HAZARDS OF MICROWAVE RADIATION

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The use of microwave is increasing day by day all over the world. Microwaves are used in mobile phones, microwave ovens, etc. Mobile or cellular phones are now an integral part of modern telecommunications. In many countries, over half the population use mobile or cellular phones and the market is growing rapidly. Researches are going on in various countries on the possible health effects of microwave radiation. In this article the results of such researches have been discussed.

Introduction

Wireless communication links have been used worldwide for many years to establish connectivity in point-to-point and point-to-multipoint applications. They include radio, television broadcast stations, mobile phones, etc. Microwave ovens are also used for cooking foods and heating previously cooked foods. Microwaves have frequency in the range 300 MHz to 300 GHz and are non-ionising radiation. While ionising radiations contain sufficient energy to rip atoms and molecules from the tissue and alter chemical reactions in the body, microwaves cannot cause ionization in the human body.

Use of mobile communication is increasing at a very fast rate and has raised concern in the society about the possible adverse effects of microwave radiation on human health. Scientists are carrying out research to find whether microwaves have any adverse health effects. Animal experiments, laboratory studies of cells, clinical studies, computer simulations, and human population (epidemiological) studies have been conducted to determine the relationship between exposure to electromagnetic fields (EMF) and a number of disorders, including depression, childhood leukemia, central nervous system disorders, cancer, melanoma, breast cancer, etc. In the past, numerous reports have presented conflicting information. Some studies1,2,3,4,5,6,7 demonstrate that EMF can impair self-regulation and cause adverse biological impacts, including: increased permeability of the protective blood-brain barrier, changes in brain wave activity, unbalanced release of neurotransmitters and hormones (especially the increase in stress hormones), immune system impairment, damage to genetic material, and lowered fertility, to name only a few of the well-established examples. Oxidative cell stress—a major cause of many diseases—has been shown to be a central effect mechanism of radiation exposure. Some demonstrated DNA damaging effects of low-level microwave radiation in brain and the potential adverse effects of these non-ionizing radiations may depend on their accumulation over a long period of time. Lai and Singh8 have observed that single- and double-strand DNA breaks in brain cells of rat after acute exposure to either the pulsed or continuous 2450 MHz radiofrequency (RF) radiation. No significant difference was observed between the effects of the two forms of radiation. They have speculated that these effects could result from a direct effect of RF energy on DNA molecules and/or impairment of DNA-damage repair mechanisms in brain cells. But they have not explained how 2.45 GHz electromagnetic waves having energy of 0.01 meV break bonds with binding energy greater than 100 meV. However, Deshmukh et al3 have also observed that low SAR microwave radiation exposure at 2450 MHz may induce DNA strand breaks in brain tissue.

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Avendano et al. have observed that use of laptop computers connected to internet through Wi-Fi decreases human sperm mobility and increases sperm DNA fragmentation. DNA breaks due to exposure to high frequency EMF used in mobile phones have been reported by the ECOLOG-Institute. Exposure to high energy RF radiation on the testis decreases the number of sperms and their mobility and causes temporary infertility.

It is to be mentioned that there is doubt about some of the reports that mobile phones have no adverse health effects have been made in the interest of mobile industries. According to Dr. Neil Cherry, of Lincoln University, New Zealand, “Strong claims by industry representatives and their consultants that there is no scientific evidence to justify the public’s fears is scientifically demonstrably wrong.” In Freiburg Appeal more than one thousand doctors requested to “Provide government funding for industry-independent research and education that do not dismiss strong scientific and medical findings of potential risks, but rather work to clarify those risks.”

RF exposure limits for mobile phone users are given in terms of Specific Absorption Rate (SAR) – the rate of RF energy absorption per unit mass of the body. It is defined as the power absorbed per mass of tissue and has units of W/kg; although SAR is usually averaged either over the whole body, or over a small sample volume (typically 1 g or 10 g of tissue). The value cited is then the maximum level measured in the body part studied over the stated volume or mass. Currently, two international bodies (International Commission on Non-Ionizing Radiation Protection (ICNIRP) and Institute of Electrical and Electronics Engineers (IEEE)) have developed exposure guidelines for workers and for the general public, except patients undergoing medical diagnosis or treatment. These guidelines are based on a detailed assessment of the available scientific evidence.

