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Assessment of the Electromagnetic Radiation Level of vehicles, computers, household appliances, personal care products, mobile phones and smartphones

Abstract. *The results of experimental studies are presented the level of electromagnetic radiation of vehicles, computers, household appliances, personal care products, mobile phones and smartphones.*

Streszczenie. *Wyniki badań eksperymentalnych przedstawiają poziom promieniowania elektromagnetycznego pojazdów, komputerów, sprzętu gospodarstwa domowego, produktów higieny osobistej, telefonów komórkowych i smartfonów. (**Poziom promieniowania elektromagnetycznego pojazdów, komputerów, sprzętu gospodarstwa domowego**)*

Keywords: electromagnetic radiation level, computers, mobile phones and smartphones.
Słowa kluczowe: poziom promieniowania elektromagnetycznego, komputery, telefony komórkowe i smartfony.

Introduction

Sustainable development of each country determines the quality of human life and health, which depends on the state of the environment, on quality of food and drinking water [1-2]. The World Health Organization (WHO) puts the problem of global electromagnetic pollution of the environment on the priority of humanity. In connection with the increasing concern about the harmful effects of electromagnetic fields on users' health, in 1996 the WHO established the International Electromagnetic Fields Project. The project provides recommendations to WHO member countries to protect the health of citizens from electromagnetic fields. The human being has five main senses: visual, auditory, olfactory, taste and tactile. But he lacks sense of the electromagnetic radiation and that poses a huge danger. Therefore, the human protection from electromagnetic radiation is extremely relevant [3-6]. During the past decades the intensive development of wireless technologies has resulted in a sharp increase in the background of electromagnetic radiation (EMR) in the environment. Significant increase of electromagnetic radiation is a natural concern about the risks to human health. Proofs of such influence are series of epidemiological studies, which show an increased risk of oncological diseases in active mobile phone users [7-10].

It should be noted that in all of the above studies, biological effects were detected at EMR intensity lower than the safety standards that approved by the International Commission on Non-ionizing Radiation Protection (ICNIRP). Despite the recent paper [11] about the research of metabolic changes in living cells for the actions of EMR, the molecular mechanisms of non-thermal effects of EMR are "bottleneck" in the understanding of the low intensity EMV effect on human health.

EMR is an electromagnetic radiation with a frequency from 30 kHz to 300 GHz is classified as non-ionizing because it does not have sufficient energy to ionize atoms and molecules. The EMF with the highest frequency (from 300 MHz to 300 GHz) belongs to the microwave range and potentially can determine the thermal effects when interacting with the substance. The main characteristics of EMF are frequency, intensity, specific power of radiation and its nature (modulated or unmodulated, constant or pulsed radiation).

To determine the amount of electromagnetic energy that are absorbed by the tissues, are use the SAR (Specific Absorption Rate). Today in the world the most widespread GSM standard uses electromagnetic waves with frequency of 850; 900; 1800 and 1900 MHz.

International safety standards set the upper limit of the EMR at 4.5-10 W/m^2 (depending on the frequency of radiation), and the SAR level should not exceed 2 W/kg when exposed to local irradiation of the human head or trunk.

The purpose of this work is to experimentally investigate the level of different sources of electromagnetic radiation (EMR).

Materials and methods

The classification of human protection methods from the negative influence of electromagnetic radiation is proposed: protection with time, distance, screening and blocking.

The first method is based on spatial or temporal separation of space, in which certain or other dangerous factors of the environment and the space in which a human is located.

The second method involves creating a safe environment that surrounds a human. This method of population protecting from the EMR involves the using of forest bands, artificial structures and terrain. In production, this method is realized through shielding workplaces or rooms or shielding radiation sources.

The third method of protection against EMF involves the using of personal protective equipment at work - special overalls, bathrobes, glasses.

