Indian Journal of Radio & Space Physics
Vol 40, December 2011, pp 340-342

Effect of electromagnetic radiation from mobile phones towers on human body

Sandeep Kumar[1,$,*] & P P Pathak[2,#]

[1]Department of Physics, Vidya College of Engineering, Meerut 250 005 (UP)

[2]Department of Physics, Gurukul Kangri University, Haridwar 249 406 (UK)

E-mail: [$]sandeepdoodhli@gmail.com, [#]pathakpp77@yahoo.com

Received 15 July 2010; revised 11 August 2011; accepted 16 August 2011

In the present paper, the elecrtromagnetic field (EMF) strength and specific absorption rate (SAR) have been calculated in close proximity to mobile phones base stations. The induced SAR inside human body tissues, particularly in fat and muscles due to mobile phone base station frequency (900 MHz) have been evaluated. The calculated values of SAR have been compared with standard limits given by various international authorities like Federal Communication Commission (FCC), International Radiation Protection Association (IRPA/INIRC), International Commission on Non-ionizing Radiation Protection (ICNIRP), Institute of Electrical and Electronics Engineers (IEEE), etc.

Keywords: Electromagnetic radiation (EMR), Specific absorption rate (SAR), Human body tissues

PACS No.: 84.40.Ua; *87.50.sg*

1 Introduction

The human body is always exposed to electromagnetic radiation (EMR) of varying intensity which depends upon the location inside the building or in open space. The human body is complex function of numerous parameters, like electrical conductivity, density and its complex permittivity[1]. The EMR is characterized by its frequency, intensity of electric and magnetic fields, their direction and polarization characteristics in free space. The fields inside the tissues of biological body can interact with them and therefore, it is necessary to determine these fields for general quantification of biological data obtained theoretically. When an electromagnetic field falls upon the human body, then it partially penetrates into human body and is attenuated by human body tissues and its parts are absorbed by body tissues[2]. The absorption of EMR is expected to raise the body temperature[3]. The variation of induced electric field inside human body tissues at two commonly used frequencies of mobile phone has been calculated by Kumar & Pathak[4]. Here, theoretically calculated internal fields have been used to evaluate SAR at different distances from the EMR source.

2 Material and Methods

2.1 Electric field surrounding the mobile phones base station

The mobile phone transmission towers transmit electromagnetic fields in the microwave frequency range. The intensity of these fields is maximum near the transmission towers and reduces with distance as it is inversely proportional to the square of distances. The value of electric field, E_0, at a distance, r, from vertical transmitting antenna of power, P, is given by Polk[5]:

$$P/4\pi r^2 = E_0^2 \varepsilon_0 c/2$$
$$E_0 = (P/2\pi r^2 \varepsilon_0 c)^{1/2}$$
$$= 7.746\sqrt{P}/r$$

where, ε_0, is permittivity of free space; and c, speed of light. The electric field, E_0, at a distance, r, from vertical transmitting antenna of effective radiated power (ERP) of 50 W (ref. 6) is

$$E_0 = 54.76/r \text{ V/m}$$

Thus, the electric field varies inversely proportional to the distances from the transmission tower.

2.2 Penetration of electric field inside human body

When the radiated field falls on a human body, the penetration of the field depends on the frequency of radiation. Thus, the field at a depth, z, due to incident electric field, E_0, on the surface is given as[5]:

$$E_z = E_0 \exp|-z/\delta|$$

where, δ, is the skin depth, whose value depends upon the frequency of radiation for biological body and is given by:

$\delta = 1/q\omega$

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

$p = \sigma/\omega\varepsilon$

where, ω, is radian frequency of radiations; ε, the permittivity of tissue material; μ, its permeability; and σ, conductivity[7].

2.3 Specific absorption rate (SAR)

The SAR is defined as the time derivative of the incremental energy (dw) absorbed by or dissipated in an incremental mass (dm) contained in a volume element (dV) of a given density (ρ). It is given by Adair & peterson[8] :

$$SAR = d/dt\ (dw/dm)$$
$$= d/dt\ (dw/\rho dV)$$
$$= \sigma E_i^2/\rho$$

where, $E_{i,}$ is the electric field inside the material. The density of fat and skeletal muscles of human body is given by Stuchly[9]. This relation represents the rate at which the electromagnetic energy is converted into heat through well established interaction mechanism. It provides a valid quantitative measurement of all interaction mechanisms that are dependent on the intensity of the internal electric field[10]. At this point, some additional information may be relevant. For instance, some effects of radio waves modulated in amplitude at extremely low frequency (ELF) are dependent on the electric field intensity[11]. Specific interactions mechanism is better understood if they would be expressed in term of SAR and modulation characteristics, even though the interaction mechanism may not necessarily be thermal. The value of SAR in human body tissues due to home appliances at various frequencies is calculated by Kumar *et al.*[12].

