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Effect of Population Density and Surroundings on the Environmental RF Radiation

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ABSTRACT

The cell-phone radiation is a potential health hazard not only to the singular user but to the whole population through the environmental pollution. The environmental radiation density may vary from place to place depending upon its absorption or reflection by surroundings, e.g., trees, buildings, human population, water bodies, etc. The present work was taken to study the effect of population density and surroundings on the environmental radiation. The power density values of radiation were measured using a hand-held portable power density meter TES 593, and specific absorption rates (SAR) were estimated from the measured values. The SAR values were compared with the safe limit of 1 mW/kg above which biological system of humans and animals starts getting affected. The studies indicated that the average environmental radiation power density values were higher in unpopulated and open areas than densely populated regions by 300%.

INTRODUCTION

The radio frequency radiation used in cellphone communication has been recognized as a new environmental hazard. There is a global concern about the ill-effects of cellphone radiation on health. Studies indicate that people living within 300 meters of cell phone tower, could suffer from sleep disturbance, depression, headache, nausea, visual disorders, respiratory problems, nervousness and agitation (Santini 2002, Khurana 2010). The slow long term exposure to cell phone radiation exposure may cause cancer (Dolk 1997, Marinelli 2004), brain tumor (Hardell 2006, Hardell 2009), male infertility (Wdowiak 2007) and DNA damage (Philips 2009, Stagg 1997).

The research studies have established a relation between radiation power density and the distance from the source of radiation such as cellphone tower (Levitt 2010, Panagopoulos 2010). However, it is not known how the surroundings of the tower affect the environmental radiation. The radiation emitted from the tower encounters many obstructions on the way and can be absorbed, reflected or diffracted by the metal objects, buildings, window panes, etc.

The presence of large numbers of concrete buildings, metal structures, etc. in cities in comparison to open areas causes absorption or enhancement (through multiple reflections) of radiation intensity. The objective of the present work is the quantitative and qualitative studies of the environmental radiation in populated urban areas (UA) and unpopulated rural areas (RA) to observe the effect of surroundings on the atmospheric radiation intensity and hence on specific absorption rate of the human body issues.

MATERIALS AND METHODS

The radiation exposure levels are mainly expressed in terms of two parameters, viz. power density and specific absorption rate (SAR). Power density measurements were performed using a hand-held portable power density measuring TES 593 Electrosmog meter from TES Electrical Electronic Corp. 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 min before noting them in the "maximum average" mode. The measurements from three different spots around the area of interest were then averaged. The measuring device was kept at a height of 1.5-1.8 m from the ground level as this is the average height at which most of the population is exposed. The power density measurements are given in milliWatts per square meter.

RA is selected as a low population density area without many concrete structures or buildings. And the UA is the one with high-rise buildings, narrow, crowded roads and dense population. RA chosen for this study is located in the outskirts of Jalandhar city of Punjab, India and UA was a market place in the same city. The readings were taken linearly up to a distance of 850 meters from the base station. The measuring distance range is reported to have maximum effect on human health (Blettner 2009, Eger 2004). The measurements in each case were taken around a single tower with no other tower within 1 km of radius. Each reading was taken at a distance of 50 m from the base station.

The specific absorption rate (SAR), is the rate at which radiation is absorbed by human body (Ghandi 1990, Guy 1986). In the present study, local SAR has been estimated for a point on the brain as the absorber. Local SAR is related to electric field through the following equation (Ghandi 1990, Guy 1986):

$$SAR = {}^{\sigma|E^2|}/_{\rho_m} = {}^{P_A}/_{\rho_m} \quad ...(1)$$

Where, $P_A = \sigma|E^2|$ = absorbed power density by the human brain tissue,

$|E^2|$ = Magnitude of electric field vector,

σ = Conductivity of the human brain tissue,

ρ_m = Mass density of the human brain tissue.

The measuring electro-smog meter showed power density and electric field values in mW/m^2 and V/m, respectively. These values were used to estimate SAR using equation (1).

