Experimental Evaluation of the Humans' Health Hazards' Potential Due to Exposure to the Microwaves' Radiations in Garaboulli City-Libya.

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ABSTRACT

There is a high concern worldwide about the effects of the high level of energy of the transmitted electromagnetic radiations for the wireless communications on the humans' health. So, the purpose of this study is to experimentally evaluate the human health safety related to the exposure to the highest energy of the transmitted microwave radiations (highest radiation risk) at the highest operating frequency 2450 MHz of all operating frequencies (850, 900, 950, 2450 MHz) within the range of 30 MHz-3GHz of the tested AL-MADAR mobile phone base station in the population area for the first time in Garaboulli City - Libya. The specific absorption rate (SAR) value is used as a measure of the rate of absorption of microwave radiation energy in the human tissues on the basis of exposing to the highest radiation risk which is considered as the worst case scenario. The SAR values are evaluated at predetermined distances (5, 40, 80, 120 and 160 meters) by using MATLAB program. The power density and the electric field measurements of the microwaves radiation of the antenna of the selected of AL-MADAR mobile phone base station, were experimentally measured by utilizing the spectrum analyzer devise (Spectrum HF-6065), in addition to the mass density and the medium conductivity values for the investigated human tissues (eye (Sclera), brain (Grey Matter), nerve and blood) at 2450 MHz frequency. The numerical results indicate that the highest SAR value is $205.4 * 10^{-6}\, W/kg$ of the human blood at the shortest distance (5 meters). This SAR value is significantly lower than the international recommended safe radiation level standards. So, for the first time, these results show that the microwave equipments which use AL-MADAR network in the Garaboulli city-Libya can be considered safe on the humans' health.

Keywords: Microwaves Radiations, Specific Absorption Rate (SAR), MATLAB Program, Health Hazards & Garaboulli City-Libya.

1 Introduction

People nowadays commonly use several applications of the microwave communication technology which are constitutively emitting microwaves radiation such as modern mobile telephone services (text messaging ; messaging multi services (MMS) ; email ; internet access ; short range communications (infrared , Bluetooth) ; business application ; gaming and photography) , which use the cellular wireless network architecture ; whereas it's work depends on mobile phone base stations (these are also known as base transceiver stations or telecommunication structures). These telecommunication structures are multi-channel two ways radio for transmitting and receiving signals, and have antennas which produce microwaves radiation whereas they are mounted on transmission towers that need to be of at a certain height order to have a wider coverage [1].

The microwaves radiation has the potential to interact with the human biological system and could cause hazards on people's health. The microwaves radiation of all frequencies between 30MHz to 3GHz is classified as non-ionizing and can potentially lead to irreparable damages in the exposed human biological tissues [2].

On the basis of the exposure to the highest microwaves radiations (EMRs) energy (the highest radiation risk which is considered as the worst case scenario); by using the SAR measure in different human tissues, for the first time in Garaboulli City-Libya, this study is designed and conducted aiming to experimentally assess the potential radiation risks on the human health related to the exposure to the highest microwave radiation energy at the highest operating frequency 2450 MHz of all operating frequencies (850, 900, 950, 2450 MHz) which is included in the internationally recommended operating very high (VHF) and ultra high frequencies (UHF) range of 30 MHz to 3 GHz according to the stratification specified by International Telecommunication Union (ITU).

2 Materials and Methods

Firstly, due to the availability of many different designs of the mobile phone base stations that vary widely in their power, characteristics, and their potential for exposing people to the microwaves radiation [1] and secondly, based on the highest radiation risk, which is fulfilled requirement by the highest experimental values of each of the power density and the electrical field received at the population area of the tested site, the MATLAB program is used to experimentally evaluate the exposure to the highest microwaves radiation energy at the highest operating frequency 2450 MHz of all operating frequencies (850, 900, 950, 2450 MHz) , within the operating VHF and UHF range of 30 MHz to 3 GHz, of the antenna of the selected AL-MADAR mobile phone base station, which is located near Garaboulli City's bridge. This selected mobile base station uses modern mobile telephone services, and its antenna's radiation is received by the population area in tested site (Garaboli city centre).

The selection of the highest operating frequency 2450 MHz of all operating frequencies of the tested mobile base station was done with full consideration of the direct relationship between the calculated SAR values and the different operating frequencies.

The calculation of the SAR value which is used as the evaluating measure tool at pre determined distances (5, 40, 80, 120 and 160 meters) , was done using the correspondent information of the power density and the electric field of each investigated human tissues. The calculated SAR value is measured in watt per kilogram (W/kg).

The experimental measurements of the highest radiation energy at each earlier mentioned different distances, were done by utilizing the spectrum analyzer devise (Spectrum HF-6065), in addition to the medium conductivity (σ) values of each of the investigated human tissue [eye (Sclera), Brain(Grey Matter), nerve and blood] that have the highest values at the highest operating frequency 2450 MHz of all operating frequencies (850, 900, 950 and 2450 MHz) which is included in the internationally recommended operating VHF and UHF range of 30 MHz to 3 GHz according to the stratification published by ITU[3].

3 Theory and Calculation

This study is conducted to experimentally assess the possible health hazards on the humans due to the exposure to the highest microwaves radiation energy at the highest operating frequency 2450 MHz of all operating frequencies (850, 900, 950 and 2450 MHz), which is emitted by the selected AL-MADAR mobile phone base station that is located in Garaboulli City-Libya for the first time on the basis of considering the exposure to the highest radiation risk in the population area at the tested site; by using the SAR measure in each investigated human tissue [3, 4, 5].

