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ELECTROMAGNETIC RADIATION EXPOSURE FROM MOBILE CELL PHONE DEVICES TO ITS VICINITY- A STUDY

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Abstract

Cell phones use Electromagnetic non ionizing radiations in the microwave range, and emit radiation energy in the form of Electromagnetic radiation. The electromagnetic radiations have very adverse effects not only related to the human health issues causing various diseases, but it may also affect the performance of a device and degrade its performance. The current study was accepted with an endeavor to come across the Electromagnetic radiation exposure level from mobile cell phone to its vicinity in terms of power density and electric field. Three different cases have been considered. In the first case Android cell phone with hotspot active mode was considered, in the second case hotspot was kept in deactivate mode while in the third case ordinary cell phone was used for our study and analysis. It has been observed that the electromagnetic radiation exposure level in the third case (ordinary cell phone) was eventually much higher as compared to all other cases over the investigated region. The finding of our study also includes that for all the cases the EM exposure level complies with the guidelines and limits set by the International Commission on Nonionized Radiation Protection (ICNIRP) for the exposure of non-ionized radiation in the form of electromagnetic field, power density or Specific Absorption Rate (SAR).

Keywords:

Electric Field, Electromagnetic Radiation, Mobile cell phone, Power Density, SAR

1. INTRODUCTION

With rapid development in the area of wireless communication, the uses of mobile cell phones and its applications drastically increase in the last few decades. Our daily life is revolutionized with the use of mobile cell phone for all age group people. Thus, atmospheric exposure of electromagnetic radiations is now increasing almost exponentially. Electromagnetic pollution levels are now reaching frightening magnitudes, highlighted by several studies carried out by scientists from all over the world, including large numbers of from India [1, 2]. These electromagnetic radiations have very adverse effects causing various health issues and also affect the performance of a device [3-7]. Thus, the atmospheric exposures of electromagnetic radiations from various sources are now a focus for the scientists and technologists from all over the world to concentrate and accomplish their study and evaluation on it. Mobile cell phones are one of such types of the most widely used device (Source) that continuously emit or radiate radio frequency in the form of electromagnetic radiation. Most of the people do not have any awareness about such type of radiation from cell phone and its adverse effects. Speaking imprecisely to a certain extent up to 2 watts of power can be transmitted by a cell phone in the range of frequency between 824- 849 MHz (CDMA), 890 – 915 MHz (GSM 900) and 1710 – 1780 MHz (GSM 1800), Thus steady revelation to such emissions have an effect on health directly [8-10]. Due to lack of awareness about the undesirable effects of such electromagnetic emission exposure and its correlated health risks, besides disregarding the probable safety measures millions of people are using cell phone for more than an hour regularly. According to the SAR (specific absorption rate) safety border, evaluation of the SAR boundary value of cell phones must be less than 6 W/kg [11-13]. In Fig.1 we have shown the various Sources of Electromagnetic radiations.

