

# Assessment of electromagnetic pollution in towns

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**Abstract** — General characteristics of electromagnetic pollution in towns is analyzed. The sources of electromagnetic pollution in towns are defined here for the case study of the town of Vinnytsia in central Ukraine (that is why the standards valid in this country were considered). The intensity of electromagnetic radiation caused by mobile phone base stations is found in the range of 0.008–0.018 W/m<sup>2</sup>.

**Keywords**—electromagnetic radiation, electromagnetic pollution, mobile phone base station

## I. INTRODUCTION

Electromagnetic pollution of towns with developed networks of electric transport, wireless communication equipment, and high population density becomes a very important factor of negative influence on people and ecosystems [1-3]. People in places with many electrical and electronic equipment, are exposed to some additional influence of this physical factor as a result of a number of objective and subjective reasons. The objective factors include the following: aspects: increased load on overhead and underground energy transmission lines, increased energetic “saturation” of buildings and structures. This is due to the expansion of electric transport networks, the increased number of electrical and electronic equipment for industrial companies and administrative buildings.

The subjective reasons include putting in operation energy transmission lines or transformer substations without taking into account the original electromagnetic field in the area [4-6].

People living in densely populated areas of modern towns and cities are increasingly exposed to electromagnetic radiation from various sources. These include: mobile communications, satellite and cable telecommunications, cable and wireless internet, and many others. Electromagnetic pollution of most towns is mainly caused by radiation from mobile phone base stations, radionavigation devices, radio equipment, high voltage energy transmission lines, etc. The radio waves cannot be effectively transmitted inside buildings or underground facilities, meet consumers’ needs for mobile networks coverage, operators set up some additional receiving and transmitting equipment inside. According to the existing data [7,8], electromagnetic radiation exceeds the maximum permissible level of 0.025W/m<sup>2</sup> in such buildings. This

pollution constitutes a potential cause for human health risks and animal populations decline [9]. Also, some research [11-17] has detected amplitude fluctuations of electromagnetic radiations for a long time.

## II. METHODOLOGY OF ELECTROMAGNETIC POLLUTION MEASUREMENTS

Measurement of electromagnetic fields is carried out indoors and outside of buildings, as well as for workplaces certification in the following cases:

1. Measurement 50Hz frequency electromagnetic field (industrial frequencies). This type of measurement is recommended research electromagnetic fields from energy transmission lines, cables, industrial equipment, transformers, office equipment, etc.

2. Measurement of electromagnetic field intensity from office equipment, computers, video- and other displays. The intensity of the electromagnetic field and magnetic flux density are recommended to measure in the frequency range of 5Hz–400kHz in residential buildings and offices.

3. Measurement of electromagnetic field intensity in the radio and microwave range. Electromagnetic field intensity is recommended to measure in the frequency range of 30kHz–300MHz, and the energy flux density of electromagnetic radiation – in the frequency range of 300MHz–300GHz. Usually, these measurements are performed in households and offices, on the territories of residential buildings, as well as at workplaces. The following equipment may be investigated: household electronic equipment, communications devices, antennas of cellular communication, stations of radio wave transmission, microwave ovens, Bluetooth and Wi-Fi transmitters, mobile phones, etc.

4. Measurement of geomagnetic field intensity (induction). Such measurements are carried out not less than once a year, or when starting new or changing existing equipment. At each point, at least three measurements should be performed, logging the largest of registered values.

To measure parameters of the electromagnetic field at industrial frequency (50Hz), the electromagnetic field detector

BE-50 was used. The experimental measurements were made near the overhead energy transmission lines of 330kV and 110kV (at the distances of 10, 20 and 50m) on the territory of one of the Kyiv regional transformer substations.

Also, the energy flux density was measured near the 50W mobile base station in Vinnytsia (at the distances of 50 and 100m) using the electromagnetic radiation detector PZ-41.

### III. INFLUENCE OF THE ELECTROMAGNETIC FIELD ON HUMAN HEALTH

It is known that the nervous system, especially its higher division, is most sensitive to electromagnetic fields (EMF). Under the influence of low-intensity EMFs, the memory of newborns suffers the most. A special sensitivity to EMF is shown by the human immune system. There are studies showing defections of immunity under the influence of microwaves, more often in the direction of their oppression. People who are allergic, may become more sensitive to electric and magnetic fields. When being next to energy transmission lines, these people acquire pathological reactions like court and loss of consciousness [18-21].

According to the latest data, there are cases of miscarriage and birth of children with congenital defects in women-operators video display terminals. Over the past 10 years, there has been an increase in leukemia and cancer in children and adults. This is associated with professional activity, living near the transmission lines, and higher intensity of magnetic and electromagnetic fields in households [22, 23].

