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Electromagnetic Pollution: Case Study of Energy Transmission Lines and Radio Transmission Equipment

Abstract. *General characteristics of electromagnetic pollution in towns is analyzed. Health statistics for people living under the influence of electromagnetic radiation is analysed. The electromagnetic pollution is measured for the case studies of energy transmission lines and radio transmission equipment in Ukraine. The induction of magnetic field near overhead power lines is found in the range of 5.5–10.5 μT while being 5 times less at the distance of 50 m. Also, strong dependence of electromagnetic field strength on the distance from radio transmitters is proved.*

Streszczenie. *W artykule analizowana jest ogólna charakterystyka zanieczyszczenia elektromagnetycznego w miastach. Pokazano statystyki zdrowotne osób żyjących pod wpływem promieniowania elektromagnetycznego. Zanieczyszczenie elektromagnetyczne mierzone jest dla przykładów linii przesyłowych energii i urządzeń transmisji radiowej na Ukrainie. Indukcja pola magnetycznego w pobliżu napowietrznych linii energetycznych znajduje się w zakresie 5,5–10,5 μT i jest 5 razy mniejsza w odległości 50 m. W artykule pokazano również silną zależność natężenia pola elektromagnetycznego od odległości od nadajników radiowych.* ***Ogólna charakterystyka zanieczyszczenia elektromagnetycznego w miastach przez linie energetyvczne i sieci transmisji radiowej***

Keywords: electromagnetic radiation, electromagnetic pollution, energy transmission line, radio transmission equipment
Słowa kluczowe: promieniowanie elektromagnetyczne, zanieczyszczenie elektromagnetyczne, linia przesyłu energii, sprzęt transmisji radiowej

Introduction

In the process of industrialization, mankind has added a number of factors amplifying the natural radiation. Therefore, EMFs of anthropogenic origin significantly exceed the natural background becoming the dangerous factor for the environment.

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].

Technogenic sources of electromagnetic fields (EMF) in populated places include mobile communication technologies, satellite and cable telecommunication, cable and wireless internet, mobile phone base stations, radionavigation devices, radio equipment, high voltage energy transmission lines, measuring and control devices, research facilities, high frequency instruments and devices in medicine and households, etc.

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. According to the existing data [7,8], electromagnetic radiation exceeds the maximum permissible level (i.e., 0.025W/m^2 in Ukraine) in buildings with additional receiving and transmitting equipment. This pollution constitutes a potential cause for human health risks and animal population decline [9]. Also, some research [11-17] has detected amplitude fluctuations of electromagnetic radiations for a long time.

Materials and methods

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

1. Measurement of 50Hz frequency electromagnetic field intensity (industrial frequencies). This type of measurement is recommended to 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 be measured 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 be measured 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, communication 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 50 m) on the territory of one of the Kyiv regional transformer substantions. Besides, the electric and magnetic field strengths were measured at the distances of 30m, 100m, and 200m from radio transmission equipment in city of Vinnytsia (Ukraine) using (field strength meter PZ-50.

Influence of the electromagnetic field on human health

Some authors believe that the nervous system is most sensitive to electromagnetic fields. Under the influence of low-intensity EMFs, the memory of newborns suffers the most. A special sensitivity to EMFs 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 convulsions 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 (Table 1).

According to the authors [24-29], low-level EMFs have a strong influence on the endocrine, immune, genetic systems of human, nervous activity, psycho-physiological status, and characteristics of encephalograms.

Resonant processes associated to human physiological rhythms play a significant role. The resonant amplification or attenuation of these rhythms, the appearance of harmonics and subharmonics, and the results of cross-modulation in nonlinear cell elements can produce a variety of psycho-physiological effects with unpredictable consequences.

Table 1. Mortality of people working with sources of electromagnetic fields. (The data do not confirm the existence of dependence and were not subject to this kind of inference.)

Category of mortality	Absolute value	Relative value [%]
Number of people	20781	100
The total number of deaths	665	0.31
Deaths from accidents	223	0.009
Mortality from illnesses	359	0.0017
Novo-formation	94	0.0045
Cardiovascular system	180	0.0085
Digestive organs	27	0.0013
Hematopoiesis and lymphatic system	20	0.001

At this point, it should be emphasized that there are reports in the literature about the impact of EMFs, 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.

