Exposure of high frequency electromagnetic fields in the living environment

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Abstract

The article concerns the identification of levels of the intensity of the electrical component of the electromagnetic field in urban areas. Methodology of measurement and legislation regarding protection against electromagnetic fields have been described. The research was carried out in the city of Lublin (Poland) and Rivne (Ukraine). The measurement values obtained were referred to the permissible environmental limits.

Key words:

intensity of electric fields, electromagnetic smog

Introduction

The electromagnetic field (EMF) spectrum covers a very wide spectrum of frequencies – from 0 Hz to a value of the order of 1023 Hz. It is global resources, and therefore it is necessary to regulate its use at international level. The national and international institutions are responsible for managing the electromagnetic spectrum. Some radio frequencies have been designed for use as basic frequencies for industrial, scientific and medical purposes.

The condition of urban development and technical infrastructure - in particular transport and telecommunications - determine the quality of the urbanized living and living environment. The living environment should be rich in features and services, it should be safe. An extensive transport, energy or telecommunications infrastructure raises the standard of living and improves broadly understood security. Unfortunately, it may have secondary effects, for example in the form of electromagnetic smog caused by emissions from many systems located in a small space.

Measurements of the electromagnetic field in the environment are the subject of wide public interest due to the dynamic development of energy, military and radiocommunication systems (in particular mobile telephony). The needs of society are growing, both in terms of speed, quality and the amount of information transmission, applications of the electromagnetic field in medicine, industry and science. Therefore, the exposure increases, and this is the basis for the intensification of research in the field of bioelectromagnetism. Therefore, the public's fears require scientific identification of the interaction of the electromagnetic field with man.

The emission of the electromagnetic field to the environment is the result of operation of any radiocommunication systems in which this is a deliberate action – electromagnetic energy is in this case an information carrier. The reverse situation is with power systems, where the electromagnetic field is a side effect of the transmission of electricity. The intensive development of radiocommunication, in particular mobile radiocommunication, results in the building of an increasing number of transceiver stations popularly referred to as base stations. The desire to obtain good transmission parameters for as many users as possible leads to a high density of base stations, but these stations can work with reduced power. This concentration brings with it certain fears of the society - an example may be the location of an educational facility in Lublin in the building of a telecommunications company with the infrastructure for transmitting and receiving GSM and UMTS systems (Fig. 1).

Fig. 1.
GSM transmitters on the building of an educational facility in Lublin

Legislation of electromagnetic environment protection

In Poland, there are independent protective regulations related to exposure to electromagnetic fields related to environmental protection and occupational health and safety. The former are regulated by the Regulation of the Minister of the Environment regarding the permissible levels of electromagnetic fields in the environment and methods of checking compliance with these levels from October 30, 2003 [4]. For the frequency range used in the GSM and WiFi bands, the permissible value of the electric field intensity of 7 V/m or alternatively the microwave power density of 0.1 W/m has been set.

Today, in many countries there is a wide public and scientific interest in the subject of the effects of electromagnetic radiation. It is worth noting that even the indicators of maximum permissible levels (MDPs) of electromagnetic radiation in various countries vary considerably. In Ukraine, MDPs were set at 0.025 W/m^2, in Russia, Belarus and Hungary 0.10 W/m^2, and in the Scandinavian countries 1 W/m^2. In the USA and some EU countries, this index ranges from 0.10 to 1 W/m^2. With reference to Ukraine, the relevant legal acts are also specified here, which define the principles of measuring and assessing the exposure of people and the environment to electromagnetic fields. The list of selected is presented in the table 1.

Permissible exposure levels are the result of model analyzes of the permissible energy absorption of the electromagnetic field (SAR). The results of these analyzes are given within wide limits, depending on the adopted model and the method of its exposure to the electromagnetic field. This approach is the result of adopting as a basis for the analysis of the occurrence of a thermal effect, omitting the possibility of non-thermal effects, whose occurrence and role are the subject of intense research (but also controversy).

Measurements, methodology and selection of places

Measurements for environmental protection purposes are made in places accessible to unauthorized persons. The measurements are based on typical meters with broadband probes (most often with a detector for measuring the electrical component of PEM). From a technical point of view, the choice of the measurement method or the time of PEM measurement in the environment is very important. This is due to the variability of field strength in time associated with the change in power transmitted by GSM, radio or television base stations, which are located relatively close to places available to the public. However, it is possible to expect some statistical relationships describing the variability of telecommunications traffic or emitted station power.

