Assessment of the risk of electromagnetic emissions through monitoring for an object on the territory of the Metropolitan municipality

Anna Bouzekova-Penkova*, Dimitar Teodosiev, Adelina Miteva
Space Research and Technology Institute, Bulgarian Academy of Sciences, Acad. G. Bonchev St, Bl. 1, 1113 Sofia, Bulgaria; email: a_bouzekova@space.bas.bg*

Abstract: *In many cases, the importance of electromagnetic fields or the so-called "electromagnetic smog" on human health, living organisms, and the environment is ignored or at least minimized. The electromagnetic field (EMF) is a combination of invisible electric and magnetic fields with charge that occur in nature. Today, the impact of electromagnetic fields on the environment is increasing from human activities with the development and application of telecommunication technologies. Measurement, continuous monitoring, database creation, and evaluation of electromagnetic field parameters in urban environments are important aspects of optimizing EMF levels to achieve a healthy living environment. The paper presents an analysis and evaluation of electromagnetic radiation measurements from base stations of mobile operators, at one site, in a lightly urbanized urban environment over a certain time interval. Initial measurements showed exceeding the levels of electromagnetic emissions according to national legislation. During the repeated measurements, it was found that mobile operators, after correcting the radiation from base station antennas, have brought the radiation levels within the permissible limits. This underscores the necessity of ongoing monitoring.*

Keywords*: ELECTROMAGNETIC RADIATION, ELECTRIC FIELD, ELECTROMAGNETIC POLLUTION, ENVIRONMENTAL LEGISLATION, EMF MONITORING*

1. Introduction

The rapid development of the telecommunications industry has led to an oversaturation of the environment, especially the urbanized one, with technical sources of electromagnetic radiation. Electromagnetic radiation (EMR) is a wave propagating through space with an electric and magnetic component. Communication devices such as: mobile phones, cordless phones, local wireless networks and radio transmission towers, provide an electromagnetic field (emission) at the time of receiving and transmitting information. Existing and new radio communication technologies are leading to an increase in the number of base stations. When these facilities are placed in close proximity to or on public and residential buildings, in order to ensure greater traffic capacity and full radio coverage of the mobile phone service area, their penetrating radiation increases the voltage in the aforementioned buildings many times over. 2G, 3G, 4G, 5G antennas, with low and high range, continuously broadcasting the signals of mobile operators penetrate our homes and workplaces and can pose a serious threat to our health. Electromagnetic radiation is invisible to us, we cannot see, taste, or feel it, and this makes it particularly dangerous, as we have no way to protect ourselves from it. Radiation (EMF) passes through material or a person's skin, causing ionization that can damage chemical structures, and if the damage occurs to critical chemicals in cells (such as the DNA molecules that make up chromosomes in the cell nucleus), the cell can become damaged and lead to the formation of cancer [1-5].

In many cases, the importance of electromagnetic fields or the so-called “electromagnetic smog” on human health, living organisms, and the environment is ignored or at least minimized. European environmental policy currently includes more than 300 legal acts, including directives, regulations, decisions and recommendations [6,7]. They cover a wide range of measures to protect the environment from pollution through standards for air quality, waste management, water, nature conservation, control of industrial pollution, chemicals, background noise and climate change. Unfortunately, despite the growing public interest and concern, not enough attention is still paid to electromagnetic fields of artificial origin as a pollutant and the effects they cause on the environment, human health and living organisms. The fact is that the level of radiation from artificially created EMI in a number of cases significantly exceeds the level of electromagnetic fields from natural sources. Therefore, monitoring is necessary. To verify, assess, control and protect the population and the environment from exposure to electromagnetic radiation in accordance with the national standards and regulatory requirements adopted for each country [8-10].