3 Results and Discussion

The calculated values of SAR in fat and skeletal muscle of human body from mobile phone base station are given in Tables 1 and 2. It is found that the harmful values of SAR for fat are up to a distance of 10 cm from the base station and for skeletal muscles these values are up to 400 cm from the base station. These values are shown in bold digits in the tables. There are standards by international bodies on exposure to the occupational and general public. The guidelines and regulations governing the safe use of RF/microwave radiations are given by the International Commission on Non-ionizing Radiation Protection (ICNIRP, 1998)[13], the Institute of Electrical and Electronics Engineers (IEEE, 2001)[14], National Council on Radiation Protection and Measurement (NCRP, 1986)[15], The Australian Radiation Protection and Nuclear Safety Agency Standard (ARPANSA, 2002)[16], etc. All these agencies have set the safe limits of whole body SAR as 1.6 W kg^{-1}.

Table 1 — Variation of SAR inside FAT at different depths

S No	Distance from tower, cm	Incident electric field (E_0), V m^{-1}	SAR, W kg^{-1} 1 cm	2 cm	3 cm
1	10	547.6	**10.10**	**3.9**	**2.41**
2	30	163.5	0.99	0.384	0.238
3	60	91.3	0.28	0.108	0.670
4	100	54.8	0.101	0.038	0.024

Table 2 — Variation of SAR inside skeletal muscle at different depths

S No	Distance from tower, cm	Incident electric field (E_0), V m^{-1}	SAR, W kg^{-1} 1 cm	2 cm	3 cm
1	10	547.6	**3848.2**	**3674.5**	**3505.4**
2	30	163.5	**342.7**	**327.4**	**312.4**
3	60	91.3	**106.8**	**102.04**	**97.34**
4	100	54.8	**38.46**	**36.74**	**35.04**
5	200	27.4	**9.61**	**9.18**	**8.76**
6	400	13.7	**2.41**	**2.29**	**2.18**
7	800	6.8	0.599	0.573	0.546
8	1000	5.47	0.383	0.365	0.348

4 Conclusion

It may be concluded that no transmission tower should be located near the populated area. It is also suggested that nobody should reach near (4 m distance) to the transmission tower.

Acknowledgments

The authors gratefully acknowledge the reviewers for their valuable suggestion for modification of the paper.

References

1 Foster K R & Schwan H P, Introduction, in *Biological effects of electromagnetic fields*, edited by C Polk & E Postow (CRC Press, Boca Raton, USA), 1996, pp 25-102.

2 Pathak P P, Kumar V & Vats R P, Harmful electro-magnetic environment near transmission tower, *Indian J Radio Space Phys*, 32 (2003) 238.

3 Mclntosh R L, Anderson V & Mckenzie R J, A numerical evaluation of SAR distribution and temperature changes around a metallic plate in the head of a RF exposed worker, *Bioelectromagnetics* (*USA*), 23 (2005) pp 377-388.

4 Kumar S & Pathak P P, Induced electric field inside and surface of human brain due to mobile phone radiation, *J Natural Phys Sci (India)*, 20 (2006) pp 47-50.

5 Polk C, *Handbook of biological effects of electro-magnetic fields*, edited by C Polk & E Postow (CRC Press, Boca Raton USA), 1996, pp 1-23.

6 Pathak P P, Kumar S & Kumar V, *Harmfulness of mobile phones tower*, XXIX General Assembly of the International Union of Radio Science (URSI 08), paper no 2395(K03), Chicago IL, USA, 9-16 Aug 2008.

7 Gabriel S, Lau R W & Gabriel C, The dielectric properties of biological tissues vol II: Measurement in the frequency range 10Hz to 20GHz, *Phys Med Biol (Italy)*, 41 (1996) pp 2251-2269.

8 Adair E R & Peterson R C, Biological effects of radio frequency radiation, *IEEE Trans Microwave Theory Tech (USA)*, 50 (2002) 953.

9 Stuchly M A & Stuchly S S, Biological effects of electromagnetic fields, *Phys Rev (USA)*, 61 (1981) 435.

10 Guy A W, *Non-ionizing radiation: Dissymmetry and interaction*, American Conference of Governmental Industrial Hygienists (ACGIH) symposium (ACGIH, Washington, USA), 1979, 75.

11 Adey W R, Tissue interactions with non-ionizing electromagnetic field, *Physiol Rev (USA)*, 61 (1981) pp 435-513.

12 Kumar V, Vats R P, Goel S, Kumar S & Pathak P P, Interaction of electromagnetic field with human heath, *Indian J Radio Space Phys*, 37 (2008) pp 131-134.

13 International Commission on Non-Ionizing Radiation Protection (ICNIRP), Guidelines for limiting exposure to time varying electric, magnetic and electromagnetic fields, *Health Phys* (*USA*), 74 (4) (1998) pp 494-522.

14 IEEE, *Safety issues associated with base station used for personal wireless communication* (IEEE, New York), 2001, pp. 110-114.

15 National Council on Radiation Protection & Measurement (NCRP), *Biological effects and exposure criteria for radio frequency electromagnetic fields Report no.* 86 (NCRP, Bethesda, MD), 1986.

16 Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), *Maximum Exposure levels to Radio Frequency Field (3 kHz-300GHz)*, Radiation Protection Series Publication No. 3 (ARPANSA, Victoria), 2002.