Work in shielded structures under the attenuated geomagnetic field (GMP) also negatively affects workers' health and pathological reactions are still possible. Congenital sensitivity to the weak geomagnetic field and appropriate behavioural reactions have been detected in many different animal species. It has been experimentally proved that weak magnetic fields influence the migratory behaviour of birds and the orientation of magnetically sensitive bacteria movement [24-27].

At this point, it should be emphasized that there are reports in the literature about the impact of EMF, but there are no unambiguous, surely confirmed reports of its significant harmfulness. In this context, the term "pollution" repeatedly used in the article should be understood in the meaning of admixture in the general substance of the phenomenon without its negative meaning, and the authors of this article themselves are far from confirming the negative impact of the electromagnetic field on the human body.

### IV. INFLUENCE OF ENERGY TRANSMISSION LINES

Electric power distribution systems, indoor energy supply networks (excluding new buildings built in the past few years) are not adapted to supply nonlinear energy consumers. As a consequence, modern low-power impulse power supplies and energy-saving lighting devices generate uncompensated electric currents of 150Hz or higher frequency, which creates magnetic fields of significant levels. The sources of high level

electric and magnetic fields include air energy transmission lines at later stages of exploitation due to contamination and deterioration of insulators, excessive sagging of wires, corrosion on electrical pillars, etc.

Some experimental measurements were made near the overhead energy transmission lines of 330kV and 110kV voltages. In many cases, the excess of maximum permissible levels (by 10-15%) of magnetic fields at industrial frequency of 50Hz was found even beyond the protection zone. The rules of computer facility operation were broken almost everywhere.

According to the measurement methodology, the density of energy flow is controlled at 2m height from the earth surface. Under these conditions, this parameter measured in Kyiv (Ukraine) is lower than the critical values (0.025W/m<sup>2</sup>). At the same time, at the heights corresponding to the fifth or higher floors, the density of energy flow is 0.06-0.07W/m<sup>2</sup> in many places.

The previous studies have shown that the reduction of the electromagnetic influence on the environment is possible only on a comprehensive basis by relevant databases creation and taking into account the economic situation.

The magnetic field induction for 110kV overhead power lines (common near or in towns) with a nominal electric current of 200A at a distance of 50m from the projection of the phase wire is about 600μT. This corresponds to the electric field intensity of 170V/m.

The results also showed the considerable excess of limit for computer equipment (in the range of 5-2000Hz) even far beyond the protection zones.

Therefore, placing computers in buildings near overhead energy transmission lines is allowed but it does not meet the current standards for electromagnetic safety when operating computer equipment. Certain investigations have shown electromagnetic fields of overhead power lines of 110kV voltage having a significant impact on biological objects even beyond the protection zones.

It should be noted that the calculation of the electromagnetic fields of overhead power lines are to be performed for ideal conditions and fixed electrical loads.

The experimental results of the aforementioned parameters are included in Table 2.

TABLE 2. MAGNETIC FIELDS NEAR THE OVERHEAD POWER LINES

Voltage [kV]	Distance [m]	Induction of magnetic field [μT]
110	10	5.5-7.3
	50	0.5-0.9
330	20	6.4-10.5
	50	0.9-1.7

The results differ from other studies, but the magnitude is the same. This fact could be explained both by the technical

conditions of the energy transmission line and the electric current at the time of the measurements.

The revision of transformers located outside the buildings has shown that they do not contribute significantly to the level of magnetic fields in the nearby old buildings.

Today, the growing number and density of energy transmission and transformation systems in towns is common. This requires the development of the measures to reduce their impact on people, computer devices, diagnostic equipment of medical institutions, etc. Ensuring workplaces to be far away from sources of electromagnetic fields of industrial frequency is problematic in such conditions.

The most efficient ways to reduce electromagnetic effects on workers is the use of underground power lines (especially in companies with high energy consumption). The implementation of such a solution has shown that at 330kV underground power line generates in comparison to similar overhead power lines electromagnetic fields of lower magnitudes.

#### V. INTENSITY OF ELECTROMAGNETIC RADIATION: CASE STUDY OF UKRAINE

Increased high frequency electromagnetic radiation is mainly caused by inconsistencies in the location of mobile phone base stations by some companies and ignoring the terrain. It is very hard to determine the contribution of various stations due to the coincidence of their working frequencies.

Today, the electromagnetic radiation of high and ultrahigh frequencies becomes more important component of external electromagnetic influence on the environment in industrial buildings. Its sources include radio equipment of airports and mobile phone base stations. The influence of stations has a high resonance among people.