3.1 Mathematical Expressions and Symbols

The MATLAB program is used to evaluate the SAR values, by applying the equation number (3) which is obtained from the equations number (1) and (2) as following:

For a sinusoidal steady state electromagnetic field, the SAR value is calculated as given in equation (1), [5];

$$SAR = \left(\sigma + \omega\varepsilon_o\varepsilon''\right)\frac{{E_{rms}}^2}{\rho} \qquad \ldots\ldots\ldots\ldots\ldots(1)$$

And by using the power density equation through applying the following formula [6];

$$P = \omega\varepsilon_o\varepsilon''{E_{rms}}^2 \qquad \ldots\ldots\ldots\ldots(2)$$

Accordingly, the equation (1) can be expressed as following;

$$SAR = \frac{(\sigma{E_{rms}}^2 + P)}{\rho} \qquad \ldots\ldots\ldots\ldots\ldots(3)$$

Where:

SAR: The evaluated specific absorption rate$[watt/kilogams(W/kg)]$.

E_{rms}: The measured value of the electric field$[Volt/meter(V/m)]$.

p: The measured value of the power density$[watt/square\ meters(w/m^2)]$.

σ: The medium conductivity$[Siemen/meter(S/m)]$.

ρ: The mass density$[Kilograms/Cubic\ meters(kg/m^3)]$.

ε'': Out of phase loss (unit less).

ε_o : The vacuum permittivity$[Farad/meter\ (F/m)]$.

ω : The angular frequency (radians / second).

The ρ values and σ values for each of the understudied human tissues [Eye (Sclera), Brain (Grey Matter), nerve and blood) at 2450 MHz frequency, are given in Table 1.

Table 1: *Clarified the difference values of Mass density (ρ), and the medium conductivity (σ) for different parts of human body at 2450MHz frequency [3, 4].*

Human Tissues	Mass Density (ρ) (kg/m³)	Medium Conductivity(σ) (S/m)
Nerve	**1075**	**1.0886**
Brain (Grey Matter)	**1045**	**1.8077**
Eye (Sclera)	**1032**	**2.0332**
Blood	**1050**	**2.5448**

4 Results and Discussion

Table 2 shows that the maximum electrical field (V/m) and the maximum power density ($\mu W/m^2$) were detected at 5 meters distance, however the minimum electrical field (V/m) and the minimum power density ($\mu W/m^2$) were detected at 160 meters distance. It also demonstrates the calculated SAR values in the tested human tissues [Nerve, Brain (Grey Matter), Eye (Sclera), Blood] at the predetermined different distances at which all the study variables were measured.

It has been well noted in Table 1 that the Blood which has the maximum SAR value, has also the maximum Medium Conductivity(σ) of 2.5448 S/m value and the nerve which has the minimum Medium Conductivity (σ) of 1.0886 S/m value, has also the minimum SAR value.

Table 2 shows also the maximum SAR value of 205.4X10^{-6} W/kg was measured at 5 meters distance in the blood and the minimum SAR value of 5.7X10^{-6} W/kg was measured in the Nerve biological tissue at the distance of 160 meters.

Table 2: *The measures power density, electric field values and the calculated SAR values of the investigated human tissues at 2450 MHz frequency at different distances.(*GM=Grey Matter)*

Distance (m)	Electric field (V/m)	Power density (uW/m^2)	SAR ($\times 10^{-3} W/kg$)			
			Human tissue			
			Eye (Sclera)	Brain (GM*)	Nerve	Blood
5	0.291	221.2	0.1670	0.1467	0.0860	0.2054
40	0.281	210.2	0.1558	0.1368	0.0802	0.1916
80	0.192	85.94	0.0727	0.0639	0.0374	0.0894
120	0.144	55.44	0.0409	0.0359	0.0211	0.0503
160	0.075	15.21	0.0111	0.0097	0.0057	0.0136

The results given above indicate that the highest SAR value is 205.4×10^{-6} W/kg of the blood human tissue that has been calculated at the shortest distance (5 meters) and at 2450 MHz frequency. Comparatively, this SAR's value is much lower than the international recommended safe radiation level standard's values. These standards are regulated by world authoritative bodies include the following with their correspondent safe SAR limits; 1.6 W/kg during 30 minutes according to the Federal Communications Commission (FCC) and 2 W/kg during 6 minutes according to the European recommendations.

It is important to note that the average time exposure of 30 minutes according to FCC and 6 minutes according to the European recommendations have a significance only in the cases that are exposed to the power or the electromagnetic fields which are higher than the allowed ones according to the related international standards. However, in the inhabitant residential populated areas similar to the tested site in this study, the FCC recommends not to apply the average time exposure parameter, so, the calculated SAR values which do not exceed the allowed ones according to the international standards, are considered as the allowable values to a continuous exposure for indefinite time period [7].

5 Conclusion

This study shows clearly that on the basis of the exposure to the highest microwaves radiation energy (the highest radiation risk which is considered as the worst case scenario) in the population area at the tested site and by considering the direct relationship between the calculated SAR values and the different operating frequencies, the obtained practical results prove that microwaves radiation for all operating frequencies that are emitted by AL-MADAR wireless communication system networks in Garaboulli City-Libya can be considered safe to the people's health.

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