RESULTS AND DISCUSSION

The maximum radiation intensity was observed at a distance of 50 meters from the tower in both the cases. The maxima was observably higher in RA (11.2 mW/m^2) than in UA (6.1 mW/m^2) as shown in Fig. 1. The average power density was also higher in RA by 300% and decreased with increase in distance from the cellphone mast.

The lower power density in PA is due to the loss of radiation intensity by multiple reflections, refraction, scattering and absorption by the surrounding structures and objects, e.g. metal boards, hoardings, water, dry wall, wood and even humans. The radiation intensity is usually weaker after reflection because the reflecting surface absorbs some of the RF energy incident on it. In RA the RF signal is mainly reflected by the ground only. Leafy trees and dust particles can also cause the scattering of the radiation in rural areas.

The merging of two curves at 700 m from the tower indicates that the radiation power values were same in both the cases (Fig. 1). This could be due to a relatively uninhibited neighbourhood at 700 m in UA making the absorption or reflection of radiation as low as in RA. More number of peaks in power density values in RA could be due to the presence of another tower located at 1 km, whereas there was no such direct interference from any other radiation source in UA.

Specific absorption rate SAR represents the actual radiation absorbed by the human body. Hence, to estimate the health hazards posed by the cell phone radiation, it is more important to calculate the SAR values than the direct power density values. SAR can be calculated by using equation (1) for human brain. In the present studies, SAR was calculated for frequencies 835 MHz, 915 MHz, 1900 MHz and 2450 MHz, which covers most of the frequency bands used for telecommunication.

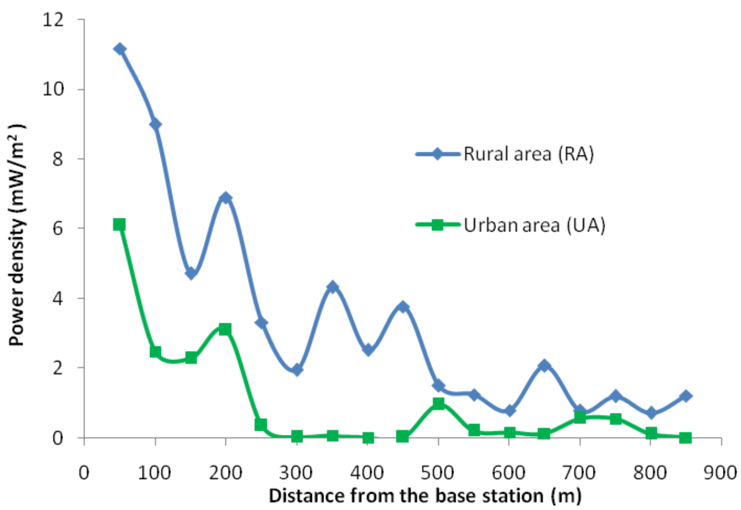

Fig. 1: Variation of power density (mW/m^2) as a function of distance (m) from the cell-phone tower in rural area (RA)and urban area (UA).

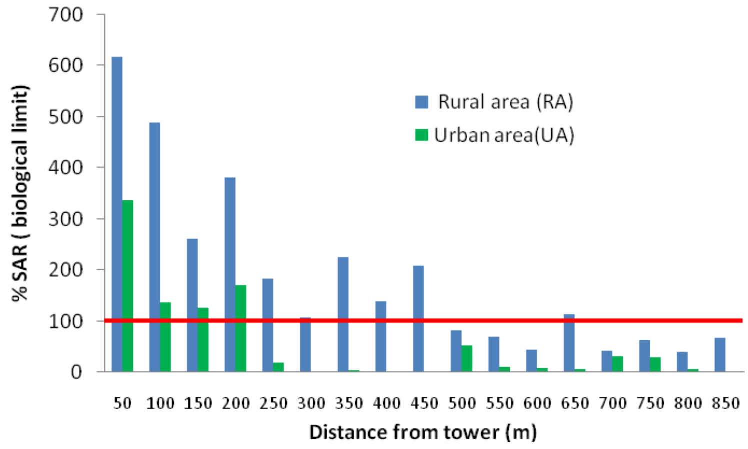

Fig. 2: Specific absorption rate estimated in terms of SAR percent of biological limit (1mW/kg) versus distance from the cellphone base station in RA and UA calculated for radio frequency 2450 MHz.