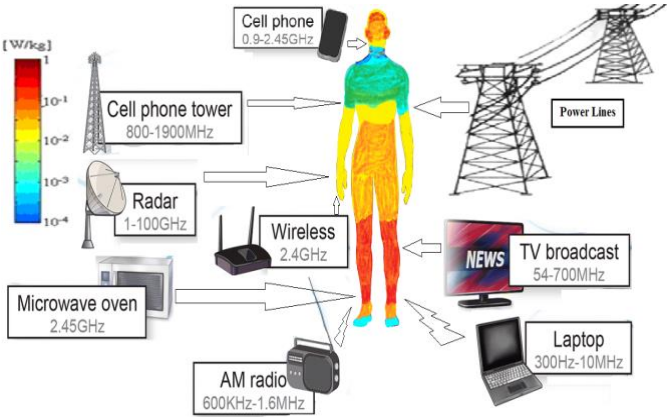

Fig.1. Various Sources of Electromagnetic radiations

The present study was carried out to investigate the electromagnetic radiation exposure level emitted from mobile cell phone in its close vicinity around 1 meter at 10 different co-ordinate positions in terms of power density and electric field. Three different cases have been considered. In the first case electromagnetic radiation exposure level from an Android cell phone was measured keeping hotspot in active mode while in the second case hotspot was kept in deactivate mode and in the third case ordinary mobile cell phone was considered during measuring the EM exposure level. It has been observed that the contribution of EM radiation from ordinary mobile cell phone is much higher as compared to the mobile cell phone with a hotspot in active mode (ON) and hotspot in deactivate (OFF) mode.

2. THEORETICAL INFORMATION

2.1 SPECIFIC ABSORPTION RATE

When a biological system is exposed to the energy which dissipated in the reactive field of an antenna, an internal field is induced in the system. The calculation of this induced field is called the study of dosimetry. Specific Absorption Rate (SAR) is an appropriate metric for evaluation of RF exposure effects on

living organisms. It is defined as power absorbed in a unit mass of tissue and measured differently in different parts of biological systems over a certain period of time. SAR is calculated by Electric field (E) induced in tissue, conductivity (σ), mass density (ρ) of tissue as shown in the equation (1) [18].

$$SAR = \sigma E^2/\rho \quad W/kg \qquad (1)$$

where σ = Electric conductivity of human tissue, E = Electric field strength inside the human body, ρ = Mass density of the biological tissue

In Table.1 we have represented the simulation parameters at 900 MHz and 1800 MHz for SAR calculation.

Table.1. Simulation parameters at 900 MHz and 1800 MHz for SAR calculation

Name of Parameters	Frequency	Value	Description
Sigma_brain (σ)	900 MHz	0.94 [S/m]	Conductivity of brain tissue
Rho_brain (ρ)		1030 [kg/m^3]	Density of brain tissue
Sigma_brain (σ)	1800 MHz	1.39 [S/m]	Conductivity of brain tissue
Rho_brain (ρ)		1030 [kg/m^3]	Density of brain tissue

2.2 ICNIRP/IEEE GUIDELINES FOR RF EXPOSURE

In accordance with the International Electromagnetic field project conducted by WHO in the year 1996 for reviewing the scientific literature on biological effects of electromagnetic field (EMF), some standards were published. The scientific committee of ICNIRP (International Commission on Non-Ionizing Radiation Protection) then prepared a guideline in 0 –300 GHz range for general public and occupational exposure (Table.2). This guideline was then finalized as a legal property by the European Commission by stating that all member countries should obey the guideline [17].

In India, for limiting the EM exposure produced by cell phone the guideline prepared by ICNIRP has been adopted. In Table.3 we have characterized various radio frequency sources in India.

Table.2. ICNIRP general public exposure limits

Frequency (MHz)	E Field (V/m)	Power Density (W/m^2)
1-10	$87/f^{1/2}$	---
10-400	28	2
400-2000	$1.375f^{1/2}$	f/200
2000-300000	61	10

Table.3. Radio frequency sources in India

RF Source	Operating Frequency	Power Transmission	Availability in Numbers
AM/FM Tower	540 KHz-108 MHz	1-300 KW	380
Wi-Fi	24-25 GHz	10-100 mW	----
Cell Tower	800, 900, 1800, 2450 MHz	20 W	5.4 lacs
Mobile Phones	GSM-900	2 W	700 + million

2.3 VARIOUS BIOLOGICAL EFFECTS REPORTED/OBSERVED

Table.4 indicates various biological effects reported/observed in the exposed group [14] - [16].

