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Studies on Cell-phone Radiation Exposure Inside a Car and Near a Bluetooth Device

Dhami, A.K.

Division of Research and Development, Lovely Professional University, Phagwara, Jalandhar-Delhi G.T. Road (NH-1), Punjab, India

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ABSTRACT: Electromagnetic radiation emitted by Cell-phones is a new health hazard, especially when they are used inside closed metal bodies such as cars, elevators etc. The modern wireless devices like Bluetooth further enhance the effect of this radiation. The present studies were taken to get quantitative information about the actual power density levels to which a human brain is exposed inside a vehicle while using a cell-phone and a Bluetooth device,and calculation of its specific absorption rate (SAR). The Cell-phone radiation was measured using a handheld portable power density meter TES 593 and specific absorption rates were estimated for human braintissue from the measured values. These were compared with the SAR values at which biological system of humans and animals start getting affected. The radiation intensity was observed to have increased by 393% when a cell-phoneandBluetoothare used insidea car as compared to no phone/Bluetooth.The specific absorption rates were calculated to be 514 times higher than the biological limit of 1 mW/Kg at exposure frequency of 1800 MHz.The radiation exposure and absorption values were also compared as a function of distance between phone and Bluetooth. The results indicated total exposure intensityand SAR valuesconsiderably higher than a human body can safely absorb.

Key words: Cell-phone Radiation, Electromagnetic Pollution, Power Density, Specific Absorption Rate

INTRODUCTION

The intensity of radio frequency pollution in the recent years has increased many folds, mainly after the advent of cell-phone age. Cell-phone radiation has been an issue of concern since last few years. Even though there is some awareness about the problems and health risks associated with cell-phone radiation and towers, but the magnitude of danger can be much graver than anticipated. Slow and long term use of cell-phone for long hours every day can be a serious health hazard. Increase in cancer cases, brain tumours and DNA damage are being attributed to the cell-phone radiation (Dolk *et al.*, 1997; Stagg *et al.*, 1997; Marinelli *et al.*, 2004; Hardelland *et al.*, 2009).

Using a cell-phone inside a car could be unsafe. Studies found that drivers exposed to high levels of car radiation fell asleep faster than drivers who were not exposed to such high levels of radiation. Some common symptoms are excessive drowsiness, headaches, neck pain, anxiety, heart palpitations, ringing in the ears, and brain fog(Hung *et al.*, 2007; Huber *et al.*, 2000). Bluetooth carries an additional form of radiation along with a cell-phone. It transmits energy at levels of 2.4 GHz of band, hence it utilizes the same microwave radiation as mobile towers. The Bluetooth radiation in itself may be less dangerous than cell-phone radiation but if both are used together, the collective effect from both the devices may lead to serious health hazards.

*Corresponding author E-mail: amarjot.d@gmail.com

In view of thedangers associated with cell-phone radiation to human health,the present studies were taken to estimate the increase in radiation intensitywhen Bluetooth is used in combination with phone, both outside and inside the car. The objective is to get quantitative information about the actual exposure of human brain to power density and estimation of its specific absorption rate inside a car when cell-phone andBluetooth are used together while driving.

MATERIALS & METHODS

Two parameters which are mainly used to express radiation exposure levels are power density and specific absorption rate (SAR). Power density measurements were performed using a handheld portable power density measuring TES 593 electro-smog meter from TES Electrical Electronic Corp (Dhami, 2012). The measuring device covered wide range of frequencies from 10 MHz to 8 GHz. The instrument was sensitive enough to detect fields as low as 0.0001 mW/m^2. It has the triple axis sensor which gave the accurate three dimensional measurements without having to point the antenna in a particular direction. The readings were allowed to stabilize for 2 to 3 minutes before noting them in the 'maximum average' mode (Dhami, 2012).

In the first set of readings, the power density measurements weretaken outside the car in a room, with phone alone and phone + Bluetooth together. The variation in radiation intensity was measured as a function of distance of phone from the Bluetooth. In the second set, readings were taken inside a parked carwithout a phone (atmospheric radiation) and were compared with the power density with phone and phone + Bluetoothinside the car. The car readings were thencompared with the readings taken outside the car.

Since the ear Bluetooth is worn on the ear while talking, to observe its effect on brain, the measuring device was kept in close proximity to the Bluetoothrather than to phone (which may be away from body when Bluetooth is in use).Mostly, the phone is kept in a pocket which can be anywhere from 6 inches to 18 inches away from the Bluetooth. The distance between phone and Bluetooth was changed by moving the phone and keeping the Bluetooth stationary. The reading was noted in the radiation measuring device, which was also kept stationary close to the Bluetooth (Fig .1).

