Comparative Assessment of SAR Under Different Power Density Exposure for Human Eye for near Field Radiation of Electromagnetic Wave at Wireless Communication of 900 Mhz and 1800 Mhz frequency

Pragati Sharma
Research Scholar, Electronics and Communication Engg, Mewar University, Rajasthan, 312901, India
sharmaprag79@gmail.com;
A K Gautam
Department of Electronics and Communication Engg, S D College of Engineering & Technology, Muzaffarnagar 251 001 (UP), India
drakgautamsd@gmail.com
Sandeep Kumar
Department of Physics, S D College of Engineering & Technology, Muzaffarnagar, 251 001 (UP), India
sandeepdoodhli@gmail.com

ABSTRACT

The cell phones were invented to fulfill the need of ease in communication but the electromagnetic spectrum at which these phones are working proved as hazardous for human being in close proximity with the human body. Concerning the harmful aspects of RF radiation, it is divided into two parts- (1) Near field radiation which generally occurs due to cell phone (2) Far field radiation depends on base transceiver station (BTS) parameters. Mobile phone handsets are low powered RF transmitters and emits an average of maximum power in the range of 0.1 watt to 1 watt.

In this paper we study the specific absorption rate (SAR) which is a measure of radiation at two commonly used frequencies of GSM i.e. 900 MHz and 1800 MHz. The tissues at which all the calculations are found are cornea, lens and iris in human eye[1] at power level of 0.1 Watt, 0.5 Watt and 1 Watt at frequency of 900 MHz and 1800 MHz. All the values clearly depicts that SAR have more effect as mobile phone kept much closer with the eye tissue.

Keywords: Cell phone, Specific absorption rate (SAR), Electromagnetic wave (EM wave), Human body, Base Transceiver Station (BTS), Global system for mobile communication (GSM), Electromagnetic Field (EMF)

Introduction

Even though the mobile communication is considered as the fundamental need of their daily life yet it is also considered as potential health risks prone by researchers, government and other concerning institutions. Mobile phones are considered as low powered radio frequency radiation emitting device. This radiated output power may vary from one cell phone to other cell phone. The maximum power output from a cell phone is regulated by mobile phone standard it is following and by the regulatory agencies in each country. Cell phone can operate continuously or sporadically therefore total exposure of electromagnetic field (EMF) radiation is quite variable. The power level of the cell phone also increases or decreases automatically within a certain span to accommodate for different situations such as inside or outside of building.

Guidelines on exposure level to microwave frequency is given by many international agencies working in this regard to limit the power level of wireless devices. The interaction of radio frequencies with a human being is a multidimensional issue which depends on many parameters.

The rate at which the amount of electromagnetic radiation is absorbed by the human body is calculated by SAR[2]. Its value decreases as the source of radiation (i.e. cell phone) is kept away from body but for close distance it is very harmful because eye is a highly sensitive human organ. Even if, the SAR value calculated is beyond the harmful level then the continuous radiation may create several eye problems.

In this paper frequencies of 900 MHz and 1800 MHz were chosen for work because these frequencies are globally adopted for Global System for Mobile Communication (GSM) services. The safe rate if radiation absorption i.e. SAR is predicted, assuming the three different radiated output powers from cell phone for variable distance with human eye.

Materials & Methods

The eye has initial layer of cornea than iris and after that lens. The dielectric properties of eye involve a relative permittivity and conductivity at cell phone radiation. The value of incident electric field (E_o) over the eye tissue at a distance 'r' from cell phone antenna of power 'P' is given by[3]

$P/ 4\pi r^2 = E_o^2\, \varepsilon_o\, c/2$

$E_o = (P/ 2\pi r^2\, \varepsilon_o\, c)^{1/2}$

$E_o = 7.746 \sqrt{P} / r$ ……..……(1)

Where ε_o is the permittivity of free space and c is speed.

Now, The induced electric field is calculated which represents the charge produced in the body due to incident electric field and it depends on tissue parameters like thickness of tissue z and the skin depth δ. It is given by[4]-

$E_i = E_0 \exp^{(-z/\delta)}$ .....……….(2)

Where $\delta = 1/q\omega$

And $q = \{\mu\varepsilon[(1+p^2)^{1/2} -1]/2\}^{1/2}$

Permeability , permittivity and conductivity of tissue is represented by μ, ε and σ respectively and its values are taken from Teerapot Wessapan and Phadungsak Rattanadecho[1].