Table.4. Various biological effects reported/observed in the exposed group

Power Density	Reported Biological Effects	References: Primary/(Secondary)
0.00001 µw/m2	Altered EEG in human subjects	Brise1978 (Firstenberg, Bevington)
0.0001 µw/m2	Effects on immune system in mice	Bundyuk 1994 (Firstenberg)
7 µw/m2	(0.05 v/m) Adverse health effects around GSM 1800	Eger / Naila study (Bevington)
20 µw/m2	Sleep disorders, abnormal blood pressure, nervousness, weakness, fatigue, limb pain, joint pain, digestive problem, - controlled study near a shortwave transmitter	Altpeter 1995, 1997 (Firstenberg)
20 to 7000 µw/m2	Behavior disorders, increased health problems, reduced milk yield in cows near TV and cell phone transmission antenna	Loscher W, Kas G 1998 (Lai)
100 µw/m2	A study of medical complaints of people with long term exposure in their homes. Over 100 µw/m2 only 5-6 % of the sample (172 people) did not experience adverse health effects.	Oberfranken 2005
600 µw/m2	Altered EEG, disturbed carbohydrate metabolism, enlarged adrenals, altered adrenal hormone levels, structural changes in the liver, spleen, testes, and brain- in white rats and rabbits	Dumanskij 1974 (Firstenberg)

600 µw/m2	Slowing of the heart, change in EEG in rabbits	Serkyuk, reported in McRee 1980 (Firstenberg)
1 mW/m2	(0.6v/m) ×3 cancer rate at ≤ 400 m from a phone mast	Eger (Naila study) 2004 (Bevington)
1.3 mW/m2	Decreased cell growth (human epithelial amnion cells)	Kwee 1996 (Firstenberg)
1.6 mW/m2	Skrunda radar (Latvia) affects children's memory, attention	Kolodynski, 1996 (Sage, Bevington)
3 – 16.4 mW/m2	Children exposed to 154 to 162 MHz had a reduction in memory /attention, reflex	(Santini)
6 mW/m2	Change in calcium ion efflux from brain tissue	Dutta 1986 (Firstenberg)
10 mW/m2	Headache, dizziness, fatigue, weakness, insomnia, chest pain indigestion	Simonenko 1998 (Firstenberg)
13 – 57 mW/m2	Two- fold increase in leukemia in adults from AM RF exposure	Dolk, 1997 (Sage)

3. METHODOLOGY

Atmospheric exposure of EM radiation from mobile cell phone devices to its vicinity were opting for the present study. The EM field exposure was measured in terms of power density (µW/cm^2) and electric field (V/m) with the help of three axis electromagnetic field strength meter model KM-195. Fig.2 exhibits the experimental setup for our present study. It is noticed that this meter covering the whole frequency band 300 MHz to 3 GHz is being utilized for cellular mobile communication. The detail specifications of the mobile cell phone devices (Gionee Marathon M4) and ordinary mobile cell phone (Samsung GT-E1207Y) used for the present study are given in Table.5 and Table.6 respectively.

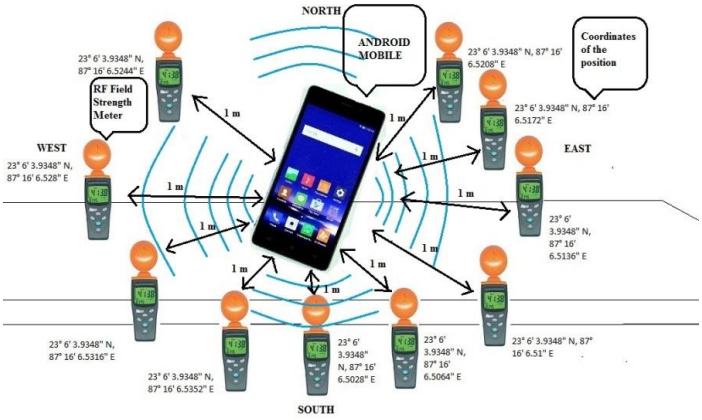

Fig.2. Experimental Setup

Table.5. Specifications of the android mobile cell phone device (Gionee marathon m4) used for the present study