The engine and air conditioning of the car were kept on during measurements.The car used for studies was Ford Figo, model Titanium. The cell-phone used was Blackberry curve, which was kept in the talk mode on the passenger seat. A class 3 earBluetooth device was used for these measurements. The models of the vehicle, phone and Bluetooth were randomly chosen depending upon their easy availability. Even different models are expected to show almost similar results.

The rate at which radiation is absorbed by the human body is measured in terms of Specific Absorption Rate (SAR). In this work, local SAR has been estimated at a point on the brain as the absorber. After including the permittivity parameter in the equation for calculating local SAR, (Gandhi, 1990; Guy, 1996), it is expressed as:

$$SAR = \frac{\sigma + \omega \varepsilon_0 \varepsilon_r''}{\rho_m} |E^2| \text{ (W/Kg)} \quad \ldots \quad (1)$$

$|E^2|$ = Magnitude of electric field vector
σ = Conductivity of the human brain tissue
ρ_m = Mass density of the human brain tissue
$\omega = 2\pi f$ = angular frequency of radiation
ε_r'' = Imaginary part of complex permittivity
ε_0 = Permittivity of free space.

The measuring electro-smog meter showed power density values in both mW/m^2 and V/m units. These values were used to estimate SAR using equation 1. Conductivity and mass density values were taken from Table 1 for frequencies 900 MHz and 1800 MHz.

Table 1. Tissue dielectric Properties for human brain

Frequency (MHz)	Conductivity ($ohm^{-1}m^{-1}$)	Mass Density (Kg/m^3)
900	0.7665	1030.0
1800	1.1531	1030.0

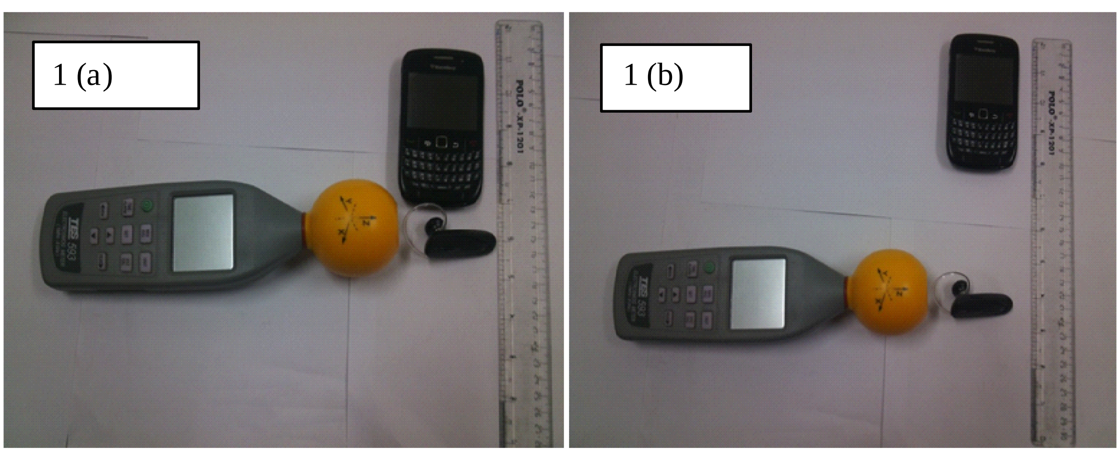

Fig. 1. Measurement of power density as a function of distance between phone and Bluetooth, 1(a) when phone is kept close to the Bluetooth, 1(b) when phone is moved away from the Bluetooth keeping the measuring device and Bluetooth immobile

RESULTS & DISCUSSION

The increase in radiation power density with the use of Bluetoothwas observed to be 313% higher as compared to phone alone when measured outside the car. Table 2 shows the power density values of cell-phone and Bluetooth outside the car at various distances between them.

The power density values were considerably high (99.5 mW/m^2) when Bluetooth and phone devices are used together and kept close to each other. It was observed that the power densitydropped by 33% when the distance was increased to 6 inches. Intensity drop was slower at farther distances. The corresponding SAR values are also mentioned in the table II. According to scientific reports, these exposure levels are much above the values at which biological changes start taking place.Fig. 2 shows how SAR values change with distance between phone and Bluetooth for 900 MHz and 1800 MHz frequencies.

The power density was observed to have increased by 393%whencell-phone and Bluetooth were usedinside the car with windows rolled up as compared to using no phone/Bluetooth. Though rolling down the front windows should not show any change in radiation as they allow the radiation to pass through, however, it showed a small decrease in power density values by 10% from that measured with windows rolled up. This could be attributed to the measurement error owing to the tolerance of the electro smog meter including isotropic deviation, frequency and temperature response.The corresponding SAR values for 900 MHz and 1800 MHz calculated using equation 1 were346 mW/Kg and 514mW/Kg.