Monitoring can be done for: source monitoring, environmental monitoring and individual monitoring, as appropriate. In this work we show individual monitoring. The rapid urbanization of the city of Bankya, Sofia Municipality, Bulgaria, and the modern world's need for communication devices have led to the number of transmitting antennas and their power exceeding the maximum permissible standards in the Site under consideration. The purpose of this type of monitoring is to verify and assess the dose of electromagnetic fields received from the base station RADOST - SID SOF0318 with three sector antennas (A1: KATHREIN 80010292, A2: KATHREIN 742266, A3: KATHREIN 742266) near the studied site. Does the facility fall within the hygienically protected zone within the meaning of regulation [8] of the Bulgarian legislation on the maximum permissible levels of electromagnetic fields in populated areas and the determination of hygienically protected zones around radiating facilities?

2. Characterization methods

Two types of specialized mobile equipment were used. One of the devices is SPECTRAN, manufactured by the German company AARONIA AG, including a SPECTRAN HF 6060 device for measurements in the range of 1 MHz to 7 GHz, with a directional antenna type HyperLOG 7060. The measurement results are visualized in real time and recorded on a laptop computer on which the manufacturer's software is installed, allowing for settings, measurements, visualization and storage of the results in graphical and digital form.

The device was set to a measurement frequency range - from 700 MHz to 2500 MHz, to cover the emission range from the RADOST Base Station - SID SOF0318. The device is equipped with a directional HyperLOG 7060 antenna. It was set to a measurement frequency range of 0.68 – 8 GHz. Measurement data is recorded every 1000 ms. The data are stored in digital files and are combined with additional accompanying information, such as coordinates, a map of the area, location of the antennas, records of the spectrograms in graphical form for each measurement interval, and photographs of the measurement locations with the installed antennas.

The second device is the NARDA AMB 8057-03, for electromagnetic monitoring of the environment in the frequency range from 110 kHz to 7 GHz, providing capabilities for continuous autonomous control of electromagnetic radiation, even in points difficult to access for observation. It uses isotropic antennas to measure the characteristics of electromagnetic fields propagating in the environment and reaching the antenna from all directions in space (360^0). The transmission of data to the server with the database is automatic, and there is also the possibility of remote setting of the device. The measurement results are stored in a specialized database containing information about the characteristics, frequency distribution and location (coordinates of the measurement points in a geographic information system GIS) of electromagnetic radiation. Mobile equipment NARDA AMB –

8057-3 provides capabilities for visualizing and reviewing measurement information for a selected time interval, date, week or day, for the entire frequency range (110 kHz – 7 GHz), a selected subrange of the frequency range (110 kHz – 7 GHz), peak values or average value for a specific frequency, a selected time interval of the day, to observe subtle effects in the distribution of radiated power for a given frequency.

3. Results and Discussion

Object - town Bankya, Sofia Municipality, Bulgaria. Measurements of electromagnetic fields in the frequency range 700 MHz to 2500 MHz were carried out with mobile equipment SPECTRAN HF 6060 in the time interval from 11:17 to 11:35 on 21.10.2015 (Fig.1). The measurement lasts for 18 minutes. The point from which the measurements were taken at the site is located ~ 25-30 meters in a straight line from the transmitting antennas of the base station. It should be noted that the measurements were conducted in a residential area, on a weekday, Wednesday. The area is without public and administrative buildings and it is assumed that the use of mobile communications is characterized by low traffic.

Fig. 1 *Location of measuring equipment and arrangement of base stations around the research site.*

Figure 2 shows the average values of the measurement results in three frequency ranges 943 MHz, 1690 MHz and 2152 MHz. Maxima are observed in the levels of measured EMI around 267 μW/cm^2, at a frequency of 943 MHz. These measured values are twenty times above the permissible level of 10 μW/cm^2, according to [8]. Excessive electromagnetic pollution has been measured. At frequencies 1690 MHz and 2152 MHz, the measured values are below the permissible level of 10 μW/cm^2, 0.8990 μW/cm^2 and 0.5070 μW/cm^2, respectively.