The value of electric field and its absorption in cornea, iris and lens is calculated for two commonly used frequencies of GSM i.e. 900 MHz and 1800 MHz. The electric field is incident upon iris and lens after passing through cornea.

SAR: SAR stands for 'Specific Absorption Rate' which is basically the amount of radiation a human body will absorb from a cell phone. Thus SAR depicts the rate at which the electromagnetic energy is converted into heat. The lower the rate, the less radiation will be absorbed. The standard limit of SAR set for cell phone radiation for the public is 1.6 Watt/Kg averaged over one gram of body tissue.SAR concept have been proven as a simple and useful approach in quantifying the interactions of RF radiation with living systems. By using pointing vector theorem for sinusoidal field, we have[5]

$SAR = \sigma E_i^2 / \rho$ …….. (6)

Where σ is electric conductivity (S/m), ρ the tissue density (Kg/m^3) and E_i is the induced electric field (V/m) inside that tissue .

Results and discussions

To investigate the SAR for fruitful condition and harmful condition, the radiated output power from Cell phone is selected as 100 milli Watt as minimum and 1 Watt as maximum for the study. Minimum power radiated at the condition of call set up while the power level may get rise during conversation which ultimately depends on the nearby environmental condition of the cell phone with respect to BTS.

Initially the incident EMF (E_o) is found out for 1cm, 2cm, 3cm, 5cm and 10cm distance between cell phone and eye tissue. It is shown in Table 1.

Now induced EMF in the tissue is found out with the help of incident EMF (E_o) and tissue parameters. It is shown in table 2-4 for cornea, lens and iris of human eye respectively.

Specific absorption rate (SAR) is being calculated and checked for safety level against the maximum SAR value of 1.6 Watt/Kg decided by many national and international agencies like International Commission Of Non Ionizing Radiation Protection (ICNIRP)[6], National council on Radiation Protection and measurement (NCRP)[7], Federal Communication Commission (FCC)[8] and The Institute of Electrical & Electronic Engineers (IEEE)[9]. SAR values are shown in table 5-7. It is found that when eye is exposed under Electromagnetic (EM) fields at 900 MHz and 1800 MHz frequencies then SAR for cornea is much higher than iris and lens. It is because of its higher electrical conductivity (σ) in S/m.

It is also found that SAR value for cornea, lens and iris of human eye is much higher than those of ICNIRP guidelines of exposure. The value goes on decreasing as the distance of cell phone with human eye increases.

Since the study is centered on comparative SAR assessment therefore the SAR values for 900 MHz and 1800 MHz is shown comparatively for various tissues of human eye in table 5-7.The only distance at which SAR can be predicted as safe is 10 cm away from human eye (as shown in tables.

Table-1: Incident electric field at various radiated output power for 1-10 cm distance between cell phone and human eye

Power(Watt)	Incident Electric Field E_o (Vm^{-1})				
	1 cm	2 cm	3 cm	5 cm	10 cm
0.1	244.95	122.48	81.65	48.99	24.49
0.5	547.72	273.86	182.57	109.54	54.77
1.0	774.6	387.30	258.20	154.92	77.76

Table 2 : The induced electric field inside cornea at 900 MHz and 1800 MHz frequency

Frequency (MHz)	Power (Watt)	Induced Electric Field E_o(Vm^{-1}) for cornea				
		1 cm	**2 cm**	**3 cm**	**5 cm**	**10 cm**
900	0.1	233.98	116.99	77.99	46.79	23.40
	0.5	523.18	261.59	174.39	104.63	52.32
	1.0	739.89	369.95	246.63	147.98	73.99
1800	0.1	230.96	115.49	76.99	48.99	23.09
	0.5	516.45	258.22	172.43	109.54	51.64
	1.0	730.37	365.19	243.46	154.92	73.04

Table 3: The induced electric field inside iris at 900 MHz and 1800 MHz frequency

Frequency (MHz)	Power (Watt)	Induced Electric Field $E_o(Vm^{-1})$ in iris				
		1 cm	2 cm	3 cm	5 cm	10 cm
900	0.1	237.45	118.73	79.15	47.49	23.74
	0.5	530.96	265.48	176.98	106.19	53.09
	1.0	750.89	375.45	250.29	150.18	75.38
1800	0.1	234.61	117.31	78.20	46.92	23.46
	0.5	524.61	262.30	174.87	104.92	52.46
	1.0	741.91	370.96	247.30	148.38	74.48