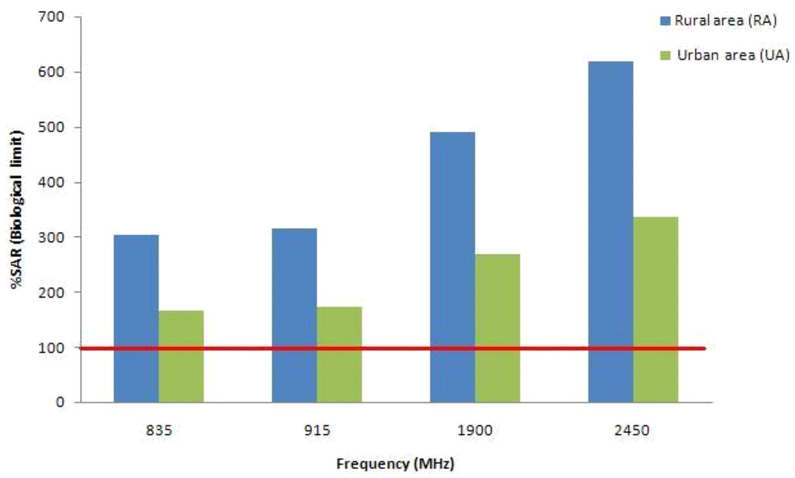

Fig. 3: Maximum value of SAR in terms of percentage of biological safe limit (1 mW/kg) estimated for radio frequencies 835 MHz, 915 MHz, 1900 MHz and 2450 MHz in rural area (RA) and urban area (UA).

In terms of SAR, harmful biological effects which start occurring in brain are reported to be at SAR as low as 0.001W/kg where an increase in molecular stress response in cells occur (de Pomerai 2000). Change in calcium concentration in heart muscle cells of guinea pigs have been noticed at the same SAR values when exposed to 900 MHz radio frequency radiation (Wolke 1996). A significant change in cell proliferation in the cells exposed to 960 MHz radio frequency radiation at SAR level of 0.0021 W/kg has been observed (Velizarov 1999). Increase in permeability of BBB (blood-brain barrier) in mice has been observed at SAR levels of 0.008 W/kg (Persson 1997). Exposure of rats to 900 MHz radiation of SAR from 0.016 to 5 W/kg showed a leak of albumin in BBB (Salford 1994). Hence, if we take into account the values of SAR at which the above mentioned changes in cells and tissue start taking place, 1 mW/kg can be called the biological limit, above which SAR should be considered harmful.

SAR was estimated in terms of percentage of biological limit and is plotted as a function of distance from base station for 2450 MHz in RA and UA (Fig. 2). Estimated SAR was higher by 600% than the biological limit for distances close to the tower. It decreased with distance but still higher than the safe limits up to 200 m. For lower frequencies (835 MHz, 915 MHz and 1900 MHz), the maximum SAR was still higher by more than 100% of the biological safe limit for both RA and UA (Fig. 3).

CONCLUSIONS

People living in open areas are exposed to higher radiation levels than those living in populated areas. The average power density is higher in unpopulated areas by about 300 % than that in populated areas. From the measured values, the SAR values for the brain tissue were calculated to assess the risk to human brain from the cellphone radiation. For radio frequency 2450 MHz, the SAR was higher by 600% than the safe biological limit of 1 mW/kg in RA. The SAR values exceeded the safe limit in RA as well as in UA up to a distance of 200 m from the cellphone tower. For other frequencies (835 MHz, 915 MHz and 1900 MHz), the maximum SAR value was 100% higher than the safe biological value for both RA and UA. At a distance of 700 m from the cellphone towers in both the regions, the radiation levels were same owing to the similar background. The studies indicate that at same frequencies and distances, different population density and surroundings can change the environmental radiation power density and hence specific absorption rates of the human body tissues.

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