**Thermal Effects**

Microwave radiation produces heat due to its absorption by water and protein molecules present in the body. This effect the functioning of the body. The portion of the body where microwave radiation is incident gets heated. The rise in temperature of the tissues depends on the frequency and power of microwave radiation being absorbed and the cooling mechanism of the system. The heat generated moves to other parts of the body by the process of conduction and through blood circulation and the body gets heated. When the thermoregulatory capability of the body or parts of the body is exceeded, tissue damage and even death can result. This occurs at absorbed power levels far above the metabolic power output of the body. When the absorbed energy increases due to the prolonged exposure or increase in power of radiation, the protecting mechanism of heat control breaks down, resulting in uncontrolled rise in body temperature. At low power of irradiation, one usually gets headache, vomiting, intraocular pain, sleep disturbances, nausea, dizziness, fatigue, nervousness, and sensation of warmth. Most of these effects are not permanent.

In the case of a person using a cell phone, most of the heating effect will occur at the surface of the head. The brain’s blood circulation is capable of disposing of the excess heat by increasing local blood flow. However, two parts of the body, the eye and the testis, do not have enough blood circulation to dissipate away the heat. Consequently, these two organs may be damaged due to exposure to RF radiation. For example, due to long exposure the protein of the eye lens is damaged and its transparency decreases, that is, cataract is produced. Exposure of 2–3 hours duration has been reported to produce cataracts in rabbits’ eyes at SAR values from 100-140W/kg, which produced lenticular temperatures of 41°C. Experiments on human and animals showed that long exposure to high energy RF radiation causes cataract.

**Effect on Skin, Tissues and Muscles**

The layers of the body can be approximated as a thin layer of epidermis, dermis, adipose tissue (subcutaneous fat), and muscle tissue. Significant injury with erythema, blisters, pain nerve damage and tissue necrosis can occur even with exposures as short as 2–3 sec. Due to the deep penetration of the radiations, the skin may be minimally affected and show no signs of damage, while muscles, nerves, and blood vessels may be significantly damaged. Sensory nerves are particularly sensitive to such damage; cases of neuritis and compression neuropathy were reported after significant microwave exposures.

A two-second burst of 95 GHz microwave focused beam heats the skin to a temperature of 54 °C at a depth of 0.4 mm and is claimed to cause skin pain without lasting damage. The depth of penetration depends on the frequency of the microwaves and the tissue type. At dozens of GHz, the radiation is absorbed in few millimeters of skin. Muscle tissue is a much more efficient absorber than fat, so at lower frequencies that can penetrate sufficiently deep, most energy gets deposited there. The muscle will be burned more than subcutaneous fat. There may be burning of the skin and deep muscles, with little damage to the intermediate subcutaneous tissues. With microwave burns there may be a delay between the time of injury and signs.
of skin damage or pain. For 2.5 GHz, the first millimeter of muscle tissue absorbs 11% of the heat energy; the first two millimeters together absorb 21%. For lower frequencies, the attenuation factors are much lower, the achievable heating depths are higher, and the temperature gradient within the tissue is lower.13

The tissue damage depends primarily on the absorbed energy and the tissue sensitivity; it is a function of the microwave power density, frequency, absorption rate in the tissue and the tissue sensitivity. Tissues with high water content show higher microwave absorption. The degree of the tissue damage depends on both the achieved temperature and the length of exposure. Microwave penetrates the epidermis with very limited energy absorption. Damage to epidermis is low unless the epidermis is very moist. The characteristic depth for lower-frequency microwave injury is about 1 cm resulting in direct heating of sub-epidermal tissue water. The heating rate of adipose tissue is much slower than that of muscle tissue. Frequencies in millimeter wave range are absorbed in the topmost layer of skin, rich on thermal sensors. At lower frequencies, between 1–10 GHz, most of the energy is however absorbed in deeper layers; the threshold for cellular injury there lies at 42 °C while the pain threshold is at 45 °C, so a subjective perception may not be a reliable indicator of a harmful level of exposure at those frequencies.14