Model	Gionee Marathon M4
Technology	GSM / HSPA / LTE
2G bands	GSM 850 / 900 / 1800 / 1900 - SIM 1 & SIM 2
3G bands	HSDPA 900 / 1900 / 2100
4G bands	LTE band 3 (1800), 40 (2300)
Speed	HSPA, LTE
GPRS	Class 12
EDGE	Class 12
Dimensions	144.7 x 71.2 x 10.2 mm (5.70 x 2.80 x 0.40 in)
Weight	176 g (6.21 oz)
SIM	Dual SIM
Type	Super AMOLED capacitive touchscreen, 16M colors
Size	5.0 inches, 68.9 cm2 (~66.9% screen-to-body ratio)
Resolution	720 x 1280 pixels, 16:9 ratio (~294 ppi density)
OS	Android 5 (Lollipop); Amigo 3
Chipset	MediaTek MT6735
CPU	Quad-core 1.3 GHz Cortex-A7
GPU	Mali-T720 MP2
Architecture	64 bits
Card slot	Micro SD, up to 32 GB (dedicated slot)
Internal	16 GB ROM, 2 GB RAM
Single	8 MP, AF
Features	LED flash, panorama
Video	1080p@30fps
Single	5 MP
Loudspeaker	Yes
3.5mm jack	Yes
WLAN	Wi-Fi 802.11 b/g/n, Wi-Fi, Direct, hotspot
Bluetooth	2.0, A2DP
GPS	Yes, with A-GPS
Radio	FM radio
USB	Micro USB 2.0, USB Host
Sensors	Accelerometer, proximity, compasses
Battery	Non-removable Li-Ion 5000 mAh battery
SAR	0.85 W/kg (head) 0.73 W/kg (body)

Table.6. Specifications of the ordinary mobile cell phone device (Samsung Gt-e1207y) used for the present study

Brand	Samsung
Model	GT-E1207Y
Network Technology	GSM
2G Bands	GSM 900/1800
Battery	Removable Li-Ion 800 mAh Battery

SAR	0.92 W/Kg (head) 0.40 W/Kg (body)
Display	1.51-inch
Resolution	128 × 128 pixels

Here we consider three different cases which are as follows:

Case 1: EMF exposure measured at 10 different co-ordinate positions around 1 meter from the cell phone keeping the hotspot mode active (ON).

Case 2: EMF exposure measured for the same cell phone device at same co-ordinate positions as case1 around 1 meter from the cell phone keeping the hotspot in deactivate (OFF) mode.

Case 3: EMF exposure measured for the ordinary cell phone device at same co-ordinate positions as case1 and case 2 around 1 meter from the cell phone.

All the measurements were carried out under same atmospheric and physical conditions on the same day.

4. RESULTS AND DISCUSSION

The measured EM exposure level from mobile cell phone to its vicinity in terms of power density (µw/cm2) and electric field (V/m) are presented in this section. Three different cases are taken into consideration. In the first case the measured values of EM exposure level, keeping hotspot active are shown in Table.7. Fig.3 shows the graphical representation of the variation of EM exposure level at different coordinates for the first case. Similarly, Table.8 shows the measured values of EM exposure level at different coordinates for the second case (hotspot off) while Fig.4 gives the graphical representation for the case 2. In the third case the variation of EM exposure level from an ordinary cell phone was investigated. Table.9 exhibit the measured values of EM exposure level for case 3 and Fig.5 give its graphical representation. The variations of the SAR value (W/kg) with electric field are presented in Fig.6, 7 and 8 for case 1, case 2 and case 3 respectively.

Table.7. EM exposure in terms of power density (µW/cm²) and electric field (V/m) from mobile cell phone Keeping Hotspot in Active Mode.

