Specific Absorption Rate Inside Human Skeletal Muscle at Second Band of Frequency (2.4 - 2.4835GHz)

Sandeep Kumar[1*]

Department of Physics, Dhanauri P.G. College, Dhanauri, Haridwar, Uttrakhand, 247667 India

Corresponding Author:- Sandeep Kumar[1*]

Abstract:- **In the current scenario the radiofrequency radiation (RFR) emitted from wireless equipment viz. mobile phone towers, mobile phones, computers, laptops, microwave ovens, high voltage electric lines etc. has been increased continuously and expose the living beings. The human cells are affected by electromagnetic fields (EMF) and with the development of the fifth generation (5G) of mobile communication technologies and frequency are far increasing; the human skin becomes the first main biological tissue of the human body. In this paper Author's evaluated SAR for skeletal muscles in human body at 2.4 GHz Radiofrequency (RF) and discuss its harmful effects.Those peoples are living nearby mobile phones towersare exposed directly by EMRand regarding their health issues due to Non-ionizing electromagnetic radiation, The Specific Absorption Rate (SAR) within human body skeletal muscle is calculated through mathematical model and results were compare with standard permitted values of SAR given by many National and International agencies like International Commission non- ionizing radiation Committee (ICNIRC), National Council on Radiation Protection and Measurement (NCRP), World Health Organization (WHO), Federal Communication Commission (FCC) and Department of Telecommunications (DOT) etc.**

Keywords:- *Radiofrequency Radiation (RFR), Specific Absorption Rate (SAR), Electromagnetic Field (EMF), Radiofrequency(RF) etc.*

I. INTRODUCTION

The Electromagnetic Radiation are constantly increasing surrounding us, therefore we are dwelling in the sea of an invisible radiation or invisible pollution which comes from herbal and manmade assets of EMR. The human fitness risks because of the invisible radiation are developing concerns; as a consequence there is a want to have a look at the interplay of microwave radiation with living organisms. The dissymmetric look at described the interaction of EMF with humans. Adey (1990) "Electromagnetic Fields and Essence of residing systems" at Prague (U.S.A) Radio waves in unfastened space are characterized by using numerous parameters viz. frequency, depth of the electric area , magnetic field , direction, and polarization etc.The tissues of human frame are complicated

capabilities of conductivity, permittivity and density. The human bodies are exposed to known electromagnetic fields (Non-Ionizing), induced electric discipline within the organic body can be calculated via fixing Maxwell's equation situation to given boundary situations. A organic body is defined by way of the complex parameters viz. permittivity, conductivity and mass density, etc. The inhomogeneity of the dielectric residences of human body tissues and the complexity of the shape make answers. The depth of the electromagnetic field depends at the parameters of the outside field, viz., the frequency, intensity, density, resistivity, conductivity, polarization and on the scale; shape and dielectric residences of the uncovered frame, The development and application of devices that emit RF radiation have appreciably extended the first-class of existence throughout the arena. yet the beneficial factors of RF/MW era were incredibly overshadowed in latest years with the aid of the general public worry of capacity results. This fear, in turn, has result in elevated radio frequency radiation (RFR) research and to new RFR protection guidelines based totally on what is understood about any biological impact. In trendy, the new hints offer an introduced margin of protection over the ones previously used. In 2000, the U.okay. National Radiation safety Board measured RF radiation level at 118 publicly reachable web sites around 17 cell Smartphone base stations. The maximum publicity became 0.00083 mW/cm2 on a playing subject of 60 m from a college building with an antenna on its roof. Normally, strength densities had been less than 0.01 % of the ICNIRP public publicity recommendations. The energy densities interior were extensively less than strength densities outside. whilst RF radiation from all assets (the cellular phone, FM, T.V., and their transmitters, and so forth.) become taken into consideration, the most power density at any web page turned into much less than 0.2 % of the ICNIRP public publicity hints. The country wide and global safety standards hints for exposure of the public to the RF radiation are most broadly standard requirements that's advanced by way of the Institute of electrical and Electronics Engineers and American national standards Institute (ANSI/IEEE). The worldwide commission on Non-Ionizing Radiation protection (ICNIRP 1998) and the national Council on Radiation safety and measurement (NCRP, 1986). In 2001, the IEEE published a announcement on cellular phone base stations or towers (IEEE, 2001).