Table 4: The induced electric field inside lens at 900 MHz and 1800 MHz frequency

Frequency (MHz)	Power (Watt)	Induced Electric Field E_o (Vm^{-1}) for lens				
		1 cm	2 cm	3 cm	5 cm	10 cm
900	0.1	239.37	119.69	79.79	47.87	23.94
	0.5	535.23	267.62	178.41	107.04	53.52
	1.0	756.94	378.47	252.31	151.39	75.69
1800	0.1	240.37	120.19	80.12	48.07	24.04
	0.5	537.48	268.74	179.16	107.49	53.75
	1.0	760.11	380.05	253.37	152.02	76.01

Table 5: Variation of SAR in cornea at 900 MHz and 1800 MHz frequency

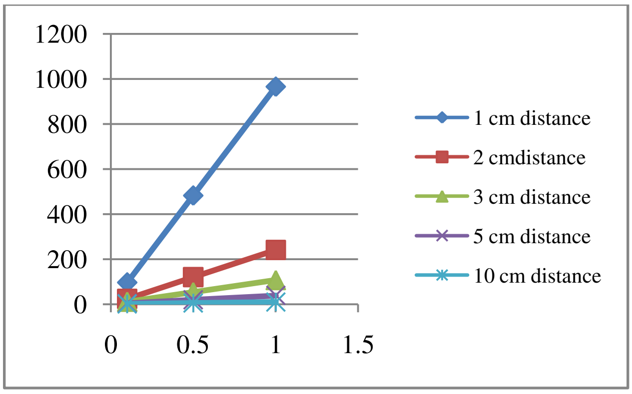
Frequency (MHz)	Power (Watt)	SAR (WKg^{-1}) distribution in cornea				
		1 cm	2 cm	3 cm	5 cm	10 cm
900	0.1	96.46	24.11	10.72	3.86	0.96
	0.5	482.26	120.57	53.58	19.29	4.82
	1.0	964.53	241.14	107.17	38.58	9.65
1800	0.1	117.89	29.48	13.09	5.30	1.18
	0.5	589.45	147.36	65.70	26.51	5.89
	1.0	1178.90	294.73	130.99	53.04	11.79

Table 6 : Variation of SAR in iris at 900 MHz and 1800 MHz frequency

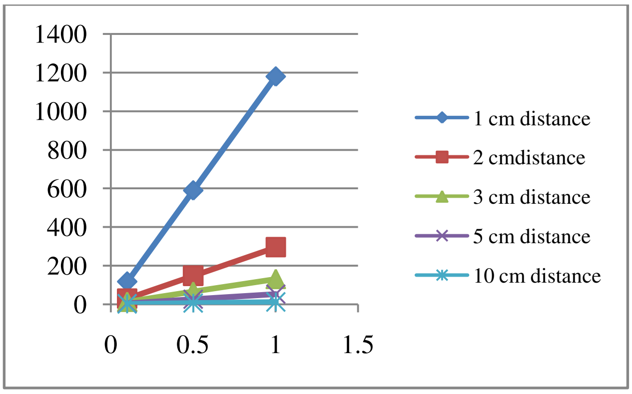
Frequency (MHz)	Power (Watt)	SAR (WKg^{-1}) distribution in cornea				
		1 cm	2 cm	3 cm	5 cm	10 cm
900	0.1	65.51	16.38	7.28	2.62	0.65
	0.5	327.56	81.89	36.39	13.10	3.27
	1.0	655.12	163.78	72.79	26.21	6.60
1800	0.1	88.07	22.02	9.78	3.52	0.88
	0.5	440.35	110.08	48.93	17.61	4.40
	1.0	880.69	220.18	97.85	35.23	8.86