The morbidity of population living under the influence of electromagnetic radiation in Vinnytsia, Ukraine, is presented in Table 2 (the data from Vinnytsia hospitals).

Table 2. The morbidity structure for people living under the influence of electromagnetic radiation

Disease	Age [years]					Morbidity [%]
	20-29	30-39	40-49	50-59	60 and elder	
Parasitic diseases	1.04	0.61	0.64	0.81	3.59	1.22
Tumors	–	0.82	1.83	0.99	1.15	1.05
Diseases of endocrine system	0.21	0.41	1.07	1.44	0.57	0.83
Diseases of nervous system	8.30	3.07	7.84	2.88	4.45	4.91
Diseases of eyes	1.24	0.82	1.40	0.54	–	0.79
Diseases of ears	–	–	0.86	–	0.86	0.33
Diseases of skin	–	–	0.97	0.72	–	0.41
Diseases of cardiovascular system	8.71	6.04	10.53	17.28	23.24	13.18
Respiratory diseases	54.60	71.41	52.20	58.78	38.74	56.45
Injuries, poisoning	2.49	1.24	2.04	0.63	–	1.19
Diseases of the musculoskeletal system	5.60	0.82	9.13	9.27	15.35	7.86
Diseases of the urogenital system	5.19	2.77	2.68	1.26	1.87	2.48
Digestive diseases	11.62	10.35	7.95	4.23	9.32	8.17
Allergic diseases	1.04	1.64	0.86	1.17	0.86	1.14

Electromagnetic pollution in Ukrainian cities

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 ($0.025W/m^2$). At the same time, at the heights corresponding to the fifth or higher floors, the density of energy flow is $0.06\text{-}0.07W/m^2$ in many places [30].

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. The experimental results of the aforementioned parameters are included in Table 3.

Table 3. 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	10	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.

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 a 330kV underground power line generates in comparison to similar overhead power lines electromagnetic fields of lower magnitudes.

The accumulated knowledge about the influence of electromagnetic radiation is not applicable for mobile phones with incomparably lower radiation level. The biological effects of radiotelephones using are divided into thermal (cataractogenic) and non-thermal (neurological, carcinogenic, and epidemiological). Study of each factor has resulted in identifying a number of consequences from exposure to low power radiation with energy absorption less than 2W/kg.

Moreover, there is an information [30] that digital radiotelephones threaten human health more than analog devices due to other frequencies. The studies are not yet completed, and it is not yet clear how the effect under consideration depends on various parameters of low power electromagnetic radiation.

High levels of EMF are found at the locations of transmitting low and high frequency stations and outside their territories. Instrumental analysis of the electromagnetic radiation near the stations shows its extraordinary complexity due to the individual nature of the intensity and distribution of the electromagnetic field. These are determined by the purpose and location of the station equipment. That is why each transmitting station needs investigation of electromagnetic pollution during the construction and operation.

A comparative analysis of the protection zones and zones of building restriction in the area of radio transmitting stations showed that the highest levels of electromagnetic radiation are observed in the areas of “old fashion” radio stations with antenna height up to 150-200m.

In the low frequency range, the wavelength is thousands of meters (2000 m at a frequency of 150 kHz). Energy of EMF can be quite high at a distance of one wavelength (or less) from the antenna. For example, at a distance of 30 m from a transmitting station (power of 500kW) operating at the frequency of 145kHz, the electric field strength was 630V/m and the magnetic field was 1.2A/m.

In the medium range of wavelength, the electric field strength at the distance of 200m from the transmitting station (power of 50kW) was 10V/m, at the distance of 100m was 25V/m, at the distance of 30 m was 275V/m.

Shortwave transmitters typically have a less power, but they are more commonly for locating in cities. Their antennas can be placed even on the roofs of residential buildings at a height of 10-100m. According to the measurements, 100kW transmitter generates the electric field with 44V/m strength and the magnetic field with strength of 0.12A/m at the distance of 100m.

Conclusion

Electromagnetic pollutants are less studied and appear less important in comparison to other types of harmful pollutants. Although there are many different sources of EMFs, including strong ones, in modern cities, this problem seems a bit neglected. In Vinnytsia, 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 EMFs 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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