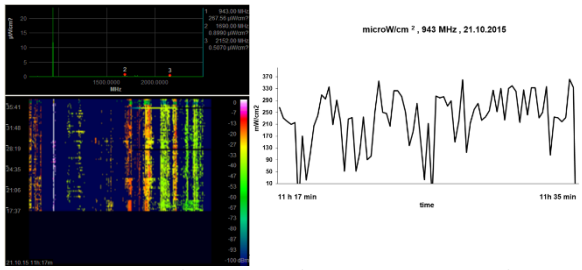

Fig. 2 *Average values of the results of measuring the energy flux density of EMF.*

In the same object, city Bankya, Metropolitan Municipality, Bulgaria, repeated continuous 24-hour measurements of electromagnetic fields with another mobile device NARDA AMB-8057-03 were carried out from May 27 to June 9, 2021 in the frequency range 100 kHz to 7 GHz. This frequency range covers the frequencies of all mobile operators operating on the territory of Bulgaria and allows to track the dynamics of electromagnetic radiation from the antennas, on weekdays and weekends. The point from which the measurements were made in the object is located ~ 25-30 meters in a straight line from the emitting antennas of a base station.

Figure 3 shows the average values of the measurement results in three frequency ranges 942 MHz, 1842 MHz and 2140 MHz. These frequency ranges were selected based on a recommendation from the EU Council [7].

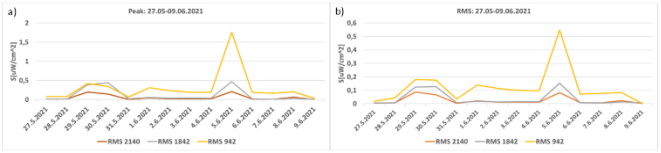

Fig. 3 *Maximum peak values (a) and maximum average values (b) from measurements of electromagnetic fields in an object.*

The maximum peak values of the measured power density of electromagnetic radiation EMF, for two of the frequency ranges 1842 MHz and 2140 MHz, are almost an order of magnitude lower than the maximum permissible standard of 10 μW/cm^2. For a frequency of 1842 MHz, the measured values range from 0.011 to 0.47 μW/cm^2, and for a frequency of 2140 MHz, they range from 0.007 to 0.21 μW/cm^2. For the 942 MHz frequency range, the measured values vary in a wide range from 0.03 to 1.75 μW/cm^2. For this frequency range, we should pay attention to the values obtained on June 5. This date is a holiday (Saturday).

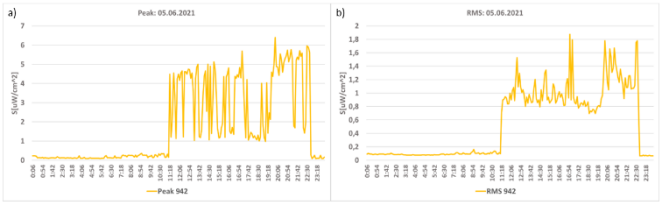

Fig. 4 *Maximum peak values (a) and maximum average values (b) from measurements of electromagnetic fields in the facility for 05.06.2021.*

Figure 4 shows the maximum peak and average values measured on 05.06.2021. The maximum peak values range from 0.083 to 6.39 μW/cm^2. It is noteworthy that the highest values were measured in the evening hours, and after 10:30 p.m. the power of electromagnetic radiation decreases sharply.

As we have already specified, this is a residential area and the use of mobile sources on weekends is higher both for the date 05.06.2021 and the previous Saturday 29.05.2021. Accordingly, the level of the measured power density of electromagnetic radiation EMF has increased, but the obtained values are below the maximum permissible standard value of 10 μW/cm^2.

The maximum average values of the measured power density of electromagnetic radiation EMF, for a frequency of 2140 MHz - vary from 0.002 to 0.08 μW/cm^2. For frequencies of 1842 MHz and 942 MHz they vary in a wide range. For frequency 1842 MHz they vary from 0.004 to 0.15 μW/cm^2, and for frequency range 942 MHz, from 0.002 to 0.17 μW/cm^2. The measured values for the three frequencies are less than the standard limit values of 10 μW/cm^2. Again, if we pay attention to the date 05.06.2021, Saturday, the measured values for the 942 MHz frequency range are higher. They are in the range of 0.07 to 1.87 μW/cm^2, which is less than the maximum permissible values according to the standard of 10 μW/cm^2.