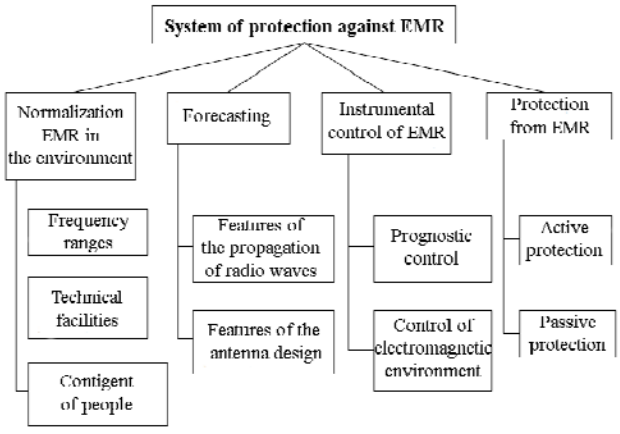

Fig. 1. The structure of the environmental and human protection system from EMF

For the protection of ecosystems from EMF, a systematic approach is used (Fig. 1), which involves the normalization of EMF in the environment, predictive prediction, instrumental control of EMF and protection from EMF.

To measure the EMR levels the following attachments: MTM-01, BE-METP-AT–003, BE-50, П3-41, ATT-2593, Narda NBM-550, Narda SRM-3000, Narda SRM-3006, ATT–2592 are used. It has been developed method detection level of the electromagnetic field of mobile phone in the presence of a protective device, and without using the device P3-41.

Temporary measurement of electromagnetic field ATT – 2592. Parameters are:

– 3-channel sensor, measurement simultaneously in three axes: X, Y, Z;

– measurement of the intensity of the electric field of 20 mV/m – 108 V/m, magnetic field intensity 53 μA/m - 286.4 mA/m;

– display current, maximum, average and maximum average;

– memory for 99 measurements.

The general scheme of electromagnetic monitoring is shown in Fig. 2 [12].

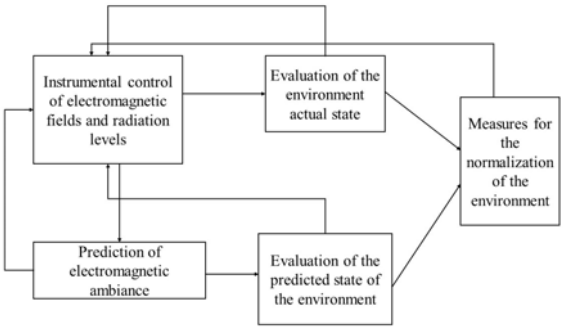

Fig. 2. Scheme of automated system of monitoring of electromagnetic settings

The proposed scheme allows to solve the following monitoring tasks:

– identification of sources of electromagnetic effects on the environment;

– control of the quantitative values of electromagnetic fields and radionuclides;

– continuous monitoring of the environment and changes that occur there under the influence of the electromagnetic factors;

– comprehensive assessment of the actual state of the environment;

– prediction of changes in the electromagnetic environment and its assessment;

– regulation and automatic response to adverse changes (trends) in the electromagnetic load on the environment;

– implementation of organizational and technical measures for the normalization of the electromagnetic environment.

The interaction of EMF with a biological object (Fig. 3) is determined by [13]:

- radiation parameters (frequency or wavelength, coherence of oscillation, propagation speed, wave polarization);

- physical and biochemical properties of a biological object as a medium for the propagation of EMF (dielectric permeability, electrical conductivity, the length of the electromagnetic wave in the tissue, the depth of penetration, the reflection coefficient from the air boundary - the living tissue).

The sensitivity of biological systems to external EMF depends from the frequency range and intensity of radiation. Range non-ionizing electromagnetic radiation when considering the specifics of EMF action on biological objects can be conventionally divided into three groups:

- constant and low-frequency fields (up to meter wavelength range);

- microwave range (wavelength from 1 m to 1 cm);

- millimeter and submillimeter range (wavelength from 10 mm to 0.1 mm).

