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Microwave Radiations and Its Effects on Human Health- A Review

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----------***ABSTRACT***----------
Since the 19th century, technologies have been intrigued by the interface of electromagnetic fields and many life manners. In the daily life each human exposures for huge amount of signals with different frequencies as mobile phone signals, TV signals, radio signals, and Wi-Fi signals. All these signals have different amount of energy levels. Especially, the number of mobile users is growing in a huge manner as the time passes for achieving the requirement of higher data rates.
Microwaves are a form of electromagnetic radiation and are considered to be that radiation ranging in frequency from (300MHz) to (300GHz), that mean it have wavelengths reaching from (1m) to (1mm) [1,2]
The microwave frequencies causes thermal and non-thermal effects, also the electromagnetic radiations are recognized as one of the cancer sources. [3]. Changes in vibrational energy of the molecules causes by the electromagnetic radiation that absorbed at molecular level and manifests [4]. Some of the risk effects on the living beings can be considered as a result of the innovatory changes in the wireless system of communication technologies. This article is an attempt to provide the reader with the information of the effects of microwave irradiation included the health effects.
KEYWORDS - *Microwaves, Radiations, Electromagnetic, Health Effects, SAR.*

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I INTRODUCTION

Recently wireless techniques especially mobile phones have grown at very fast in convenient communication systems in the world. That growth in these techniques also noted in significant form in Iraq. These techniques used microwave frequencies, which noted as a form of electromagnetic radiations. According to the handshaking role, mobile phones has many advantages as well as it have a harmful side.

Many adversarial effects on health causes by electromagnetic radiations [5]. The hazard for human health from the electromagnetic radiations well be increased with the growing in the number of devices that used the microwave frequencies in daily life [6].

The radiation can be defined by the energy emitted as waves from a source through a suitable medium or space and immersed by another body [7]. Depending on the energy of the radiated atoms it is often classified as either ionizing or non-ionizing [8]. As a comparison between these two types of radiations, Non-ionizing radiation have a longer wavelength i.e. lesser frequency, and lesser energy. In the other hand, ionizing radiation have a shorter wavelength i.e. higher frequency, and higher energy [9]. Fig. (1) Illustrates the Electromagnetic spectrum [10]. The electromagnetic fields that responds by the microwaves radiation effect on the human health in different forms such as biological effects, physiological effects, effects on pregnancy and cancer, behavioral effects, and genetic effects [11,12]. In this article the highlight well be focused on the as biological effects and physiological effects.

II SAR OF MICROWAVE RADIATIONS

The specific absorption rate (SAR) can be defined as a measure for the energy of the electromagnetic deposited by a natural mass when showing to radiations form a radiating device as a mobile phone [13]. This definition can be formed as the derivative of the incremental energy (dw) with respect to the time that absorbed in an incremental mass (dm) enclosed in a volume component (dv) of a known density (ρ) [14]. That can formulated as in eq.(1)

