

STUDY ON ELECTROMAGNETIC POLLUTION GENERATED BY COMMUNICATION SYSTEMS

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Abstract: *This article explores the impact of electromagnetic pollution generated by modern communication systems on the environment and human health. The study looks at the main sources of electromagnetic pollution, including base stations for mobile phone networks, transmission antennas, and other equipment used in communications infrastructure. The effects of exposure to electromagnetic fields (EMF) on the human body are investigated, with a focus on possible risks to public health, including neurological and carcinogenic disorders. International regulations and standards aimed at limiting exposure and protecting the population are also presented.*

Keywords: electromagnetic field, communication systems, electromagnetic pollution

1. INTRODUCTION

The last two decades have highlighted an unprecedented development of communication technologies that use radiofrequency electromagnetic field sources used for individual, industrial, medical and commercial purposes. From global communications and rapid access to information, to industrial automation and the development of smart cities, the use of radio frequencies has revolutionized the way we live and work. Although the exponential proliferation of new communication devices has facilitated and eased human activity, they have led to a growing concern about the impact on human health. In this sense, a growing body of research has focused on the effects of the interaction between electromagnetic fields and living matter, both in the short and long term.

Along with technological progress, recommendations provided by accredited international bodies regarding the maximum permissible values of exposure or absorption of electromagnetic energy in the body have also appeared. These guidelines and standards are designed to protect human health and ensure that exposure levels remain within protective limits.[1]

The electromagnetic exposure of a person during the use of the mobile terminal for various voice or data applications has remained one of the challenging aspects to investigate, especially in 4G and 5G mobile communication networks, due to the very high variability of the signals emitted in time and space (including through the implementation of beamforming and beamsteering techniques). The development of electronics, especially applications with high

processing and transmission speeds and low consumption, of nonlinear electrotechnics, through the diversification of communication and data transmission networks, has led to an increase in the degree of electromagnetic pollution, both in the environment and in energy, communication and other networks. If the presence of the electromagnetic field in the environment in which we live can be classified among the known factors of environmental pollution, then, of these, the so-called electromagnetic pollution, currently has the highest growth rate and the widest spread in populated areas of the globe, but also the greatest psychological impact on the population.

2. NORMS AND ORGANIZATIONS

Currently, worldwide, actions are being taken to limit electromagnetic fields on living organisms, the most important of which are:

- regulating the permissible intensity of electromagnetic fields, for industrial activities and for homes, in urban or rural centers;

- the application of protective measures in carrying out activities with electromagnetic field sources, among which the following can be mentioned:

- protection against strong, constant and low-frequency magnetic fields, making screens from ferromagnetic materials that have a high permeability, such as iron-nickel alloys;
- protection by limiting the exposure time, using acoustic or optical warning devices;
- protection by carrying out activities at the calculated distance from the electromagnetic field source;
- protection by using reflective surfaces of the electromagnetic field, such as metal foils;
- protection by using gowns or other protective clothing, made of cotton, silk, etc.

fabrics in the structure of which thin metallic threads are inserted, forming meshes of 0.5 x 0.5 mm. [2]

Thus, the ICNIRP standard recommends the maximum permissible SAR (Specific Energy Absorption Rate) level for the population, at whole-body exposure, at 0.08 W/kg. For partial exposure, higher values are allowed: max. 2 W/kg in the head and trunk area and max. 4 W/kg in the limb area. In the case of power density S , for frequencies > 10 GHz, the maximum permissible value is 10 W/m².

All values corresponding to controlled exposure in occupational environments are 5 times higher (SAR values of 0.4 W/kg for the whole body, 10 W/kg for the head and trunk, 20 W/kg for the limbs, respectively S of 50 W/m²). It should also be noted that all SAR specific power values are considered to be averaged over an exposure time interval of 6 minutes, and the values imposed on partial exposure are considered to be averaged over a volume corresponding to 10 g of tissue around the maximum local value. [3]

The power density S is considered spatially mediated on an area of 20cm² of the exposed body and temporally on an interval of $68/f^{1.05}$ minutes (where the frequency f is introduced in GHz). The biological considerations that led to the choice of these sizes as basic restrictions and to the establishment of the permissible values are primarily based on the thermal effects of the accumulation of energy in the tissues.

Experiments carried out on animal and human subjects have shown that an average energy accumulation over the whole body of about 4 W/kg, for about 30 minutes, leads to an increase in body temperature by 1 ÷ 2°C and exceeds the thermoregulatory capacities of a healthy body. Heating the body with more than 1°C can have effects of altering health (e.g. decreased psychomotor performance). Table 1 presents various standards recommended by the most renowned organizations in the field.