Table 7 : Variation of SAR in lens at 900 MHz and 1800 MHz frequency

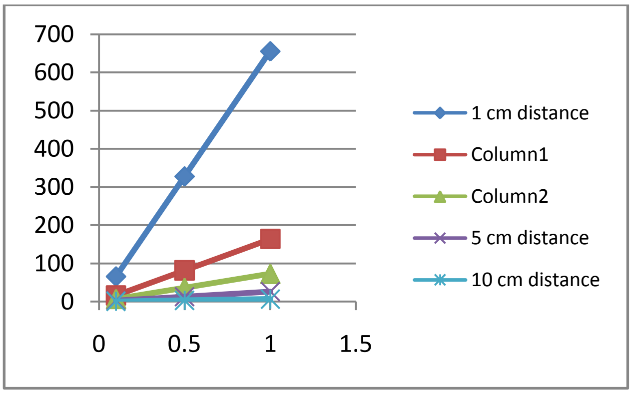
Frequency (MHz)	Power (Watt)	SAR (WKg^{-1}) distribution in lens				
		1 cm	2 cm	3 cm	5 cm	10 cm
900	0.1	50.99	12.75	5.67	2.04	0.51
	0.5	254.96	63.74	28.33	10.20	2.55
	1.0	509.93	127.48	56.66	20.40	5.10
1800	0.1	70.99	17.75	7.89	2.84	0.71
	0.5	354.92	88.73	39.44	14.20	3.55
	1.0	709.84	177.46	78.87	28.39	7.09



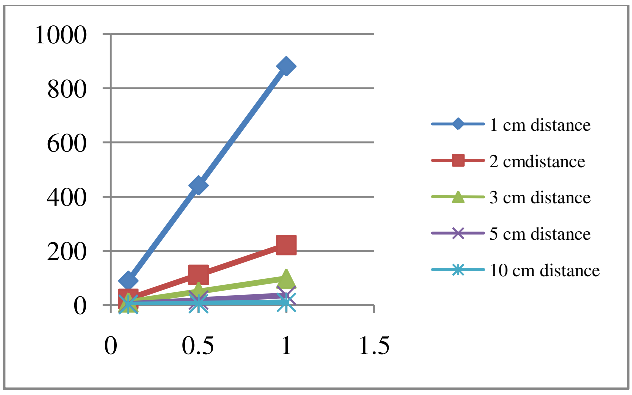
900 MHz cornea



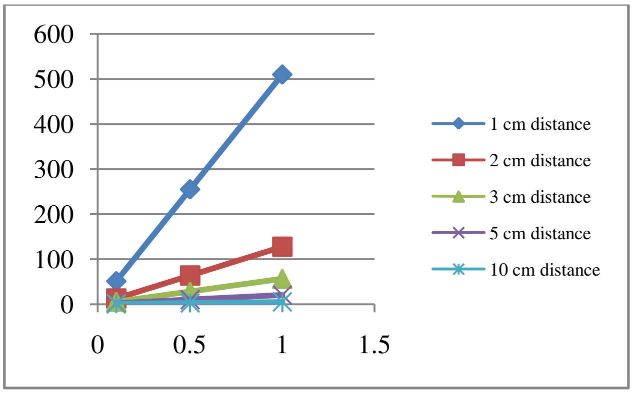
1800 MHz cornea



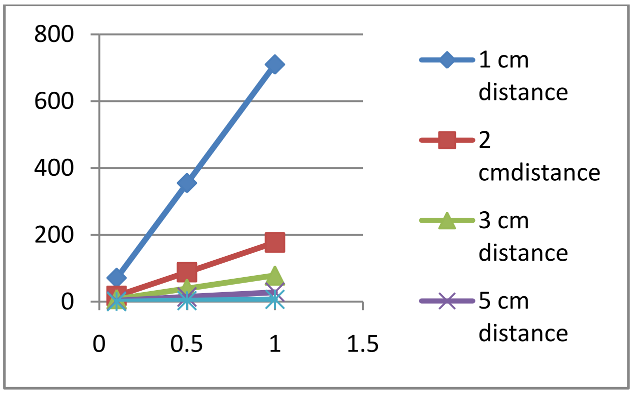
900 MHz Iris



1800 MHz Iris



900 MHz Lens



1800 MHz Lens

4. Conclusion

The energy absorption in human eye is calculated through numerical computations of SAR in which dielectric properties of various tissues of human eye plays a major role in findings the SAR value. SAR distribution found much higher in cornea than of iris and lens which highly affect the outer part of the eye. As SAR depicts the absorption rate of radiated power therefore a high value of SAR proved as dangerous for human eye and closer distance of cell phone may cause for its damage.

SAR values also raises linearly with an increase in radiated power from the cell phone and decreases with the increase in distance of cell phone and user. It is found that 10 centimeter is suggested as the safe distance which should be mandatory to keep the radiation level under the safe limits as described by the ICNIRP and other authorized agencies. Thus it can be concluded that even a low power cell phone (case of near field radiation) can cause serious health damage if not keep distant up to a safe level.

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