The health chance from microwave radiation publicity immediately depends at the charge of power absorption (Osephuk and Peterson, 2003) and distribution of radiation strength within the body. The absorption and distribution are strongly depending on body size, orientation, frequency and polarization of the incident radiation. each theoretical and experimental dissymmetric records indicates that microwave Radiation absorption processes most whilst the lengthy axis of the frame is each parallel to the E-area vector and identical to the four-tenths of the wavelength of the incident microwave Radiation area.

II. INTERACTION OF EMR WITH HUMAN HEALTH AND METHODOLOGY

The interaction of microwave radiation with residing organism, inclusive of human being is a complex function of many parameters. The biological responses are because of the EMF inside the biological tissues of humans. The amount of radiation pondered, transmitted and absorbed for a given exposure discipline is decided with the help of electrical houses of living organism systems. The publicity discipline is characterized via the frequency, depth, density, conductivity, resistivity, polarization and near-discipline of a radiator. The interplay of biological fabric with an electromagnetic source relies upon at the frequency of the source (Moulder and Foster, 1995). it is able to be considered on a macroscopic or microscopic (molecular, cellular) level, on the molecular degree, two basic mechanisms governs the interaction, viz., area price polarization at lower Radiofrequency and subject-brought on rotations of polar molecules at higher radiofrequency and microwave frequencies (health components, component I and II, 1977, 1978) due to the interplay of EMR with human frame tissues,the electromagnetic strength is transformed into the ok.E of molecules, and ok.E additionally converted into thermal electricity or heating which raise the human frame temperature (Mclntosh et al., 2005).The evaluation of SAR in human frame tissues viz.blood, bones and muscle tissues because of EMR at 900 MHz, 1800 MHz and 2400 MHz is evaluated by using Rani et.al (2018). Sandeepkumar & P.P Pathak (2024) also evaluated specific absorption rate internal humanskeletal muscle at 935 MHz and 960 MHz. The EMR from mobile phones transmittower falls on the human body then it penetrates into human frame and impacts the organic tissues of human frame. the electrical discipline is propagated from the tower in all instructions and hence the price of electrical area rely on the gap from the tower and its transmission power is given by Polk (1996).

$$\frac{P}{4\pi r^2} = E_0^2 \; \in_0 C/2$$

Where

c is speed of light

$\in_0$ is the permittivity of free space

$$E_0 = \frac{P}{(2\pi r^2 \in_0 c)^{1/2}}$$

$$E_0 = \frac{7.746\sqrt{p}}{r}$$

Thus the electric field around the mobile phone transmission tower is inversely proportional to the distance from the towers. The inducedelectric field at depth z inside human body tissues due to incident electric field E_0 on the surface of human body is given by Polk (1996)

$$E_z = E_0 exp|-z/d|$$

Where d is the skin depth or penetration depth (The penetration or skin depth is the distance at which the field is reduced to $1/e$ of its original value at the boundaries). It depends upon the frequency of radiation for biological body is given by

$$d = \frac{1}{q\omega}$$

$$q = \sqrt{\frac{\mu\varepsilon}{2}\left\{\sqrt{(1+P^2)}-1\right\}}$$

$$P = \frac{\sigma}{\omega\epsilon}$$

$\omega = $ Radian frequency of electromagneticradiations

$\mu=$Permeability of tissue material

$\epsilon=$Permittivity of tissue material

$\sigma=$Conductivity of tissue material.

➢ *Specific Absorption Rate (SAR):*
It is defined as the time derivative of the incremental energy (dw), which is absorbed or dissipated is an incremental mass (dm) of the human body and contained in a volume element (dv) of a given density (ρ)

SAR = d/dt (dw/dm) = d/dt (dw/ ρdv)

For sinusoidal electro-magnetic fields

SAR = σ E^2_i/ρ

σ = conductivity of the tissues

E_i = induced electric field inside human body tissues

ρ = density of tissues materials

SAR can be calculated for different values of induced electric field and specific values of conductivity and density of human body tissues

> *Induced Electric Field and SAR for Skeletal Muscles at 2.4 GHz.*

The SAR for human skeletal muscles at various distances from mobile phones transmitted tower at emitted power 2 W has been calculated by Pathak et al. (2008). Author's calculate the induced electric field and SAR at various depth in skeletal muscles at transmitted power 50 W and 1000 W given in Tables 1 for 50 W transmitted power at frequencies 2.4 GHz. and Tables 2 for 1000 W for same frequency. The induced electric field and SAR with depth inside skeletal muscles is shown in Figure 1&2at50 W and Figures 3 & 4 at 1000 W power respectively.