Moreover, disturbances of other cellular processes, like the synthesis of proteins and the control of cell functions by enzymes, have been demonstrated. In numerous experiments on humans as on animals influences on the central nervous system were proven, which reach from neuro-chemical effects to modifications of the brain potentials and impairments of certain brain functions, e.g. deficits in the ability to learn simple tasks when exposed to the fields. From experiments with volunteers, who were exposed to the fields of mobile phones, there is clear evidence for influences on certain cognitive functions. Possible risks for the brain also arise from an increased permeability of the blood-brain barrier to potentially harmful substances, observed in several experiments on animals exposed to mobile phone fields.15

Possibility of Cancer

The ECOLOG-Institute, Germany, reported in a press release9 in April 2001, that investigations on sub-populations with an elevated exposition to high frequency EMF used in mobile phones and from animal experiments, point on a cancer-promoting effect. Experiments on cell cultures yielded clear evidence for geno-toxic effects of these fields, like DNA breaks and damage to chromosomes, so that even a cancer-initiating effect cannot be excluded. The findings that high frequency EMF influence cell transformation, cell promotion and cell communication also point on a carcinogenic potential of the fields used for cellular telephony. In 2006 a large Danish group conducted a study about the connection between mobile phone uses over 420,000 Danish citizens for 20 years and showed no increased risk of cancer. In 2011 a follow-up study confirmed these findings. Based on the data gathered from 13 participating countries the International Agency for Research on Cancer (IARC) has classified radiofrequency EMF produced by mobile phones as possibly carcinogenic to humans, so additional research into the long-term, heavy use of mobile phones needs to be conducted. The National Cancer Institute says that only some of the numerous studies conducted have suggested an increased risk for certain types of brain tumors. For example, M.J. Schoemaker et al16 showed that people who used cell phones for 10 years or more had an increased risk of a tumor on the same side of the head that they regularly held the phone. The finding was later confirmed by M. Hours et al. Some national radiation advisory authorities have recommended measures to minimize exposure to their citizens as a precautionary approach.

According to the March 2001 report by the European Parliament STOA, “the main problem is not cancer. … Cancer takes a long time to develop. Typically, other problems show up first: neurological, reproductive, and cardiac. Problems with severe headaches sleep disturbances, memory loss, learning disabilities, attention deficit disorder, and infertility show up long before cancer. When cancer does appear, it’s typically brain tumors, leukemia, and lymphoma.9 The ECOLOG-institute recommends not to exceed a precautionary standard of 0.01 W/m². “Dr. Neil Cherry says, “The actual expose levels at which these genetic effects are shown are about 0.5 to 1.2 µW/cm². There is no safe threshold.”9

Studies in Russia have demonstrated that long-term exposure to very low levels of microwave radiation can pose health risks, and this has led to Russian and European Union safe limits of 1 mW/cm² versus the established safe limit in the U.S. of 5 mW/cm².

Microwave Oven

A standard microwave oven emits about 600-700 W of power to cook food. For microwave ovens the main danger posed is one of proximity. Under United States
federal guidelines, the maximum allowed leakage of radiation from a microwave oven in use is 5 mW. This radiation leakage drops off by a factor of 10 with square of the distance from the source. If someone receives 5 mW of exposure at a distance of 2.5 cm from a microwave oven, stepping back to a distance of 25 cm would reduce this exposure by a factor of 100, or to 0.05mW.

Chemicals decomposed by the effects of radiation may pose some health risks, such as being carcinogenic, reducing immune function, or impairing memory. Due to these unknowns, baby formula and blood for transfusions is never heated by microwave radiation in hospitals. It is also known that certain soft plastic food packaging has the potential to leach plastic compounds into food if it is used as a container or covering in the microwave, and it is therefore recommended that food be microwaved only in glass or plastics clearly designated as microwave-safe.

**Conclusion**

It has been shown that microwaves have some adverse effects on health and we must be conscious about it. It is not possible to avoid it but we may reduce its adverse effects by taking some precautionary measures. For example, holding a cell phone and its receiving antenna slightly away from the head, encasing it in a carrying pouch, or using ear phones so that the device could be set down at a distance will reduce exposure to microwave radiation to a great degree. Growing children should be discouraged to use mobile phones.

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