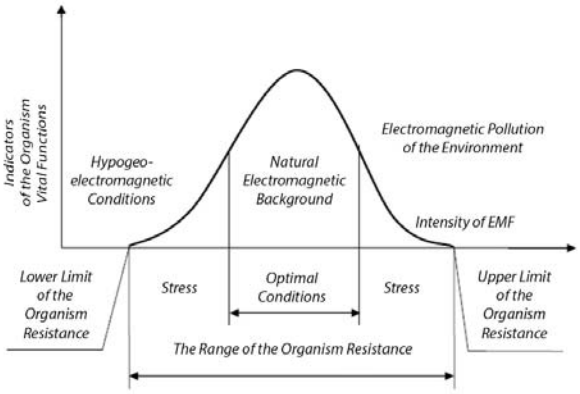

Fig. 3. Change of the organism life individuals from emption influence intensity [13]

Results and discussions

For the protection of ecosystems from EMF, a systematic approach is used which involves the normalization of EMF in the environment, predictive prediction, instrumental control of EMF and protection from EMF.

In the table 1 the results of the impact of computers on users are showed [14].

Table 1. Results of the computer monitor influence for users [14]

Symptoms of computer exposure	Percentage of operators reporting symptoms			
	Work on displays, months			
	Up to 12 incom-plete chan-ges	Up to 12 full chan-ges	More than 12	More than 24
Depression	3	16	22	50
Lowering intellectual abilities	-	3	12	40
Hair loss	-	-	3	5
Muscle pain	11	14	21	32
Pain in the region of the heart, disturbance of the rhythm	-	5	7	32
Decreased sexual activity	12	18	34	64
Headache and pain in the eyes	8	35	51	76
Fatigue, dizziness	5	32	41	69
Violation of night sleep	-	8	15	50
Drowsiness throughout the day	11	22	48	76
Change mood	8	24	27	50
Increased irritability	3	11	22	51

This information is particular interest against the background of recent news. On July 22, supporters of the International EMF Scientist Appeal movement have appealed to the UN with calling to develop new standards to protect nature and human from the harmful effects of 4G and 5G cellular networks.

Measurements have shown that most devices fit into the norm, with the exception of HTC Desire SV, Nexus 4 (Table 2). In terms of EMR, mobile phones are more dangerous than smartphones, especially mobile phones of the "old" pattern.

When in early 2019, the analytical company Statista has published the rating of the most dangerous smartphones in terms of radiation that adversely affects the human body (fig. 4), Xiaomi Mi A1 with the result of 1.75 W / kg topped the list. As it turned out, the new Xiaomi Mi A3 absorption coefficient of electromagnetic radiation is almost 6 times lower.

Table 2. The electromagnetic energy density of mobile phones and smartphones [15]

Brand (smartphones)	The measurement result, $(W / m^2)10^{-3}$	Brand (phones)	The measurement result, $(W / m^2)10^{-3}$
Samsung GT-7272	2,6	HTC Desire X	4
Samsung GT-S5830	7	Nexus 4	21,3
Samsung GT-8160	12,1	Huawei Ascend P6	11,8
Samsung GT-7562	6,4	LG L90	3,2
HTC Desire SV	35,7	Nokia Lumia 720	12
HTC Desire 500	5	Nokia 501	3,6
HTC One M7	1,8	Samsung Duos	18,7 (5,8)*
HTC Evo 3D	1,5	Nokia 201	19,6 (15,4)

Note: * 1.87 - at the time of the call, 0.58 - during a call

In Ukraine, the permissible SAR level is defined by the DSTU EN 50360: 2007 standard and is 2 W/kg, as in Europe, and the Ukrainian State Center for Radio Frequencies is involved in device certification. For comparison, in the USA, the Federal Communications Agency (FCC) certifies only those devices whose SAR does not exceed 1.6 W/kg.

