



Impact of Radiofrequency and Microwave Fields on Human Health

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Abstract

This paper discusses potential biological impacts of mobile communication electromagnetic fields as well as other sources of radiofrequency (RF) and microwave (MW) fields. Both thermal and non-thermal probable effects are explained. The biological impacts of heat on the skin and eyes is taken into consideration, including some thermal effects such as the immune system, RF hearing, blood-brain barrier, and behavioral consequences are also taken into account. Standards for human health and safety are numerous. ANSI/IEEE, FCC, and ICNIRP are only a few of the organizations that are introduced in this presentation. Suggestions for safeguarding human health are also made.

Keywords- – RF/MW, electromagnetic fields, mobile phone, Biological effects.

I. INTRODUCTION

These days, mobile communication services are vital to human existence. The adoption of these new technologies by users has been widespread. The interaction between electromagnetic fields and human tissues is influenced by a variety of elements, including dielectric characteristics, exposure source design, field frequency, and age, exposure conditions, tissue size and shape, field strength, time intensity factor, direction, and field polarization [1], [2]. In this work, we discuss the potential health risks that mobile communication and microwave frequency fields have to human health. Negative health effects arise when the body is unable to regulate the high temperature of its tissues through regular biological processes like blood flow and sweating. Several studies have demonstrated that the biological system, including blood might happen. [3] The body's internal dielectric field affects how microwaves and radiofrequency radiation behave biologically. For the purpose of protecting human health, the internal fields need to be identified and a good restriction database established. The assessment of how radiofrequency fields interact with biological tissues is determined by dosimetry investigations, which are included in. [4], [5] The body's conductivity and the source's frequency determine whether electromagnetic fields are absorbed, reflected, or transmitted when they move from one medium to another. The field's absorbed energy transforms into several forms, primarily heat, and has the ability to alter the body's regular functioning. [5], [6].

II. The biological consequences of radiofrequency and microwave

Different frequencies of electromagnetic fields have distinct impacts on human bodies. Two mechanisms impact the human body: 1. Heating is a significant consequence in RF and microwave frequency fields. It might let's start with some intense burns. 2. Induce magnetic and electric currents that have the potential to alter the heart's or the central nervous system's regular current (CNS). The two categories of biological impacts of RF and MW are: 1. consequences of heat 2. non-thermal outcomes.

2.1 Effects of heat

The dielectric properties of permittivity, conductivity, and permeability are present in human body tissues. As a result, human tissues have the ability to absorb electromagnetic fields, which can then create conduction and displacement currents. The following factors affect the temperature increase during microwave exposure: frequency or wavelength; length of exposure; specific body area exposed and heat removal efficiency; thickness of skin and subcutaneous tissue; and intensity of the field strength. Heat is produced by these displacement and conduction currents, which convert electromagnetic energy. The amount of water in the tissue determines how well fields are absorbed. Electromagnetic waves may enter thicker and fatty (higher water content) tissues more easily than they do into thin tissues. The human body produces heat when ingested energy is transformed into There are thermal impacts. Additionally, when the human body is subjected to electromagnetic radiation, exposed tissue's body temperature rises above normal, potentially leading to biological effects. There are two types of heating: induction heating happens at higher frequencies, and dielectric heating happens at very low frequencies (few kHz to MHz). microwaves to radio frequency. It is apparent that both the SAR and the heating increase with frequency. As the body's thermal regulation system, blood flow can influence and control an increase in body temperature, releasing heat that has been added by exposure. Tissue absorption of electromagnetic radiation occurs at varying rates and is measured in watts per kilogram (W/kg) units.