Coordinates (Latitude, Longitude)	**Power Density (µW/cm²)**	**Electric Field (V/m)**	**SAR (W/kg) at 900 MHz**	**SAR (W/kg) at 1800 MHz**
23°6'3.9348"N, 87°16'6.5028"E	21.96	11.5	0.120694175	0.178473301
23°6'3.9348"N, 87°16'6.5064"E	17.1	10.16	0.094205887	0.13930445
23°6'3.9348"N, 87°16'6.51"E	22.96	11.86	0.128368955	0.189822179
23°6'3.9348"N, 87°16'6.5136"E	2.713	3.33	0.010119967	0.014964632
23°6'3.9348"N, 87°16'6.5172"E	3.733	4.279	0.016709952	0.024709397
23°6'3.9348"N, 87°16'6.5208"E	6.908	5.552	0.028131283	0.041598387
23°6'3.9348"N, 87°16'6.5244"E	12.473	8.779	0.070336496	0.104008222
23°6'3.9348"N, 87°16'6.528"E	0.8603	2.038	0.003790522	0.005605133
23°6'3.9348"N, 87°16'6.5316"E	0.8973	2.1	0.00402466	0.005951359
23°6'3.9348"N, 87°16'6.5352"E	0.9382	2.125	0.004121056	0.006093902

Table.8. EM exposure in terms of power density (µW/cm²) and electric field (V/m) from mobile cell phone keeping hotspot in deactivate (off) mode

Coordinates (Latitude, Longitude)	**Power Density (µW/cm²)**	**Electric Field (V/m)**	**SAR (W/kg) at 900 MHz**	**SAR (W/kg) at 1800 MHz**
23°6'3.9348"N, 87°16'6.5028"E	7.778	7.007	0.044807928	0.066258532
23°6'3.9348"N, 87°16'6.5064"E	9.716	7.834	0.056008993	0.082821809
23°6'3.9348"N, 87°16'6.51"E	3.676	4.781	0.020860663	0.030847151
23°6'3.9348"N, 87°16'6.5136"E	7.401	6.918	0.043676894	0.064586045
23°6'3.9348"N, 87°16'6.5172"E	10.087	7.934	0.057448014	0.084949723
23°6'3.9348"N, 87°16'6.5208"E	11.62	8.508	0.066061068	0.097686048
23°6'3.9348"N, 87°16'6.5244"E	12.073	8.63	0.06796921	0.100507661
23°6'3.9348"N, 87°16'6.528"E	10.113	7.783	0.05528212	0.081746965
23°6'3.9348"N, 87°16'6.5316"E	9.627	7.331	0.049047522	0.072527718
23°6'3.9348"N, 87°16'6.5352"E	11.262	8.28	0.06256786	0.092520559

Table.9. EM exposure in terms of power density (μW/cm²) and electric field (V/m) from ordinary mobile cell phone

Coordinates (Latitude, Longitude)	Power Density (μW/cm²)	Electric Field (V/m)	SAR (W/kg) at 900 MHz	SAR (W/kg) at 1800 MHz
23°6'3.9348"N, 87°16'6.5028"E	177.7	33.33	1.013821	1.499160749
23°6'3.9348"N, 87°16'6.5064"E	100.66	25.11	0.575419	0.850885261
23°6'3.9348"N, 87°16'6.51"E	187.62	31.04	0.879294	1.30023245
23°6'3.9348"N, 87°16'6.5136"E	185.46	30.76	0.863502	1.27688045
23°6'3.9348"N, 87°16'6.5172"E	152.3	30.86	0.869125	1.285196159
23°6'3.9348"N, 87°16'6.5208"E	74.14	21.17	0.409009	0.604810457
23°6'3.9348"N, 87°16'6.5244"E	66.27	20.12	0.369442	0.546302928
23°6'3.9348"N, 87°16'6.528"E	76.75	22.07	0.444524	0.657328166
23°6'3.9348"N, 87°16'6.5316"E	72.85	21.56	0.424217	0.627299713
23°6'3.9348"N, 87°16'6.5352"E	86.89	23.26	0.493753	0.730124625