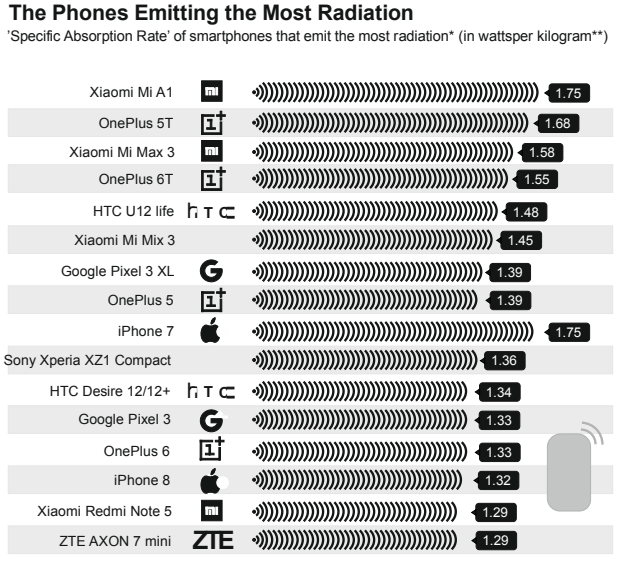

Fig 4. Specific Absorption Rate' of smartphones that emit the most radiation (in Watts per kilogram) [16]

It turns out that with an indicator of 0.301 W / kg, the Xiaomi Mi A3 is one of the safest in terms of radiation in the Xiaomi assortment and in the market as a whole.