Table 1 SAR for Skeletal Muscles of Human Body at 2.4GHz (50 W)

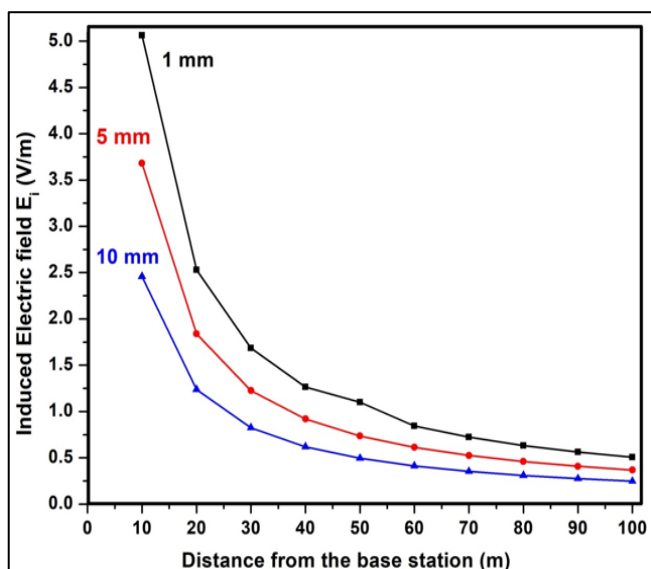| Distance from the mobile phones towers (m)	Incident Electric Field (V/m)	Induced Electric field (V/m)			SAR (W/kg)		
		1 mm	5mm	10mm	1mm	5 mm	10 mm
10	5,477	5.061	3.680	2.457	0.614	0.325	0.147
20	2.738	2.529	1.839	1.237	0.153	0.081	0.036
30	1.825	1.686	1.226	0.824	0.068	0.036	0.016
40	1.369	1.265	0.919	0.618	0.038	0.020	0.009
50	1.095	1.011	0.735	0.494	0.024	0.012	0.005
60	0.913	0.844	0.613	0.412	0.017	0.009	0.004
70	0.782	0.723	0.525	0.353	0.012	0.006	0.002
80	0.685	0.633	0.460	0.309	0.009	0.005	0.002
90	0.608	0.562	0.408	0.274	0.007	0.003	0.001
100	0.548	0.506	0.368	0.247	0.006	0.003	0.001

Fig 1 Variation of Induced Electric Field for Skeletal Muscles at 2.4 GHz (50 W)
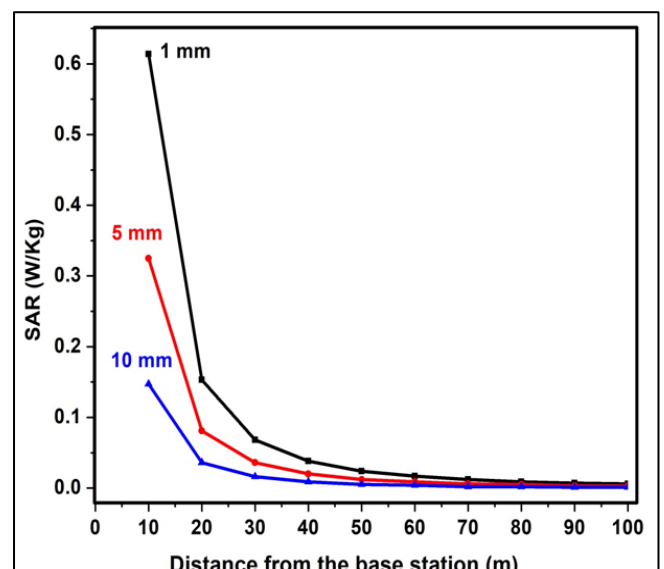

Fig 2 Variation of SAR for Skeletal Muscles at 2.4 GHz (50 W)

Table 2 SAR for Skeletal Muscles of Human Body at 2.4 GHz (1000 W)