The current safety limits recommended by ICNIRP (International Commission on Non Ionizing Radiation Protection)and many countries are higher by many orders than the actual unsafe levels recommended by scientific reports. Some other places like Salzburg, Austria have adopted the much lower exposure limits of 1mW/m^2. Biological effects in animals and humans start at even lower exposure levels. In the present studies, the power density value measured inside the car is approximately 947 times higher than the Salzburg limit. The hazards associated with this high radiation exposure can vary from brain cancer to DNA damage.

Table 2. Variation of radiation intensity as a function of distance between phone and bluetooth. The radiation intensity is measured in terms of power density (mW/m^2). Estimated values of Specific Absorption Rate (SAR) are also shown

Distance of bluetooth device from phone (inches)	Power Density (mW/m^2)	SAR (mW/Kg) At 900 MHz	SAR (mW/Kg) At 1800 MHz
0	99.5	31.34	48.85
6	66.20	20.85	32.50
12	67.8	21.36	33.28
18	70.9	22.33	34.81
24	45.9	14.45	22.53
30	39.8	12.53	19.53

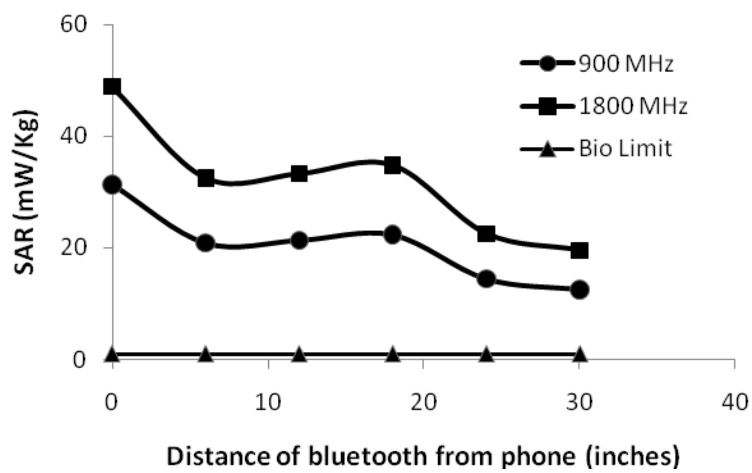

Fig.2. Plot of SAR versus distance of Cell-phone from Bluetooth outside the car. Specific absorption rate is calculated at a point on the brain as absorber for two transmission frequencies, 900 MHz and 1800 MHz

In terms of SAR, harmful biological effects which start occurring in brain are reported to be at SAR as low as 1 mW/Kg where an increase in molecular stress response in cells occur (Dhami, 2012; Pomerai , 2000).Change in calcium concentration in heart muscle cells of guinea pigs have been noticed at the same SAR values (Dhami, 2012; Wolke, 1996). Increase in permeability of BBB (blood-brain barrier) in mice has been observed at SAR levels of 8 mW/Kg (Dhami, 2012; Persson, 1997). BBB is a selective barrier, which allows transport of the indispensable nourishing elements such as glucose towards brain, but blocks the potentially harmful substances for nerve cells. Exposure of rats to 900 MHz radiation of SAR from 0.016 to 5 W/Kg showed a leak of albumin in BBB (Dhami, 2012; Salford, 1994). Hence, if we take into account the values of SAR above which changes in cells and tissue start taking place, 1 mW/Kg can be called the biological limit. The values above this SAR should be considered harmful.

Since, the safety limits vary from country to country and there is still no common consensus on what should be the permissible limit, the data has not been compared with the adopted limits. Though the actual radiation levels are important to evaluate, however, more important to know is how they are absorbed by the human body. Hence, SAR values have also been estimated and compared with the SAR value of 1 mW/Kg, which is called the biological limit in this work.Hence comparing these with biological response of 1 mW/Kg, the specific absorption rates calculated for brain were approximately 346 times higher than biological limit for 900 MHz frequency and 514 times higher for 1800 MHz frequency, when cell-phone and Bluetooth are used together inside a car.

CONCLUSIONS

Increase in cell-phoneradiation levels inside a car were estimated in terms of power density and specific absorption rate. The same were estimated for the additional effect of Bluetooth device. This data indicated that talking on phone while driving in a car is a serious health threat. The radiation intensity was estimated to be 393% higher inside a car when cell-phone is used along with aBluetooth. The estimated SAR values are 514 times higher than the biological limit at 1800 MHz. Hence, it is much higher than the levels at which biological changes start taking place inside a human body because of radiation exposure.The effect can be reduced by opening the windows while on a call or using an antenna on the roof of the car, which can dissipate the trapped energy through it and hence dilute its effects. Although driving and talking oncell-phone remains to be a dangerous combination, using a speaker and a hands free phone without an ear piece, is the safer way to talk and drive.

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