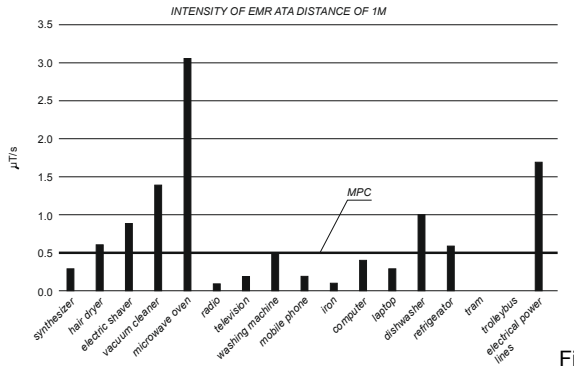

Fig. 5. Intensity of EMR from 1 m distance

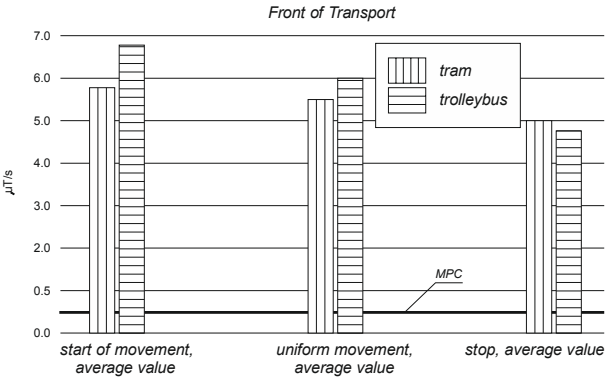

Fig. 6. Intensity of EMR at Front of Transport

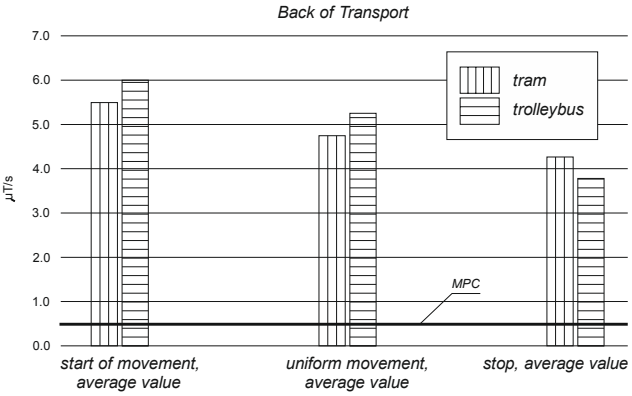

Fig. 7. Intensity of EMR at back of transport

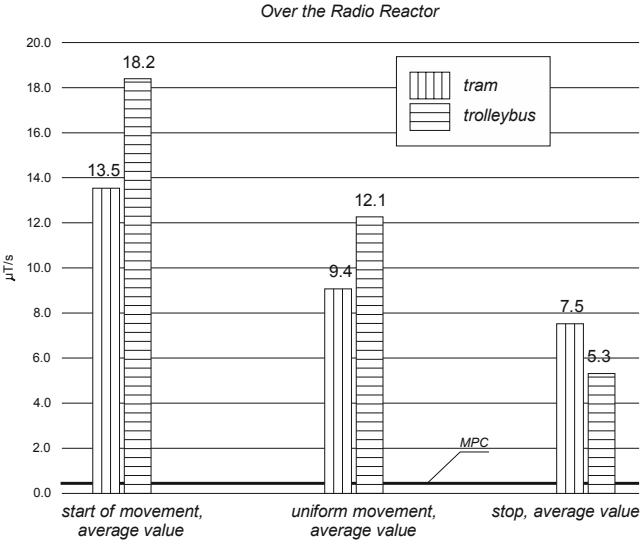

Fig. 8. Intensity of EMR at over the Radio Reactor

Minimum and maximum values of intensity measurements of radiation experimentally are obtained for such objects (Fig. 5-11): synthesizer, hair dryer, electric shaver, vacuum cleaner, microwave oven, radio, television, washing machine, mobile phone, iron, computer, laptop, dishwasher, refrigerator, tram, trolleybus, electrical power lines (EPL) [17, 18].

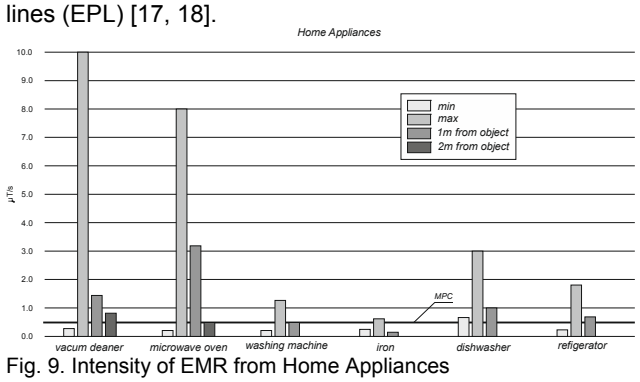

Fig. 9. Intensity of EMR from Home Appliances

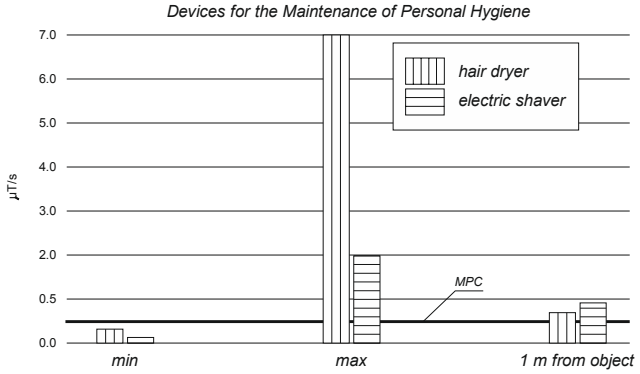

Fig. 10. Intensity of EMR from Devices for the Maintenance of Personal Hygiene

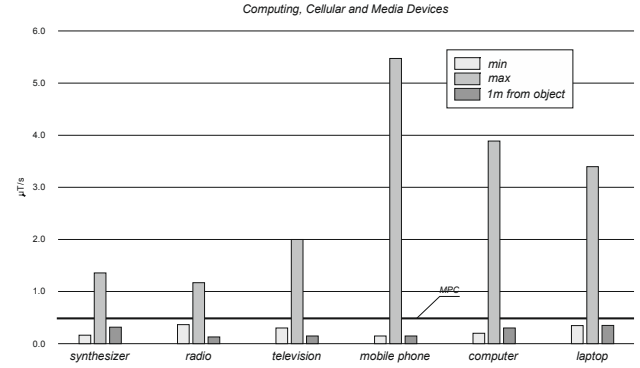

Fig. 11. Intensity of EMR from Computing, Cellular and Media Devices

Conclusion

The influence of electromagnetic radiation on a human was evaluated and appropriate recommendations for protection from EMR were developed. Technologies of a human protection from electromagnetic radiation are considered. The results of experimental studies of electromagnetic fields are presented.

It has been experimentally established that the maximum level of the electromagnetic field of a trolleybus exceeded the permissible value by 44 times, a tram - by 30 times; a vacuum cleaner - 20 times, a microwave oven - 16 times, a hair dryer and a transmission line - 14 times, a mobile phone 9 times, a computer 8 times, a laptop 7 times. Different sources are studied.

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