| Distance from the mobile phones towers(m)	Incident Electric Field (V/m)	InducedElectric field(V/m)			SAR (W/kg)		
		1 mm	5mm	10mm	1mm	5 mm	10 mm
10	24.49	23.43	19.640	15.771	13.37	9.395	6.057
20	12.24	11.71	9.816	7.882	3.339	2.346	1.513
30	8.16	7.809	6.544	5.255	1.485	1.043	0.6726
40	6.11	5.857	4.900	3.934	0.835	0.584	0.3769
50	4.90	4.689	3.929	3.155	0.535	0.3760	0.2424
60	4.08	3.904	3.272	2.627	0.3712	0.2607	0.1680
70	3.50	3.340	2.807	2.254	0.2717	0.1919	0.1237
80	3.06	2.928	2.454	1.970	0.2088	0.1466	.0945
90	2.72	2.603	2.181	1.751	0.1650	0.1158	0.0746
100	2.45	2.344	1.969	1.577	0.1338	0.0944	0.0605
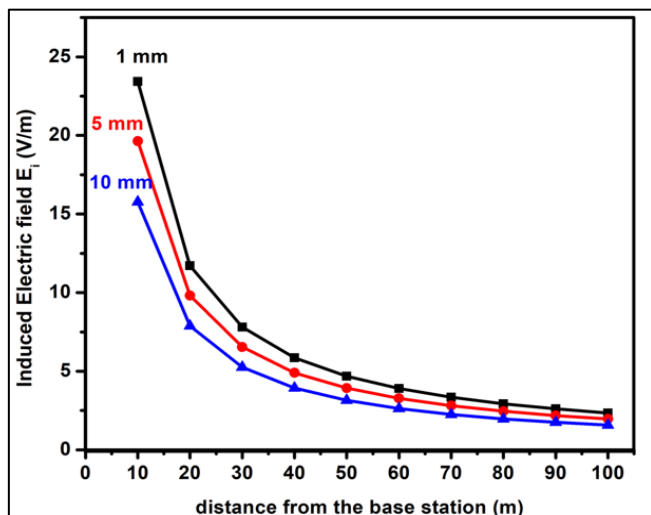
Fig 3 Variation of Induced Electric
Field at 2.4 GHz (1000 W)

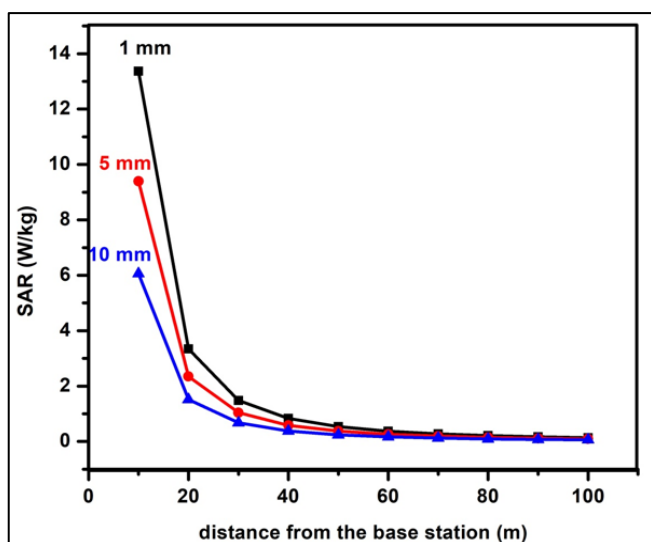Fig 4 Variation of SAR for Skeletal
Muscles at 2.4 GHz (1000W)

III. RESULTS & DISCUSSIONS

The calculated values of SAR for human skeletal muscleare shown in table 1& 2 and graphical representation shown in figure 2&4 there are some valuesare found above the standard safety limitations set up by many national and international agencies and this limitation is 1.6 w/kg. The Induced electric field and SAR at Effective radiated power 50, and 1000 Watt are calculated. These are shown in tabular form (table 1&2) as well as in pictorial representation (figure 1to 4). The distance from towers 10 meter to 100 meters is to be used for calculation of induced electric field and SAR. The skeletal muscle tissues of human body is used for evaluation induced electric field &SAR. There are some values across the standard limit given by different above said agencies.The Tables 1& 2shows the values of induced electric field and SAR for different values of distances from mobile phones towers , all these values of SAR calculated at 50 W radiated power lies in safe zone and below from standard value given by many national and international agencies while the values of SAR calculated at

1000 W radiated power shown in table 2 are not found safe values ,it is found that SAR values for up to 20 meters distance from the mobile phone towers above the limit of permitted values and harmful for human being shown in red digits.The graphical representation of SAR shows that up to 20 meters distances from mobile phone towers are in highlycritical zone. The Authors advised people that do not reside near the towers of mobile phones up to 100 meters distance and do not come in the range of 20 meter distance especially from antenna. It was observed that in public domain, thereare various service provider mobile phone towers are set up in residential colonies and dense populated areas. There should be guidelines to set up the transmission towers by the Authorities like local municipal, district headquarters and National Green Tribunal, New Delhi.

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