The description of the principles of taking measurements around the base stations is very laconic and leaves a lot of freedom in determining the places of measurements. This is justified because the base stations are installed in various places and in different configurations - antenna towers, installations on the roofs of buildings, antennas of microcells in rooms.

For the purpose of this work, the measurements were brought to analysis in two areas - the agglomeration of the city of Lublin in Poland and the city of Rivne in Ukraine. The measurements were of monitoring nature. Places that could potentially affect the

Table 1.
Ukraine state safety standards and principles when working with electromagnetic field sources from 18.12.2002 No. 476

Parameters	Maksimum values				
	1-10 kHz	10-60 kHz	0,06-3 MHz	3-30 MHz	30-300 MHz
Electric field, V/m	1000	700	500	300	80
Magnetic field A/m	75	57	50	-	3,0
Power density	> 300 MHz - 0,025 W/m2				

surroundings due to the proximity of radiocommunication or radio-television installations were selected. The aim of the measurements was to show whether there are no PEM levels above the permissible levels in places accessible to the public in the surroundings of the installation.

Measurements in Lublin were taken on 18 and 19 September 2017. 16 points were selected, which were presented on the map (Figure 2). The choice was taken into account - space availability (communication routes) and proximity to the existing telecommunications infrastructure. The measurements were carried out with two mobile meters operating in the 50MHz-3.5GHz band: TES92 and TM-195. Measurements were carried out at each point first with the first meter and then with the second one. Measurement with each meter lasted for 10 minutes, and the average value is presented in Table 2.

As you can see, the measured values have never exceeded the admissible levels. However, the actual levels are measurable, have relative value in relative terms, and therefore indicate the need for continuous monitoring. In terms of comparison of the qualitative emission levels between meters, a clear "boost" of the results by the TM-195 meter can be

Table 2.
The measured values of electric fields in Lublin

Location of the point (name of street)	TES92 [V/m]	TM-195 [V/m]
Nadbystrzycka	0,422	0,549
Diamentowa	0,461	0,524
Jutrzenki	0,680	1,177
Al. Warszawska	0,182	0,259
Wiklinowa	0,291	0,340
Willowa	0,390	0,473
Mełgiewska	0,243	0,337
Inżynierska	0,602	0,823
Głęboka	0,994	1,064
Długa	0,372	0,450
Al. W. Witosa	0,092	0,155
Zemborzycka	0,140	0,220
Lubartowska	0,161	0,232
Al. M. Smorawińskiego	0,765	0,818
Droga Męczenników Majdanka	0,039	0,140
Żeglarska	0,048	0,067