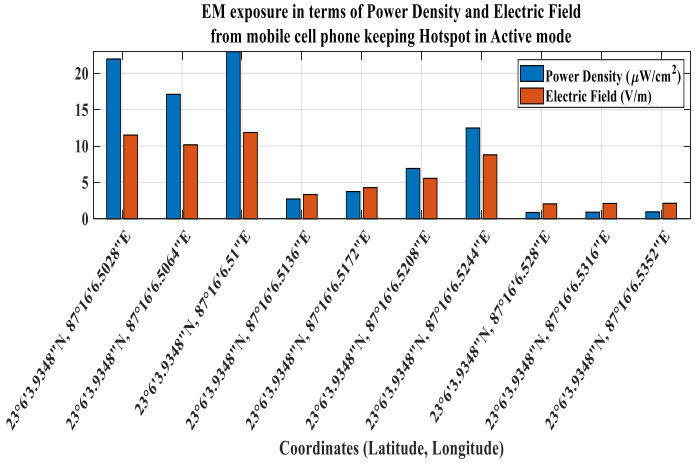

Fig.3. Graphical representation of EM exposure from mobile cell phone keeping hotspot in active mode

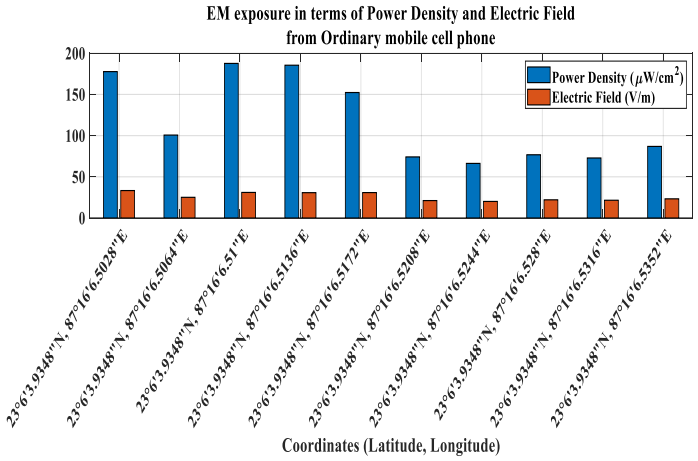

Fig.5. Graphical representation of EM exposure from ordinary mobile cell phone

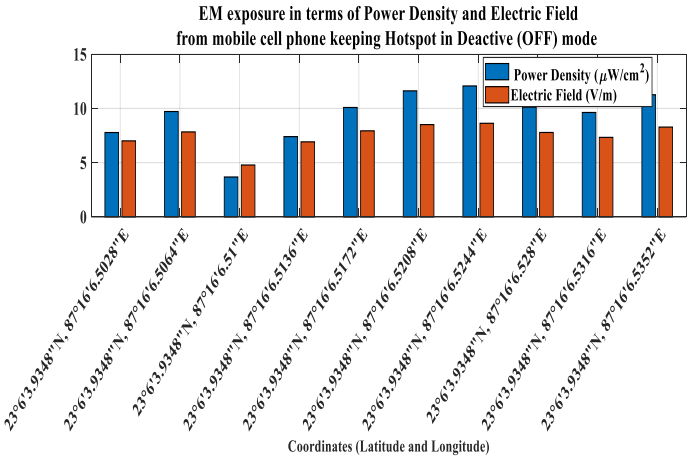

Fig.4. Graphical representation of EM exposure from mobile cell phone keeping hotspot in deactivate (OFF) mode

