Numerical Analysis of Specific Absorption Rate and Corresponding Increase in Temperature at 2.45 GHz on Skin Tissue

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Abstract

The tremendous growth in the number of communication devices including cell phones and base stations has augmented the public concern about the wellbeing of these devices. Many governing bodies and scientific communities are working on hostile possessions of cell phone radiations. The present study explores the numerical analysis of specific absorption rate (SAR) for skin tissue at frequency 2.45 GHz. Elevation in temperature has been calculated by taking two variable parameters i.e. distance and exposure time. It has been found that with the increase in distance from source (mobile phone) and observer (person using mobile phone) from 1 cm to 50 cm, SAR decreases nearly to 98%.

Keywords: *cell phone radiations, Specific Absorption Rate, thermal effects, Skin tissue.*

1. Introduction:

Mobile phones have become an indispensable part of human life. Initially, the mobile phone calls were expensive, so the users of mobile phones were very less. But substantial improvement in mobile phone technology has increased its user worldwide. Now this advanced technology serves the purpose of entertainment, photography, internet surfing and much more. To support this rapid growth, the cellular tower demand has also been increased. Mobile phone radiations are non-ionizing radiations which generate a modulated radio frequency electromagnetic field. These non-ionizing radiations do not have enough energy to ionize atom, hence these radiations are not capable to rupturing chemical bonds directly. The electromagnetic spectra of Non-ionizing radiations can be alienated into two groups i.e. electromagnetic field and optical radiations. The optical spectra further consist of infrared (IR) waves, ultraviolet (UV) and visible light and while electromagnetic fields mainly consist of extremely low frequency (ELF) microwaves and radio frequency waves. The microwave and RF waves are generally used for communication purpose. So, microwave and RF waves are area of interest for the present study. In literature, many scientific reports are available talking about non ionizing radiation of cell phone and its possible health effects [1-6]. But studies are available otherwise too [7-9]. However, the Bio-initiative description which was released in December 2012 and is the largest description covering research reports from 1990 to 2012, gave irrefutable and considerable indication of the jeopardies allied with cell-phone radiations. [10]. Recently, at National Institutes of Health US, a researcher group beneath National Toxicology Program (NTP) has also shown the risk of cancers in the brain associated under the exposure of cell phone radiation [11]. These reports have further increased the public concern about the hazardous effects of cell phone radiation. Usually, we keep mobile phone closer to our skin both in online and offline mode. Hence skin is most vulnerable to these radiations. So, it's become vital to study the ill effects of cell phone radiations on human skin.

Table 1: Dielectric and Thermal Properties of Skin Tissue [15]

Tissue	Skin
Specific Heat (J/K.Kg)	3662
Mass Density (Kg/m^3)	1100
Permittivity ϵ_r (2450 MHz)	38
Conductivity σ (siemen/meter) (2450 MHz)	1.46

2. Material and Methods:

Comprehensive acquaintance of dielectric possessions of biological tissue is crucial for the better empathetic of electromagnetic radiation interaction with human body tissue. Dielectric properties of human tissues strongly depend upon intensity of electric and magnetic field, frequency, direction of propagation, temperature and polarization. The parameter with which the penetration depth of EM radiation in human body tissue can be calculated is called Specific Absorption Rate (SAR). For the calculation of SAR, Electric field and corresponding temperature increase, the following formulas (1-3) from my previously published paper has been considered. [12-14]

$$SAR = (\frac{\sigma + \omega\varepsilon_O\varepsilon_r}{\rho})E^2 \quad (1)$$

$$\text{SAR} = C\frac{dT}{dt} \quad (2)$$

$$E = 7.746\frac{\sqrt{P}}{r} \quad (3)$$

3. Results and Discussion:

Taking ‘r’ as 1cm, 5cm, 10cm, 20cm and 50cm and power as 1W, the value of induced electric field is found to be 774.6V/m, 154.92V/m, 77.46V/m, 38.73V/m and 15.49V/m.

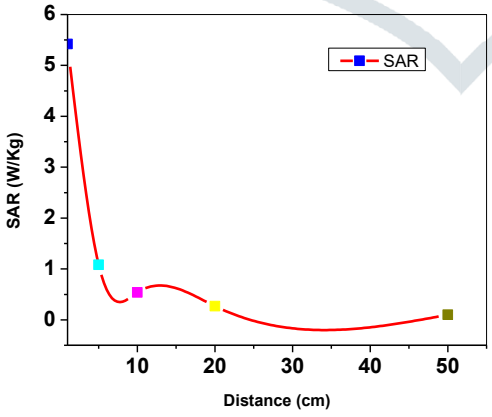

Figure1: Variation of Specific Absorption rate with distance from mobile phone.

Table 2: Increase in Temperature in degree centigrade at different time interval

Distance from Mobile Phone In cm	SAR in W/Kg	Increase in Temperature in degree centigrade at different time interval					
		60 Sec	120 Sec	180 Sec	240 Sec	300 Sec	360 Sec
1	5.442	0.089164391	0.178329	0.267493	0.356658	0.445822	0.534986
5	1.08	0.017695248	0.03539	0.053086	0.070781	0.088476	0.106171
10	0.54	0.008847624	0.017695	0.026543	0.03539	0.044238	0.053086
20	0.27	0.004423812	0.008848	0.013271	0.017695	0.022119	0.026543
50	0.1	0.001638449	0.003277	0.004915	0.006554	0.008192	0.009831

From Figure 1, it is clear that Specific absorption rate (SAR) decreases with decrease in distance. With a change in distance from 1 cm to 50 cm, SAR decreases nearly to 98%. Temperature rise has been calculated by taking two variable parameters i.e. distance and exposure time. The difference in temperature distribution pattern can be attributed due to induced electric field inside the tissue. Radiations penetrate inside human body through skin. So, temperature increase for skin tissue is expected to be the highest. From table 2 it is clear that the exposure duration also significantly affects the rise in temperature. A longer exposure time means large heat accumulation inside the tissue, thereby higher increase in the temperature of concerned tissue. It has been estimated that when exposure time increased from 60 sec to 360 sec, the corresponding elevation in temperature of respective tissue rises up to nearly to 83%. The safety limit decided by ICNIRP (International Commission on Non-Ionizing Radiation Protection) is 2W/Kg. [16] All calculated values of SAR at a distance of 5cm are less than this safety limit. But studies are also available which shown that human body start responding to these radiations at a very lower limit of SAR 0.001 W/kg.[17] Considering 0.001W/Kg as safe biological limit, future safety limit should need revision.

4. Conclusion:

In the present work, a theoretical model has been proposed for the study of specific absorption rate (SAR) with varying distance between the source of radiation and exposed human tissues. In addition, corresponding temperature increases inside human skin tissue is also calculated. The hazardous effects initiate from the duration of exposure. For lesser duration, no significant rise in temperature has been noticed. Similarly, the distance plays equal role. So, it is recommended that one should not keep every time phone closer to human body to avoid long term effects.

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