Table 1 Rules on exposure of the body to electromagnetic radiation

Normative act	Exposed people	Exposed area	Permissible value for SAR [W/kg]	Considered tissue mass
ICNIRP	Population (uncontrolled exposure)	The whole body	0,08	Whole body
		Head and truncation	2	10g
		Member	4	10g
	Professionals (controlled exposure)	The whole body	0,4	Whole body
		Head and truncation	10	10g
		Member	20	10g
IEE/ ANSI	Population (uncontrolled exposure)	The whole body	0,08	Whole body
		Head, thorax and limbs	1,6	1g
	Professionals (controlled exposure)	The whole body	0,4	Whole body
		Head, thorax and limbs	8	1g
NRPB	Professionals and population (controlled and uncontrolled exposure)	The whole body	0,4	Whole body
		Head	10	10g
		Trunk	10	100g
		Member	20	100g

Organizations that deal with these norms and standards include the following:

a) international:

- WHO – World Health Organization;
- EC – European Community;
- IEEE – Professional Organization of Electrical and Electronic Engineers;
- INIRC – International Committee on Non-Ionizing Radiation;
- ICNIRP – International Commission on Non-Ionizing Radiation Protection.

b) national:

- ACER - Association for Electromagnetic Compatibility in Romania;
- CNIITICE - National Interuniversity Center for High Voltage Engineering and Electromagnetic Compatibility;
- ICMET - National Institute for Research, Development and Testing for Electrical Engineering. [4]

3. ELECTROMAGNETIC POLLUTION

Electromagnetic pollution, or electromagnetic smog, refers to excessive exposure to radiation generated by modern devices, such as mobile phones, antennas, and Wi-Fi routers. In a world increasingly dependent on technology, this form of pollution has become a concern for public health and the environment.

Electromagnetic pollution refers to the excessive presence of artificial electromagnetic fields generated by electronic devices, telecommunications and other modern technologies. This includes radiation emitted by mobile phones, telecommunications antennas, Wi-Fi routers, household appliances and other equipment that emits electromagnetic waves. Although electromagnetic fields also exist in nature, increased exposure to artificial ones can have

negative effects on human health and the environment. Associated risks include sleep disorders, headaches, chronic fatigue and, in some cases, more serious risks such as neurological conditions and cancer.

3.1. Sources of electromagnetic radiation

Artificial sources of electromagnetic radiation are created by human activity and have become much more common with the increased use of technology. They are divided into two main categories, depending on the frequency of the radiation emitted:

a. *Sources of non-ionizing electromagnetic radiation.* This radiation has a lower energy and is not capable of ionizing atoms or molecules in biological tissues, but it can generate thermal or non-thermal effects on the body. [5]

- Telecommunication networks (antennas and towers): They emit radiation in microwave frequencies and radio waves (e.g. 3G, 4G, 5G).
- Mobile phones and smartphones: They emit radio waves and microwaves to transmit the signal.
- Wi-Fi routers: Uses radiation in the microwave spectrum.
- Appliances: Microwave ovens, televisions, and other electrical appliances emit low-frequency electromagnetic fields.
- High voltage lines: They emit very low frequency electromagnetic radiation.

b. *Sources of ionizing electromagnetic radiation.* This radiation has a high enough energy to ionize atoms and molecules, which can cause serious damage to biological tissues and DNA.

- X-rays: Used in the medical field for imaging and diagnosis.
- Gamma radiation: Emanating from radioactive sources, nuclear power plants or in industrial processes.
- Radioactive materials: Used in nuclear and medical applications.

According to the European Commission, non-ionizing electromagnetic radiation sources can be classified according to the frequency of the radiation emitted and the type of technology. These sources are present in our daily environment and include both household devices and more complex technological infrastructures.

High frequency (HF) radiation covers frequencies between 3 MHz and 300 GHz and is the most widespread source of non-ionizing electromagnetic radiation. Sources include:

- *Mobile phones and telecommunications antennas:* They emit radiation in the microwave band and radio waves, being a common source of daily exposure.
- *Wi-Fi routers:* Internet connection devices emit HF radiation during operation.
- *Bluetooth and other wireless technologies:* Operates in the high-frequency spectrum used in wireless data communications.
- *Microwave ovens:* They use microwaves to heat food and are a common source of electromagnetic radiation in households.