2.2. Damage to the Eye

Electromagnetic fields can cause damage to the cornea, cataracts, retina, lenses, and iris. The human eye is a special organ with special characteristics that make it vulnerable to electromagnetic field injury. Although blood flow is essential for cooling heated tissue, it is absent in the human eye, and a lack of blood flow in the cornea can result in cataracts. Due to its sensitive nature, the eye is a region that requires extra care and attention. The amount of water in the tissue affects how much the body temperature

risers as a result of electromagnetic field absorption. As a result, thick and fatty tissues are more susceptible to electromagnetic wave penetration than thin ones. The eye's lens

2.3 Damage to the Skin

There is minimal biological penetration of several high frequency (RF/MW) electromagnetic spectrum components. tissues. The link between frequencies and penetration depth is depicted in equations 1 and 2. [14] The electromagnetic radiation remains at the skin's surface and is absorbed due to limited penetration. It raises the skin's temperature in particular areas, which results in burning sensations. Heat exhaustion, heat stroke, severe burns, and skin burns are among the potential injuries. [15]

$$\alpha = \sqrt{\pi f \mu \sigma} \quad (1)$$

$$\delta = \frac{1}{\alpha} \quad (2)$$

III. Effects that are not thermal

Numerous researchers have reported on the nonthermal impacts. The section that follows contains a few of these consequences.

3.1 The BBB (blood-brain barrier)

Certain molecules are vital to the brain and can pass through the blood-brain barrier (BBB), separating the two. Actually, this barrier has two primary purposes. The first is to optimize the fluids surrounding the brain by allowing some essential substances, like glucose, to pass through selectively. The other is to shield the brain from dangers by keeping out poisons and other dangerous substances. The BBB is broken by the brain's increasing temperature, which has detrimental impacts on people's health. The majority of researches state that electromagnetic waves with high strength can alter the BBB's permeability. [16]–[18].

3.2 Radiofrequency Hearing

RF hearing is the term used to describe how the human auditory system reacts to radiofrequency fields. According to certain research on humans and animals, low-level microwave radiation can cause subjects to hear knocks, chirps, clicks, buzzes, or hisses. According to [19], the energy in a single pulse determines RF hearing rather than average power density. RF hearing may occur if the head is subjected to brief microwave pulses (less than 70 μ s). These noises can be altered by different modulations. Further details are available in [3], [19]–[23].

3.3 Effects of behavior

The nervous system is primarily electrical in nature, and it regulates behavior. These subjects are the subject of a great deal of research. A few of these studies indicate reduction in REM sleep, slower motor function and reaction time in school-age children, altered nervous system activity, disorientation in space, lack of focus and "fuzzy thinking," and changes in the electrical activity of the brain [3], [18].

3.4 Immunesystem and other impacts

The impacts of the human cell research include altered school-age white blood cell activity, headaches, weakened immunity, elevated heart rate, elevated blood pressure, genetic damage to DNA and alterations in DNA repair capacity, cell proliferation, and cancer. [3], [24], and [25].

IV. Guidelines

Every country in the world has regulations in place to lessen the biological impacts of electromagnetic fields and to safeguard people who live and work close to sources of electromagnetic fields, such as BTS antennas and radars.

Table 1. SAR Limits for RFR [3]

standard	Frequency range	Local SAR in head			Local SAR in limbs		
		Public	occupiteinal	Public	occupiteinal	Public	occupiteinal
FCC	100KHz-6GHz	0.08	(30) 0.4 (6)	1.6	[1] 8 [1] (6)	4	[10]+ 20 [10] (6)+
ICNIRP	100KHz-6GHz	0.08	(6) 0.4 (6)	2	[10] (6) 10 [10] (6)	4	[10] (6) 20 [10] (6)
ANSI/IEEE	100KHz-6GHz	0.08	(30) 0.4 (6)	1.6	[1] (30) 8 [1] (6)	4	[10] (30)+ 20[10] (6)+

Note: () Averaging time in minutes. [] Averaging mass in grams. + In hands, wrists, feet, and ankles.

CONCLUSION

There is a description of the potential biological effects of electromagnetic fields at RF and MW frequencies. Thermal and nonthermal impacts are the two categories of effects. It is imperative to take into account these likely consequences and not preventable. The rules and regulations are set for the protection of human health and safety. We should shield ourselves from the many types of waves and electromagnetic fields that surround us at different frequencies since some of them can be harmful to human health. Workers in occupied environments, like RADAR, are aware of the importance and dosage of fields and are equipped with tools, such dosimeters, to protect themselves. However, the people who reside in or close to these surroundings are unaware of the importance and dosage of fields, thus regulations are put in place to safeguard

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