An Evaluation of the Electromagnetic Radiation Levels of Tbilisi School Environments Using Direct Measurements

Tamar Nozadze
Department of Electrical and Electronics Engineering, Laboratory of Applied Electrodynamics and Radio Engineering, Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia
tamar.nozadze@tsu.ge (corresponding author)

Giorgi Ghvedashvili
Department of Electrical and Electronics Engineering, Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia
giorgi.ghvedashvili@tsu.ge

Received: 9 July 2025 | Revised: 5 September 2025 | Accepted: 6 September 2025

DOI: https://doi.org/10.48084/etasr.13256

ABSTRACT

Technological advances have led to an increase in ambient Electromagnetic Field (EMF) levels, adding to the natural background EMFs. Modern electronic devices contribute to this rise, resulting in what is known as Electromagnetic (EM) pollution. With the widespread adoption of wireless technology, concerns have grown about the biological effects of long-term EMF exposure, particularly for vulnerable groups, such as children and individuals with underlying health conditions. Current international safety standards primarily focus on human exposure and do not consider the potential effects on plants and animals. EMFs from communication devices are classified as "possibly carcinogenic," yet public awareness and precautionary measures remain limited, partly because EMFs are invisible to humans. Although it is difficult to completely avoid exposure, adhering to the proposed limits can help reduce the health risks. Children are a particularly important group to consider when examining the potential effects of EM radiation. Since children spend much of their day at school, they experience prolonged, nearly continuous exposure to EM fields. This study aims to assess the EM background in selected school zones in Tbilisi, Georgia. Direct measurements were utilized to map the EMF levels in the selected schools, identify high-exposure areas -"hot-spots", and evaluate compliance with the safety standards.

Keywords-environment; EMF measurement; EM pollution; human exposure; ICNIRP limits; school locations

I. INTRODUCTION

The advancement of modern technologies has contributed to a rise in the environmental levels of Electromagnetic Fields (EMFs). While EMFs have always existed naturally, human-made electronic devices now significantly add to this background, leading to what is known as Electromagnetic (EM) pollution. This issue has become increasingly pressing. Consequently, concerns have arisen regarding the potential adverse health effects of prolonged exposure to EM fields. Living organisms, including humans, have adapted to natural background EM radiation [1, 2]. Additionally, over time, they develop resilience to certain environmental changes. However, no such adaptation mechanism currently exists for the changes caused by exposure to artificial EM fields. The rise of EM pollution threatens not only human health but also the environment and ecosystems as a whole [1, 2]. EM radiation can affect biological organisms through both thermal and non-thermal mechanisms, with impacts that may be either direct or indirect. Living systems possess the capacity to adapt to external influences, a process known as compensation. There are two types of compensation: physiological and pathological. Physiological compensation allows an organism to maintain normal function despite exposure to such influences. In contrast, pathological compensation occurs when external factors induce changes or disruptions that may lead to significant biological harm [3]. However, distinguishing between these two forms of compensation is often challenging, as the transition from normal adaptation to harmful disruption is not always clearly defined.

In 2011, the World Health Organization (WHO) and the International Agency for Research on Cancer (IARC), drawing on existing scientific evidence, classified EM fields as possibly carcinogenic to humans [4]. Since EM fields are imperceptible to human senses, individuals are generally unaware of their presence. Avoiding exposure entirely to EM fields is quite challenging, but it is possible to reduce the intensity of such exposure by limiting the use of emitting devices whenever feasible. By reducing the dose of the received radiation, the human body and health can be protected. In [5, 6], it was shown that EM fields may contribute to the development of oncological diseases, hormonal imbalances, and disturbances in blood composition in humans. External EM field exposure can also interfere with the proper functioning of electronic devices. High-intensity EM fields may disrupt the operation of implanted pacemakers, causing irregularities in the generation or delivery of impulses, which in severe cases could lead to the patient's death [7-9].

The current safety standards and recommendations are primarily based on the guidelines from the WHO, which in turn rely on the recommendations of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and IEEE standards. To date, none of the guidelines for protection against radio-frequency radiation specifically address bio-species other than humans [10-12]. Scientifically, it is difficult to state with certainty that adhering to the established limits of EM field exposure can completely prevent potential long-term harm. However, maintaining EM field levels below these threshold values can help minimize health risks.

It is generally assumed that animals, plants, and ecosystems are protected on condition that humans are protected. However, varying the exposure conditions and interaction mechanisms of EM radiation may cause specific effects on flora and fauna [12]. Insects are particularly vulnerable to EM radiation compared to mammals, birds, and reptiles. The total biomass of insects is decreasing by approximately 2.5% annually, suggesting that they could face extinction within the next century. The loss of insect diversity and abundance could have devastating consequences for food chains and pose a serious threat to entire ecosystems. Authors in [12-14] noted a direct correlation between steadily increasing EM field levels and these environmental problems. The 5G technology uses frequencies that have a particularly strong impact on insect populations. Due to their small body size, insects absorb energy more efficiently at high-frequency ranges compared to humans. The insects, birds, and other species living near cellular antennas mounted on pine trees are vulnerable because the existing EM regulations do not cover wildlife [12-14]. Scientists believe that the gradual decline of bees and other pollinators, linked to EM radiation, may pose more immediate and widespread problems than global warming. All these findings serve as a warning signal that healthy ecosystems are undergoing detrimental changes, which will likely manifest in the near future, with inevitable consequences for human health and quality of life.