The electromagnetic radiation of the abovementioned frequency ranges at the height of two meters above the earth surface in the city of Kyiv (with the largest density of radio transmitters in Ukraine) was found to be in the range 0.008-0.018W/m<sup>2</sup> (the limit in Ukraine is 0.025W/m<sup>2</sup>).

In some places, e.g. in the central districts of the city with a complex terrain, electromagnetic radiation is higher – 0.023W/m<sup>2</sup>. But due to the high density of mobile phone base stations located on buildings roofs with a direct visibility, electromagnetic radiation significantly increases at higher measurement points.

The energy flux density near the 50W mobile station is shown in Fig. 1.

Conducting the measurements in city conditions does not allow to exclude the influence of other radiations. According to the data, the maximum permissible levels are exceeded at the height of the third floor and above, as well as at a distance corresponding to the real distances between buildings.

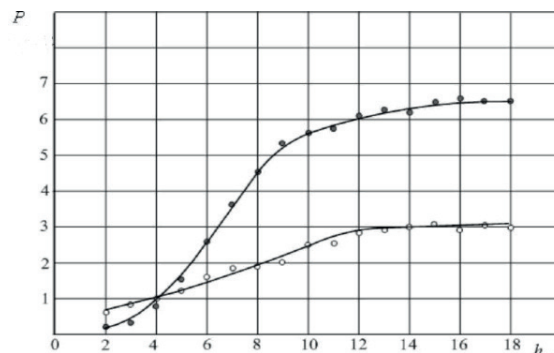


Fig. 1. The change of electromagnetic radiation intensity ( $P \times 10^{-2} \text{ W/m}^2$ ) from mobile phone base station by the height above the earth surface ( $h$ , m): ● – at the distance of 50 m, ○ – at the distance of 100m

Another case is Vinnytsia. This is a typical regional center in central Ukraine with a population about 400,000 people. Therefore, there are many sources of electromagnetic radiation. The main contribution is provided by mobile phone base stations.

According to the monitoring data on the location of radio emitting objects and taking into account the distance to residential territories, more than 70% of these objects are located in densely populated areas. Levels of electromagnetic radiation may exceed the permissible value by 2–20 times. On average, up to 2,000 people live or work in the influence zone of one of such objects. Besides, the zone of electromagnetic pollution may cover educational institutions or children's establishments.

According to the measurements, the largest electromagnetic pollution is found in the central densely populated areas of the town, i.e. streets: Soborna, Kyiv, Pyrogov, Keletska, Khmelnytske shose. This is the result of the highest concentration of mobile phone base stations in the central part of the town. Most people in Vinnytsia work or move through the town center. Thus, to provide a good communication and reliable operation of mobile networks, operators have installed additional base stations in the town center. The locations of the mobile phone base stations in Vinnytsia are shown in Fig. 2 (different colors correspond to different mobile operators).

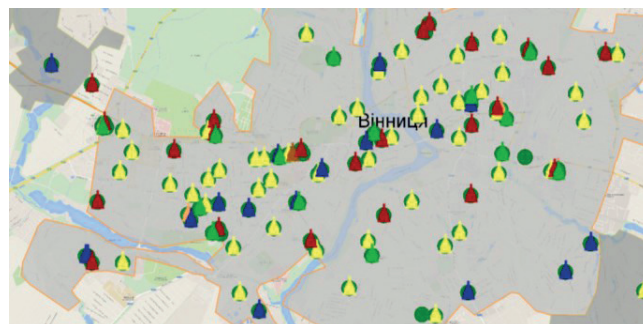


Fig. 2. Mobile phone base stations in Vinnytsia

The average intensity of electromagnetic radiation from mobile phone base stations (up to 2 meters height above the ground level) in Vinnytsia range from 0.008 to 0.018 W/m<sup>2</sup>.

## VI. CONCLUSIONS

Electromagnetic pollutants are less studied and appear less important in comparison to other types of harmful pollutants. Although there are many different sources of EMF including strong ones, in modern this problem seems a bit neglected. In Vinnytsya, a typical Ukrainian city, base stations of mobile phones are the main source contributing to this type of pollution. In the considered case, power density is lower than the maximum permissible limits for Ukraine and much lower than the permissible limits in Poland, as well as extremely lower than the permissible limits in most European countries, the USA and Japan. Nevertheless, the authors believe that Vinnytsia and other cities need careful additional study, for which one of the main goals must be to monitor the existing EMF to develop justified maximum permissible limits.

The presented results were collected in accordance with the Ukrainian standards of electromagnetic safety (DSanPiN 3.3.6.096-2002 of 07.09.2009 and the Act on Safety at Work). According to these rules, the applicable levels are very strict and are stricter than world standards. It seems to be deliberate to correct them most efficiently by standardizing them with the standards of other countries.

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