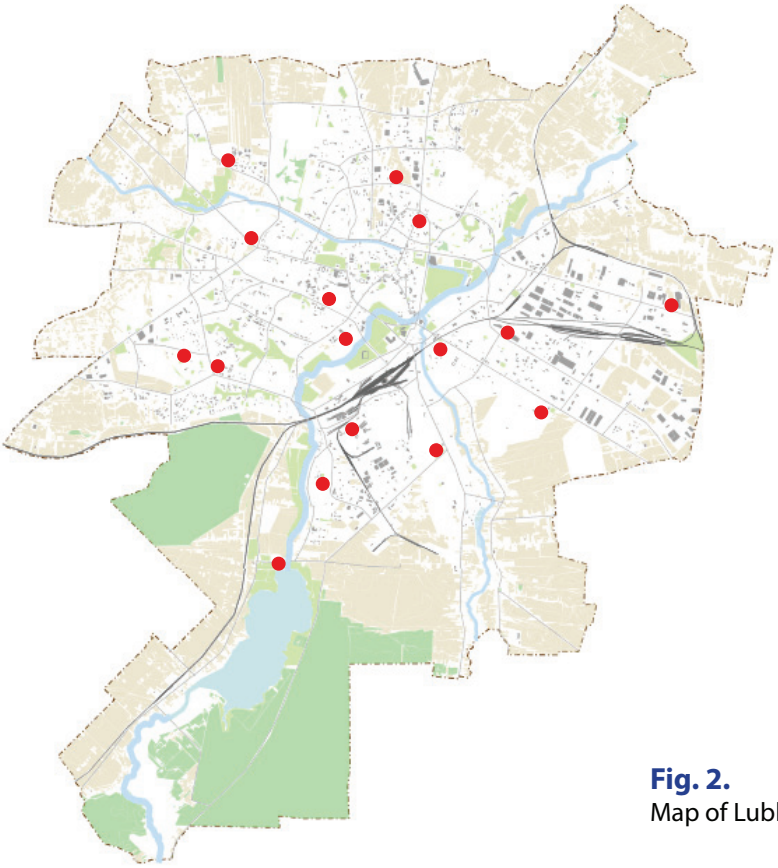

Fig. 2.
Map of Lublin with measurement points

seen, however, both measures converge to indicate areas with higher and lower emission levels. In order to specify the participation in the measured emission of specific radiocommunication technologies during the measurements, the ESM140 dosimeter was also measured. The obtained results for the second day of measurements are shown in Figure 3. Measurements concern transmission channels from base stations towards mobile phones.

Recently the number of radio equipments of different designs and for various purposes are constantly increasing, especially in densely populated urban areas. This results from the high land and real estate prices that's why the significant number of living and working places is concentrated on a small area. Such situation is typical for large and small cities of Ukraine, in particular the city of Rivne. Although the prevalence of housing development, its height and, correspondingly, the increase of population concentration in a small area contributes to the fact that the inhabitants of such conglomerates can quickly get to their workplaces, to nearby shopping centers, schools, kindergartens and other places, yet such arrangement cause the deterioration of the overall ecological situation, including the *electromagnetic situation*. In such areas because of increase of population concentration the mobile operators, the internet providers, the television and the radio broadcasting stations, special communication systems and other services for ensuring data transmission are increasing the number and the power of the equipment and that in turn causes the abundant electromagnetic pollution in these territories.

Taking electromagnetic safety into consideration we measured the total electromagnetic radiation to reveal the most unfavorable conditions in densely populated areas and near powerful communication means of transmission systems. One of such areas is situated near the powerful transformer substation, which supports a significant part of the city of Rivne, and near which there are people's dwellings (Fig. 4). The averaged results of measuring the tension of electromagnetic and electric fields are