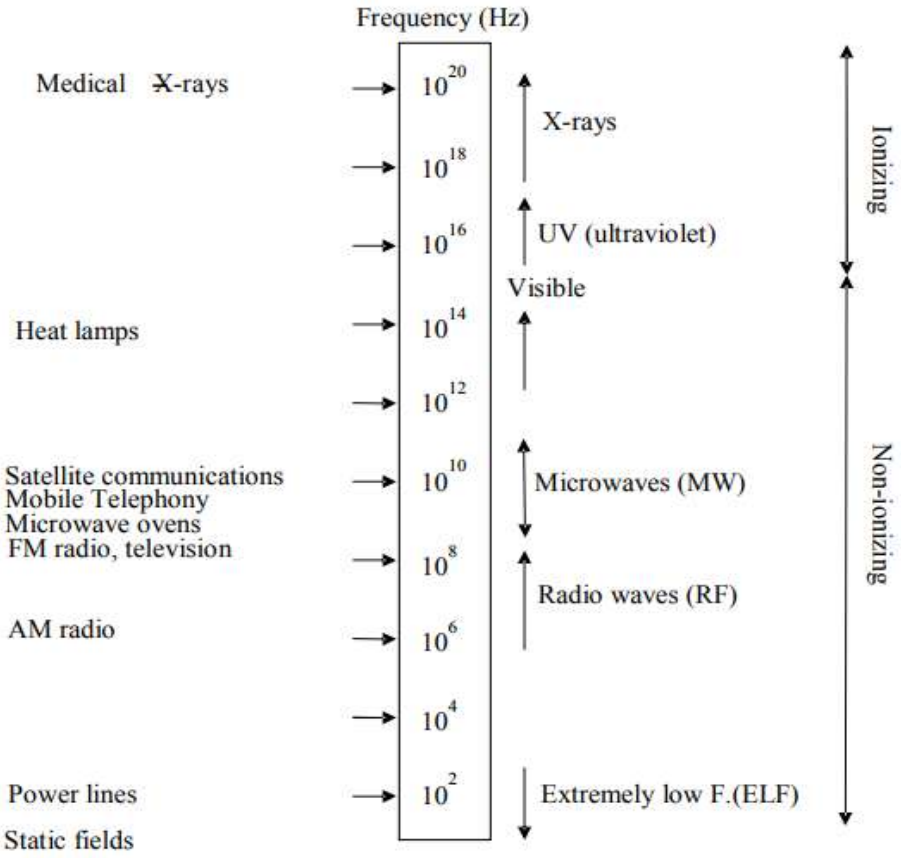

Fig.1 The Electromagnetic spectrum

$$SAR = \frac{d}{dt}\left(\frac{dw}{dm}\right) = \frac{d}{dt}\left(\frac{dw}{\rho dv}\right) \qquad W/Kg \quad \dots (1)$$

The relation of SAR with the internal E-field can give by eq. (2) [15].

$$SAR = \frac{\sigma |E|^2}{2\rho} \qquad W/Kg \quad \dots (2)$$

Where, (σ) is the conductivity body measured by unit Siemens /meter, (ρ) is the density of mass measured by unit kilogram/ cubic meter, and (E) is the r.m.s. strength of the electric field measured by unit Volts/meter. Although the microwaves has effects on the human health, but there are determined rang of SAR for using these frequencies with satisfying the safety conditions [16]. According to the directive 2004/40/EC for (0 Hz to 300 GHz), the SAR has a determined values should not be exceeds for satisfying the safety condition [17,18]. Table (1) presents the exposure limit values of the directive 2004/40/EC in the (0 Hz to 300 GHz).In the below table, r.m.s. refer to root mean square, WB refer to whole body, and F refer to frequency in Hz. It's should be noted that each 1g (gram) of mass equivalent approximately 1cm3 [19].

III BIOLOGICAL EFFECTS OF MICROWAVES RADIATIONS

In addition, the positive side of technologic that make the life easier, it also include side that harm the life quality by its assured risky effects[20]. Many researches and studies on human provided that there is adverse effects of the human health when exposure to the microwave radiations [21]. Biological effects can be defined as the measurement of body response for a changing in the environmental conditions [22]. The electromagnetic radiations can be absorb by water-based bodies such as humans, and animals, so electric currents can be produced inside the cells that formed like these bodies [23].

Table 1 The exposure limit values of the directive 2004/40/EC in the (0 Hz to 300 GHz).

Frequency range	of Current density (r.m.s.) for head and trunk J (mA/m2)	SARWB (W/kg)	SAR for (head and trunk) (W/kg)	SAR for (Limbs)	Pwer density S (W/m2)
Up to 1Hz	40	--	--	--	--
1 to 4 Hz	40/F	--	--	--	--
4 to 1000 Hz	10	--	--	--	--
1 to 100 kHz	F/100	--	--	--	--
100 kHz to 10 MHz	F/100	0.4	10	20	--
10 MHz to 10 GHz	--	0.4	10	20	--
10 to 300 GHz	--	--	--	--	50

The particular biological reactions of electromagnetic radiation energy generally associated with the amount of the absorbed energy. Many features as the frequency, field intensity and field orientation, body mass, dielectric constant and conductivity are determined the absorption amount and distribution of electromagnetic radiation energy [24]. Since the human body contain about 70% liquid, thus the body well absorb the electromagnetic radiation energy when he exposed to this radiations [25]. The concentration effects of the electromagnetic radiation energy is much more significant in the body parts that consist more fluid as brain [26].