From the measured power density of electromagnetic radiation EMF for all fourteen days of measurements, a recurring daily trend of a decline in the levels of radiated power from mobile operators is observed, after 10:30 p.m. to 6:00 a.m. - 6:30 a.m. This is explained by the end of the day and the intensive use of mobile communication devices. This trend of difference is repeated when comparing workdays and weekends.

Conclusions

The results obtained from measuring electromagnetic radiation in a site located in a lightly urbanized environment prove to us the need for monitoring. To carry out regular measurements and thus to check and control the parameters of all sources of EMF. To seek solutions to the problem of environmental pollution with this new

pollutant, including methods for analyzing the risk to human health and related solutions for the development of urban infrastructure.

During the initial measurements of electromagnetic fields in the frequency range of 943 MHz, maxima in the levels of measured EMF were observed ~ 267 μW/cm^2. These measured values are more than twenty times the permissible level of 10 μW/cm^2. Excessive electromagnetic pollution has been detected. For the frequency ranges 1690 MHz and 2152 MHz, the measured values are below the permissible level of 10 μW/cm^2. Cases of exceeding the maximum permissible standards under the Bulgarian National Standards in individual sites on the territory of Sofia Municipality are rather an exception. The presence of isolated cases of exceeding the permissible norms may be due to the degree of urbanization, inconsistency between the construction control authorities and those controlling the installation of new broadcasting antennas, their power and location. All this has a significant impact on the intensity of electromagnetic emissions. In this case, one of the frequencies at the date of measurement was not set to operate within the permissible radiated power level of 10 μW/cm^2 [8].

During repeated continuous, all-day and continuous monitoring of fourteen days in the same site at the request of citizens and in the three frequency ranges 942 MHz, 1842 MHz and 2140 MHz, the levels of the measured radiated power of electromagnetic radiation are below the maximum permissible norm of 10 μW/cm^2. This proves that after the initial measurements with high values, SRHI took action to eliminate the discrepancies, in accordance with the procedure specified in the regulatory framework and they were eliminated. Therefore, it is crucial to conduct monitoring and control of EMF to ensure a high level of protection of the population and the proper functioning of the Base Stations within the permissible norms.

3. References

1. IARC Classifies Radiofrequency Electromagnetic Fields as Possibly Carcinogenic to Humans. https://www.iarc.fr/wp-content/uploads/2018/07/pr208_E.pdf
2. M. Repacholi. Low-level exposure to radiofrequency electromagnetic fields: health effects and research needs. Bioelectromagnetics.19(1), 1-19 (1998) DOI:10.1002/(SICI)1521-186X(1998)19:1<1::AID-BEM1>3.0.CO;2-5
3. K. Kesari, M. Siddiqui, R. Meena, H. Verma, S. Kumar. Cell phone radiation exposure on brain and associated biological systems. Indian J Exp Biol. 51(3), 187-200 (2013)
4. D. Brenner, R. Doll, D. Goodhead, E. Hall et al. Cancer risks attributable to low doses of ionizing radiation: Assessing what we really know. Proceedings of the National Academy of Sciences. 100(24), 13761-13766 (2003) https://doi.org/10.1073/pnas.2235592100
5. Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures – Part 1: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz). (2005) https://webstore.iec.ch/publication/6588
6. Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz), International Commission on Non-Ionizing Radiation Protection (ICNRP), non-governmental organization. (1998)
7. Council of the European Union, Council Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz), Official Journal of the European Communities, L 199/59, Brussels, Belgium. (1999)
8. Ordinance No. 9/1991 on maximum permissible levels of electromagnetic fields in populated areas and determination of hygienic protection zones around radiating objects, of the Ministry of Health and the Ministry of Environment and Water (SG 35/1991, amended and supplemented, SG 8/2002, published in SG 42/07.09.2022). (2022)
9. Health Act, published in SG 70/2004. (2004)
10. Ordinance 36 on the conditions and procedure for exercising state health control, promulgated, SG 63/2009. (2009)