

some of the health issues related with the cellular phone radiations.

KEYWORDS : Electromagnetic Waves (EMW), Radiofrequency (RF), Cellular phone

Introduction:

Now days, cellular phones are an integral part of modern telecommunications in every individual life (WHO, 2001). Cellular phones are defined as devices emitting radiofrequency electromagnetic waves (RF-EMW). These waves transmit signals from the cellular phone to the base stations and antennas. The frequency of such waves is low and ranges from 800-2200 MHZ (Bernhardt, 1999). However there is still risk to the human user, because our bodies can act as antennas that absorb these waves and convert them into eddy currents. The mechanisms of cell phones operate in such a way that the sound wave produced from the speaker goes through a transmitter and converts the sound into a sine wave. This sine wave then travels to the antenna, which then projects the wave out into space. Average power usage of the transmitter is about 0.75 to 1 watt, with a maximum of 2 W. The propulsion of the electric sine wave running through the transmitter circuit also yields an electromagnetic field. As the electric current oscillates back and forth, these electro-magnetic fields continue to build up and collapse, resulting in electromagnetic radiation.

The preliminary cell phone system, Analogue NMT (Nordic Mobile Telephone) system, was introduced in the 1980s, and operated at an electromagnetic resonance of 902.5 MHz. A decade later, the GSM (global system of mobile communications) succeeded it, operating at a radiofrequency of 902.4 MHz, pulsing at 217 Hz. The most recent DCS (digital cellular system) operates at a radiofrequency of 1800 MHz. Advances in cell phone telecommunication systems are obviously associated with an increasing signal frequency, which correlates with higher energy radiofrequency waves. In order to measure the impact of radio frequency electromagnetic waves on the human body a standardized unit called the SAR value (Specific Absorption Rate) was established. The SAR measures the rate of radiofrequency energy absorption in the body, expressed as watt/Kg (Eggert et al., 2001; Moulder et al., 1999). Device specific SAR tests are conducted at the highest power level of the device, in all four frequency bands. Since 1996, the FCC (Federal Communication Commission) has limited the maximum legal SAR of any handheld mobile device to 1.6 watts per kilogram, and from the year 2000 onwards, all cell phone manufacturers must place labels on their phones providing their radiation levels.

INTERACTION OF CELL PHONE RADIATION WITH BIOLOGICALTISSUES

Cell Phones Have a Dual Effect on the Human Body

Electromagnetic waves (EMW) emitted from cell phones and even microwaves oven fall within the low frequency range of EMW between 300 MHz to several gigahertz. Such level is far below the high frequency EMW of X-ray and gamma rays. EMW travel through space at the speed of light, however, their energy level depends on their frequency and wavelength. The energy carried in EMW is composed of electrical and magnetic fields and it is better represented by the term power density (PD). PD is defined as the amount of power per unit area in a radiated microwave field and is usually expressed in milli- or microwatts per square centimeter (mW/cm2 or μ W/cm2). Nevertheless, the level of energy in such EMW is so low that it cannot break the covalent bonds in biological molecules. This type of radiation effect on molecular level is called non-ionizing radiation to differentiate it from the ionizing radiation effect of high frequency EMW. In general, the exposure to EMW from different sources is divided into two categories: "continuous" and "pulsed" according to the characteristics of the emitted waves. The biological effects of pulsed wave exposure are even more harmful than that of continuous variety from other sources (Lebedeva et al., 2000).

Thermal and non-thermal effects are the main mediators of EMW interaction with biological system and both the electrical and magnetic properties determine sequelae of such effects on human body.

Thermal Effects

The tissue temperature increase resulting from exposure to EMW is referred to as "thermal effects". Heat is primarily associated with absorption of high frequency EMW radiation resulting from enhanced electrical conductivity of the tissue media. Thermal effects may cause disruption of cell function and development. It has been studied that radio frequency radiations causes DNA breakage, which further causes problems with replication of the molecule and thus impairing cell division (Frei et al., 2011). Increment of tissue temperature in an organ is related to imbalance between heat generation and heat dissipation. Heat generation depends on SAR and energy level (power density) of emitted EMW which must exceed 100mW/cm2 to have heating impact on biological tissues. In contrast, heat dissipation involves three mechanisms: heat conduction to other tissues, convection through blood perfusion, and radiation to the surroundings. Generally, the two most vulnerable organs to thermal effects are the eyes and testes because of limited capacity of heat dissipation. However, the power density of the cell phone EMW and SAR is so low that the increment of body tissue temperature is negligible at the current level of frequency and energy of EMW in modern cell phones.

Non-Thermal Effects

The vast majority of the sustained cell phone EMW related biological consequences can be explained by "Nonthermal effects". These effects include all the interactions of EMW with biological tissues without production of heat or a measurable rise in temperature. Specifically, the magnetic field, rather than the electrical field, of EMW has the most harmful potential on living organism because of its ability to penetrate human bodies while electrical field has poor human skin penetration ability. In fact, the induced alternating currents in our bodies resulting from cell phone EMW exposure can explain the biological non thermal effects at tissue, cellular and sub-cellular levels.

At the cellular and sub-cellular level, EMW may exert direct or indirect effects on cell membranes, cytoplasm and nucleus. Various short-term and long-term effects are associated with mobile radiations. Short-term effects may include sleep disorders, headaches, depression, memory loss, etc. while long-term effects can be brain tumor, cancer, DNA damage. Breast cancer was one of the most observed cancer associated with mobile radiations while that of prostate, pancreas, bowel, skin, lung, and blood also increases. Children and teenagers, below the age of 20 are five times more likely to get brain cancer, as the penetration rate of radiations is much deeper and their brain is not fully developed (Graham et al., 2001). EMW are also responsible for causing hormonal imbalance in the body. A study revealed that women and men who were exposed to higher levels of EM radiations for a

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night in the laboratory, were found to have increased serum estrogen levels in women and decreased testosterone levels in men (EWG, 2009). The increased levels of estrogen develop the risk of cancer and decreased level of testosterone has been related to development of prostate and testicular cancers (Graham et al., 2001). Melatonin, hormone secreted by pineal gland in brain and is responsible for sleep cycle is also effected by EM radiations. The level of melatonin is higher at night and is low during the day. When this hormone is inhibited by radiations many problems are caused like sleep disorders, insomnia, headaches, etc. The cells are repaired and rejuvenated while sleeping but lack of sleep can lead to development of cancer.

DNA damage, another major health problem, associated with EMW. Weak electromagnetic fields release calcium ions from cell membranes. Leakage of calcium ions into the cytosol acts as a metabolic stimulant, that is responsible for growth and healing, and also promotes the growth of tumors. Loss of calcium ions causes leaks in the membranes of lysosomes releasing DNA's that causes DNA damage. Another possibility of DNA damage can be through increased free radical formation inside cells, which further causes cellular damage in the mitochondria (Blackman, 2009).

Mobile phones became an integral part of the most people live for easier connectivity and wireless communication. Mobile phones emit electromagnetic radiations which is associated with many health risks. The influence of cell phones and their effects on human health are still being tested and studied. The addiction and huge reliance on cell phones carry some risks on human development and health.

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