The radiation of high frequencies signals i.e. the fast moving particles obtrudes a cell with sufficient energy to hit electrons from molecules that frame the cell. After losing electrons, the molecules well become ions. The regular working of the cell disorders with the existence of these ions [27]. These effects can be classify into two natures including thermal and non-thermal effects [28]. The first class of effects resulted from the exposure to the electromagnetic radiations energy for long time and causing a rise in body mass temperature of more than 1^{o}C by absorption of these radiations [29]. In the other hand, the non-thermal effects is the effects that occurred not due to the rising of body mass temperature body mass temperature, here the electromagnetic radiations energy directly interaction with the cell molecules[30]. Absorption of microwave radiations energy may change the propagation rate of cells, enzyme action and distress the genes in the DNA of cells [31].

IV MICROWAVE RADIATION STUDIES ON HUMANS AND ANIMALS

According to the saving energy low its, certainly that the electromagnetic radiations have effects on the human body, because these radiations have energy amount [32]. There is a lot of searches and studies on human and animals focused the high light on the effects of microwaves on the health and life.

In 2013, Bhargavi K, et. al. [33], proposed a mobile phone radiation effects on human health. In this project, electroencephalogram machine is used to determine the brain operation in three conditions including, without any radiations, with using mobile phone, which use a GSM standard, and with using mobile phone, which use a CDMA standard. After analyzing results, they conclude the mobile radiations have certain hazards on the human brain.

In 2011, Adam Santorelli, et. al. [34], simulated SAR levels in microwave breast imaging: 3-D safety assessment with plane-wave illumination. In this work, they obtain the data from the FDTD simulations run by SEMCAD-X. They noted the quantity of energy absorbed by the breast in microwave imaging techniques have a negative health effects unless under the SAR limited values.

In 2006, Emília Sánchez [35], introduced a report that titled what effects do mobile phones have on people's health. That is a health evidence network (HEN) which give the health effects of regular exposure to mobile phones. The conclusions of this report was the use of a mobile phone has a significantly negative health effects.

In 2016, Iris Atzmon, et. al. [36], introduced a microwave/radiofrequency (MW/RF) radiation exposure and cancer risk: Meta-Analysis of accumulated empirical evidence. In this article the authors analyze 57 studies, published through 30 years,(1982 – 2012) and determined the association of the cancer hazards with the exposure to the MW/RF radiation by using meta-analysis tools of the WinPepi© software. They concluded the exposure to MW/RF radiation increased the risk of morbidity including melanoma, lymphoma, leukemia, and brain/CNS cancers.

In 2009 Neha Kumar, " [37], published a paper that titled biological effects of electromagnetic radiation. In this project, the authors documented the risk of brain cancer increased significantly on the side as one held the phone as compared with other side.

V CONCLUSIONS

This research focused the highlight of absorption of the electromagnetic radiations by the human body and the negative effects on the human health caused by these radiations. The study is based on past studies and real experiments on human and animals that referenced in the paper. There are a negative effects of the

electromagnetic radiation especially in radiofrequency field that used in the communication systems, radio, TV, cellular systems, and internal wirelessly systems. In this research, we noted that the microwave radiations have effects established for different levels of biological systems starting from micro cells to the completely human system and animals. Depending on the past review studies and experimental studies the negative effects of the microwave radiations does not have direct hazards on the human health. The harmful effects of the electromagnetic radiation increased with the increasing of exposure to the electromagnetic spectrum. The hazards of the microwave radiations can be reduce if there are a safety consideration is tacked in the design of the devices that used the microwave radiation especially in its antennas, such a smart antenna that reduce the power level of the microwave radiations.

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