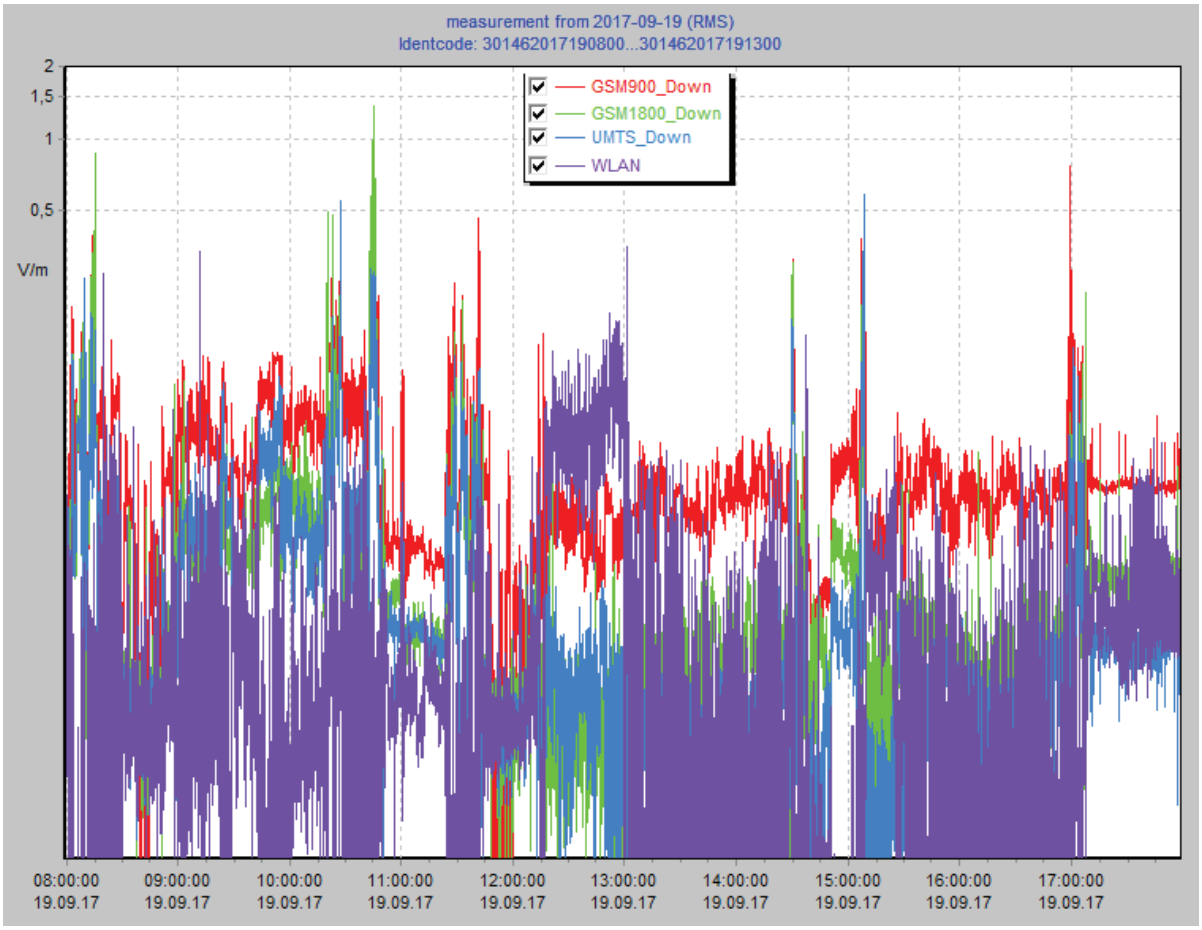

Fig. 3.
Electric field strength values from GSM900, GSM1800, UMTS and WLAN technology measurement by ESM140 meter

presented Tabl. 3. Another most dangerous territory in view of electromagnetic safety, is situated near the television tower not far from Rivne. There are television and radio repeaters, radio relay antennas and antennas of mobile-communication base stations on this TV tower. Near this station there are private dwellings (Fig. 5). The results of measurements are presented in Table 4. Measurements were taken on July 2017.

As a result of the conducted research it was determined that in order to ensure the safety of people who live near the sources of electromagnetic radiation, it is necessary: to operate the radio equipment in accordance with the design standards, passport data and the established operating conditions; to conduct continuous monitoring of the electromagnetic situation and to introduce the building constraints near the objects of the data.

Fig. 4.
The territory not far from the transformer substation (Rivne)

Fig. 5.
The TV station and the territory around the TV station (v. Antopil, Rivne)

Table 3.
The measuring results in the territory around the transformer substation (Rivne)

Nr.	Distance	Power density	Electric field
	m	μW/cm²	V/m
1	200	0.008	18.5
2	150	0.01	16.5
3	55	0.012	21
4	15	0.11	54
5	280	0.009	10

Table 4.
The measuring results in the territory around the TV station (v. Antopill, Rivne)

Nr.	Distance to mast	Power density
	m	μW/cm²
1	1300	0.45
2	1000	0.27
3	980	1.00
4	960	2.50
5	637	0.27
6	320	5.20
7	247	11.0
8	261	2.40
9	169	4.80
10	357	2.20
11	1280	0.20
12	507	0.21
13	456	0.35
14	990	0.30
15	4830	2.30
16	5100	1.10
17	5720	0.50
18	485	0.12

Conclusions

Most devices and installations do not entail the urgent need for measuring and evaluating exposure to electromagnetic fields. Analyses confirm that emitted fields usually do not exceed permissible limits [2,3,4]. Nonetheless, independent research is a response to public anxiety concerning potential bad health effects of chronic exposure even on relatively weak fields. The subject of fields emission should be also analyzed in terms of the environment condition and occupational health.

The results of the conducted study on electromagnetic fields are very promising. In Lublin and Rivne, no exceedances of the value of electromagnetic emission were noted. The selection of measuring points indicates that they are monitoring measurements. They can be treated as measurements of the so-called "Electromagnetic background". However, their regular repetition will allow you to analyze the trends of changes in the environment.

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