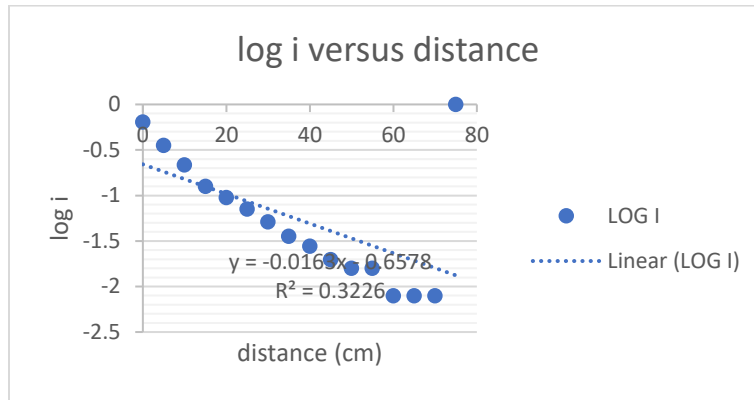


Figure 5: A graph of log I against distance D(cm)

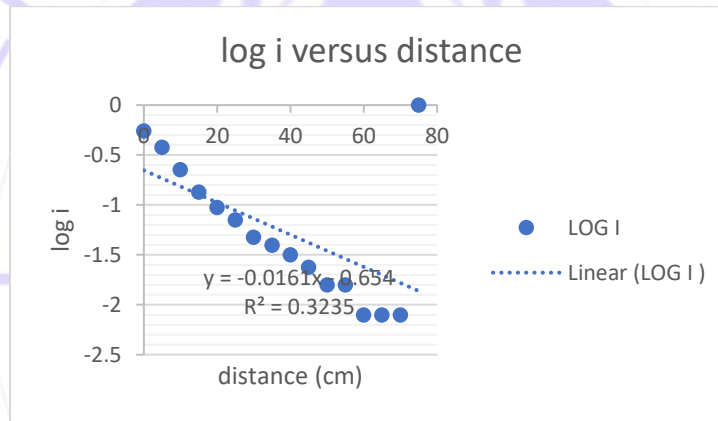


Figure 6: A graph of log I against distance D(cm)

Table 1 The phone was ON during the experiment as the light showed, the sensor of the light meter was brought close to the phones and the variation of intensity at different distances were obtained. The result showed that at zero (0 cm) distance, the intensity was highest with the value of 0.7031 Wm^{-2} . Then at 5cm, the intensity decreased close to half of the initial intensity. As the distance increased the intensity continue to decrease until at 30 cm distance that the decrease in intensity was less compared to when the sensor of the light meter was close to the surface of the phone. At 60 cm distance and 65 cm distance, the intensities were both at 0.0079 Wm^{-2} and at 70 cm and 75 cm, the intensities have the same value, 0 Wm^{-2} .

In Table 2, because the phone was ringing the intensity obtain was higher than when the phone was not ringing with the value of 0.81765 Wm^{-2} at zero (0 cm) distance. The table followed almost the same pattern with table 4.1, until at 25 cm, 30cm, 35 cm, 40 cm, 45 cm, 50 cm where the variation in intensities are 0.05925 Wm^{-2} , 0.05135 Wm^{-2} , 0.03955 Wm^{-2} , 0.0316 Wm^{-2} , 0.0237 Wm^{-2} and 0.0158 Wm^{-2} which implies that, the difference in intensities are not much compared to when the sensor was close to the surface of the mobile phone. Still at 60 cm, 65 cm and 70 cm the intensities were the same 0.0079 Wm^{-2} and at 75 cm the sensor measured zero intensity.

Table 3 showed the result obtained for 2G SIM card network in afternoon when the phone was at normal condition (not ringing). The intensity was 0.6004 Wm^{-2} when the distance between the phone surface and the sensor was zero (0 cm). At 5 cm the intensity dropped to nearly half of when the phone was at 0 cm, which is 0.36735 Wm^{-2} . Around 30 cm down to 55 cm the variation in intensity is not much, it around a difference of 0.0079 Wm^{-2} . At 55 cm, 60 cm and 70 cm there is completely no difference in intensities as distance continuously increased. At 75 cm the

intensity was 0 Wm^{-2} indicating no light intensity at a very far distance from the source.

Table 4 showed afternoon reading when the mobile phone was ringing. The intensity at 0 cm was a little bit greater than the intensity obtained when the phone was at normal condition with the value 0.62015 Wm^{-2} . When the sensor was kept at 5 cm the intensity obtained was 0.42265 Wm^{-2} . The intensity continued to decrease with increased in distance. The table also showed that 25 cm, 30 cm, 35 cm, 40 cm, 45 cm and 50 cm. The intensities were 0.07505 Wm^{-2} , 0.0553 Wm^{-2} , 0.0395 Wm^{-2} , 0.0316 Wm^{-2} , 0.0237 Wm^{-2} and 0.0158 Wm^{-2} and the difference was not that much. At 60 cm and 65 cm, and 70 cm it showed constant value of the intensity obtained.

Table 5 showed that the reading obtained at night for normal condition of the phone, the intensity at 0 cm was 0.6399 Wm^{-2} , at 5 cm it was 0.3555 Wm^{-2} : the intensity continued to decreased with wide gap until at 20 cm, 25 cm, 30 cm, 35 cm, 40 cm, 45 cm and 50 cm that the intensity does not vary very much and the intensities were 0.0948 Wm^{-2} , 0.0711 Wm^{-2} , 0.05135 Wm^{-2} , 0.02765 Wm^{-2} , 0.01975 Wm^{-2} , 0.0158 Wm^{-2} . Around 60 cm, 65 cm and 70 cm there was constant value is 0.0079 Wm^{-2} . At 75 cm there was no intensity obtain.

Table 6 indicated the intensity obtained when the phone was ringing and in contact with the light sensor was 0.6715 Wm^{-2} which is higher than the intensity obtained when the phone was at normal condition at 0 cm. as usual the intensities continue to decrease with significant difference until around 25 cm, 30 cm, 35 cm, 40 cm, 45 cm, 50 cm and 55 cm, with their intensities; 0.06715 Wm^{-2} , 0.05135 Wm^{-2} , 0.0395 Wm^{-2} , 0.02765 Wm^{-2} , 0.037 Wm^{-2} , 0.0158 Wm^{-2} and 0.01185 Wm^{-2} respectively which shows less difference in the value of intensities for this distances. At 60 cm and 65 cm there was only a constant value of intensity while at 75 cm there was a 0 Wm^{-2} intensity.

5. Conclusion

In physics, radiation is the emission or transmission of energy in the forms of waves or particles through a space or medium. Also radiation can be described as energy or particles from a source that travel through a space or medium. Light, heat, and microwaves used for wireless communication are all form of radiation. Includes particles and electromagnetic waves that are emitted by some materials and carry energy. The results obtain from Tables 4.1 to 4.6 showed that intensity varies with distance, the tables also indicated that 2G SIM card give higher intensity than 3G and 4G SIM cards. It could be seen clearly that for all the readings taken, the intensity vanished at 70 cm. The results obtained from the experiments pointed out that, intensity decreases with increase in distance which its graph obeyed de-lambert law, also when mobile phone was ringing gives more intensity than at normal condition. The results also clearly showed that morning and night reading gives higher values of intensity than in the afternoon reading. This implied that temperature may also have effect on the intensity. 2G SIM card network produced more intensity compared to 3G SIM card network and 4G SIM card network. Our results agrees with the results obtained in Ojuh and Isabona (2015). Their results for different networks are very closed to ours.

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