3.2. The main sources of electromagnetic pollution in Romania

Electromagnetic pollution in Romania has become an increasingly visible problem, with the increase in the use of modern telecommunications technologies and electrical infrastructure. This refers to the excessive presence of non-ionizing electromagnetic radiation in the environment, coming from sources such as telecommunications antennas, mobile phones, Wi-Fi routers, high-voltage lines and other electronic devices. [6]

The main sources of electromagnetic pollution in Romania are:

1. Telecommunication antennas and mobile networks (3G, 4G, 5G): Romania has implemented modern communication networks, including 5G, which are associated with an increase in exposure to high-frequency electromagnetic radiation. While these networks are essential for connectivity and development, there are debates about the possible health risks.

2. Mobile phones and wireless devices: With a high penetration rate of mobile phones and a wide use of Wi-Fi routers, electromagnetic pollution generated by these devices is a concern on an individual and collective level.

3. High-voltage lines and electrical infrastructure: In rural and urban areas, high-voltage lines emit low-frequency radiation. Prolonged exposure to electromagnetic fields generated by these sources can have health effects, such as sleep disturbances and increased risk of chronic disease, according to some studies.

4. Household appliances and electronic equipment: Household appliances such as microwave ovens, televisions, computers, and other devices contribute to electromagnetic pollution in homes and offices.

In Romania, the regulation of electromagnetic pollution is governed by national and European norms, which set limits for exposure to electromagnetic fields. The National Authority for Administration and Regulation in Communications (ANCOM) monitors compliance with these standards in telecommunications. There are also initiatives that aim to raise public awareness about the responsible use of electronic devices and reducing radiation exposure.

4. EFFECTS ON HUMAN HEALTH

Electromagnetic pollution, also known as electromagnetic smog, can have multiple effects on human health and the environment. In Romania, the uncontrolled placement of GSM antennas and the intense use of wireless devices have generated serious concerns about the impact of these electromagnetic fields (EMFs). [7]

Research conducted by the Romanian Institute for Public Health has highlighted a number of negative effects on human health, caused by exposure to electromagnetic radiation emitted by mobile phones and GSM antennas. These effects include:

- **Dizziness:** People exposed to EMF in the long term may experience frequent dizziness, which can affect daily activities.

- **Chronic fatigue:** A common reported symptom is the persistent feeling of fatigue, even after adequate periods of rest.

- **Concentration and memory problems:** Exposure to EMF can lead to difficulty maintaining attention and retaining information.

- **Sleep disorders:** Electromagnetic radiation can disrupt sleep cycles, causing insomnia or unrestful sleep.

- **Increased stress:** People exposed to high levels of EMF may experience increased levels of stress and anxiety.

Although the direct link between EMF and various chronic conditions, such as cancer, is still debated in the scientific community, some studies suggest a potential risk, especially with prolonged exposure and high intensities.

Electromagnetic pollution not only affects human health, but also the environment. Animal species, especially migratory ones and insects, can be negatively influenced by electromagnetic fields, which can disrupt their natural behavior and life cycles. For example,

some studies indicate that radiation from mobile phone antennas can affect the orientation of birds and bees, having a negative impact on biodiversity and ecosystem balance. In conclusion, awareness of the effects of electromagnetic pollution and the implementation of appropriate prevention measures are essential to minimize the risks associated with it and to protect public health and the environment.

5. CONCLUSIONS

Modern communication systems, such as mobile phone networks, Wi-Fi and 5G technologies, generate a significant level of electromagnetic pollution. This phenomenon is becoming increasingly relevant as the requirements for global connectivity increase. Although research continues, there is evidence to suggest that prolonged exposure to electromagnetic fields can have negative health effects, including possible risks of damage to the nervous system and the development of serious conditions such as cancer.

Innovative technological solutions, such as the use of more energy-efficient and lower-radiation equipment, can help reduce electromagnetic pollution. Research into materials and infrastructure design can also lead to the development of safer and less harmful communication networks.

Electromagnetic pollution is an emerging problem for both public health and the environment. In order to minimise the risks associated with electromagnetic pollution, it is essential to adopt protective measures. Also, educating and raising public awareness about the risks of electromagnetic pollution and the preventive measures available are essential to reduce exposure and protect health. It is the responsibility of the authorities and each individual to adopt preventive measures to protect public health and the environment from the risks associated with exposure to electromagnetic fields.

Given the uncertainties related to the long-term effects of EMF exposure, it is necessary to continue research and monitoring to provide more accurate scientific data and to update regulations and protective measures, in line with the evolution of knowledge in the field.

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