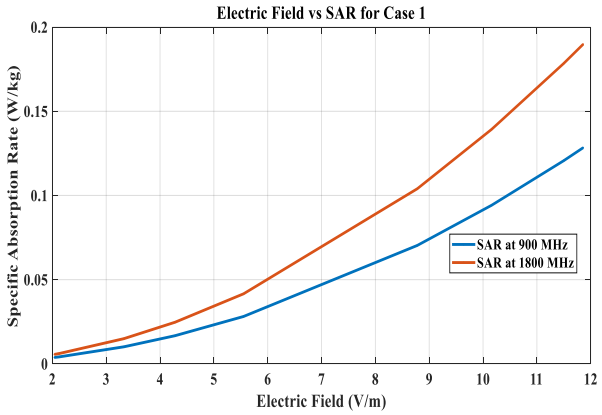

Fig.6. Variation of SAR with Electric field for Case 1

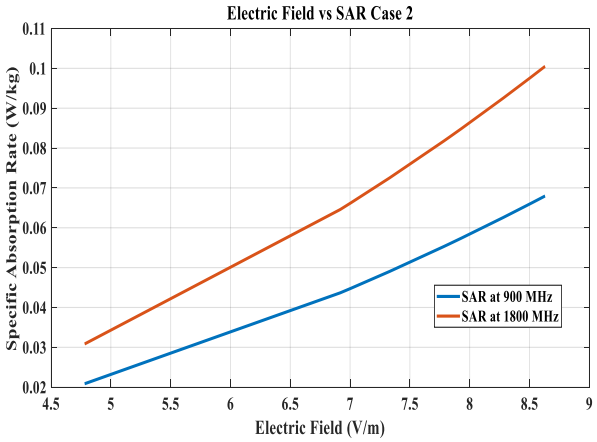

Fig.7. Variation of SAR with Electric field for Case 2

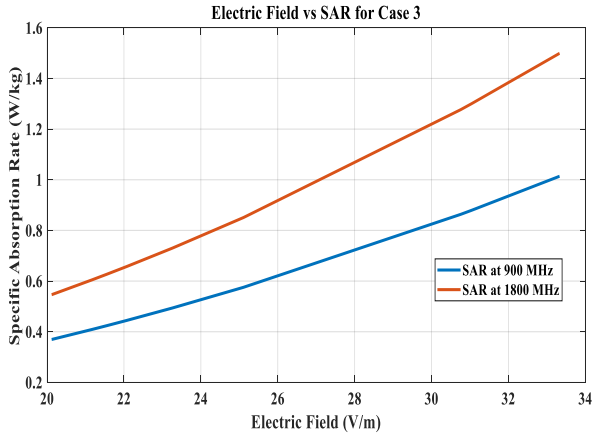

Fig.8. Variation of SAR with Electric field for Case 3

It has been observed that the electromagnetic radiation exposure level varies around the mobile cell phone with co-ordinates. Furthermore, the experimental results also clearly exhibit that the radiation level again depends on the types of devices and its applications. The EM radiation exposure levels from ordinary mobile cell phone are eventually much higher as compared to android mobile cell phone with hotspot active / hotspot deactivate mode. The finding of the study also includes that the SAR values exclusively relies on an electric field and its variation. Higher electric field results in high SAR value. The maximum power density and electric field were recorded as 187.62 μW/cm² and 33.33 V/m respectively, with corresponding maximum SAR value of 1.013821 W/Kg (900 MHz) and 1.499160749 W/Kg (1800 MHz) for ordinary mobile cell phone device.

5. CONCLUSION

Our study investigates and measured the electromagnetic radiation exposure level from mobile cell phone device to its close proximity around 1meter across the cell phone at different co-ordinates. The measurement was carried out with respect to two very important parameters, power density and electric field associated with atmospheric exposure of EM radiation and its possible health risks. Also, it was established that not only the power density, but electric field also varies at diverse co-ordinates locations results in variation in SAR value simultaneously. However, in all the cases the atmospheric exposure of electromagnetic radiation from mobile cell phone device complies with the standard exposure limits and guidelines set by ICNIRP/IEEE for RF exposure. Steady exposure to such emissions may influence health directly. Thus, it may be recommended to create more awareness about the various adverse effects of EM radiations on the environment with its associated health risks and restrict the continuous use of such mobile cell phone and correlated EM emission exposure from it.

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