The potential health risks associated with EM radiation are particularly concerning for sensitive groups like children, adolescents, pregnant women, and those with compromised health. The prolonged exposure to EM fields may trigger a range of biological responses, most notably behavioral alterations and an increased risk of developmental disorders [15-19]. Children, particularly school-aged pupils, represent a group of special interest when assessing the potential impact of EM radiation. Schools are environments where children spend a significant portion of their day, resulting in continuous exposure to EM fields. It has been indicated that the effects of such exposure may be both immediate and long-term. Short-term effects can include symptoms, such as difficulty in concentrating, increased anxiety, and visual disturbances, while long-term consequences, though still not fully understood, may involve serious health outcomes, including the potential development of tumors [20, 21].

It is important to emphasize that the full extent of health risks associated with prolonged EM exposure remains unclear. However, available measurements suggest that the background EM levels are steadily increasing. Naturally, this raises concerns among parents regarding whether school environments are truly safe from the standpoint of EM pollution.

Considering these concerns, the present study aims to measure EM field intensities at selected school locations in Tbilisi, Georgia, to assess the level of EM pollution. Based on the collected data, specialized software tools were utilized to generate a thematic map of EM pollution, highlighting specific areas that warrant attention in terms of EM safety.

II. METHOD

The concentration of users in places, such as schools, hospitals, and shopping malls, can fluctuate depending on the day of the week and the time of day, which in turn affects the levels of the EM fields present in these environments. To evaluate the background EM field levels, measurements were conducted during daytime hours at public school sites, specifically around the school perimeter, where no special permissions were required. These measurements were taken periodically to monitor the trends in EM field values at selected locations, and the results were visualized using appropriate diagrams. Data collection occurred from January to June 2024. Additionally, measurements were performed during weekends (once a month), with the timing between measurements adjusted based on the weather conditions.

The methodology for the measurements followed the recommendations outlined in relevant standards and guidelines. In accordance with the ICNIRP guidelines, exposure to Radiofrequency (RF) EM fields was assessed through the parameter of power density (W/m^2). The HF-B8G device was utilized for the measurements. The potential impact of metallic structures, soil properties, and device accuracy on measurement results was considered and mitigated as follows: The HF-B8G Triple Axis RF Meter is factory-calibrated for the frequency range of 10 MHz to 8 GHz, with an absolute error of ±1.0 dB at 1 V/m and 2.45 GHz, and a frequency response deviation of ±1.0–2.4 dB depending on frequency. Before measurements, the Calibration Factor (CAL) was verified and adjusted in accordance with the manual, ensuring that the readings were accurate and consistent. Measurements were performed in open areas or at a sufficient distance from large metallic objects. The meter operates reliably in far-field conditions, where the reflections and interference from nearby metallic structures are minimal. However, when the meter was near unavoidable metallic structures, the readings were cross-checked along multiple axes using the XYZ function to account for potential field distortion. Although the HF-B8G primarily measures electric fields in free space, care was taken to minimize the effects from soil conductivity and moisture, which can influence near-field readings. Measurements were performed with the sensor elevated or at consistent height above ground to reduce the ground-related variability. The meter was set to "All axis" mode (XYZ) for isotropic measurement and readings were taken using the instantaneous, maximum, and average modes as needed. Any low-battery indicators were checked to avoid measurement drift, as battery voltage can affect sensor performance. The tri-axis digital processing and isotropic sensing reduce orientation and directional errors. Overall, the HF-B8G meter's design, calibration procedures, and careful measurement setup ensured that the influences from metallic structures, soil conditions, and device limitations were minimized and accounted for in the data collection.

For this study 75 public school locations were selected. For the measurements, a frequency range from 1 MHz to 8 GHz was chosen, which the measuring device can accurately capture using an isotropic antenna to assess non-ionizing radiation.

To minimize the impact of weather conditions such as humidity, all measurements were performed under consistent weather specifically during clear, cloudless periods. Additionally, measurements were taken at the same time of day to eliminate any variations caused by differing times. Measurement points were positioned approximately 1.5 m above the ground, corresponding to the average height of a person. At each selected location, the measurements were taken in a stationary state, with the measuring device configured to continuously record the EMF level for at least 10 min. During this period, it was possible to detect variations in the EM field level caused by user activity and environmental conditions. Multiple measurements were taken at various points around the schools, with the EM field maximal value recorded for analysis. The corresponding GPS coordinates of the measurement locations were taken for monitoring purposes to ensure accuracy for future revisits. The EM field measurements were performed during weekdays and weekends across several locations. This approach aimed to explore how the pollution levels relate to the number of active mobile phone users and the time of the measurement.

The measured data were recorded and subsequently imported into Excel for processing and analysis. The spreadsheets that were created were an appropriate method of organizing the substantial quantity of data that were gathered. The collected data were analyzed to check their compliance with safety standards. The processing of the measurement results enabled the identification of specific school locations in the city that stand out due to higher levels of EM pollution. The research primarily focused on quantifying the radiated energy and evaluating whether the selected schools are safe with respect to the EM exposure.

The measurement campaign was conducted from January to May 2024 and was repeated in 2025 for monitoring purposes. The repeated measurements were carried out in the same season and weather conditions, in areas with high EM pollution. Authors in [22] demonstrated that the EM field values are significantly affected by environmental factors, such as temperature and humidity. Five measurement sessions were conducted over the weekend in the selected schools within the specified time frames.

III. RESULTS AND DISCUSSION

With the growing number of mobile phone users, the design and placement of base stations have become increasingly significant. Typically, base stations are mounted on towers ranging from 10 to 30 m in height. The positioning of antennas is carefully selected so that the main radiation beams reach the ground at approximately 50 to 200 m from the tower. The coverage area of a single base station can extend up to 30–40 km. Figure 1 shows the network coverage map by three different mobile operators in the study area. Authors in [23] showed that while the exposure to EMF tends to increase with the progression of mobile network technologies, the exposure levels still stay within established safety thresholds.

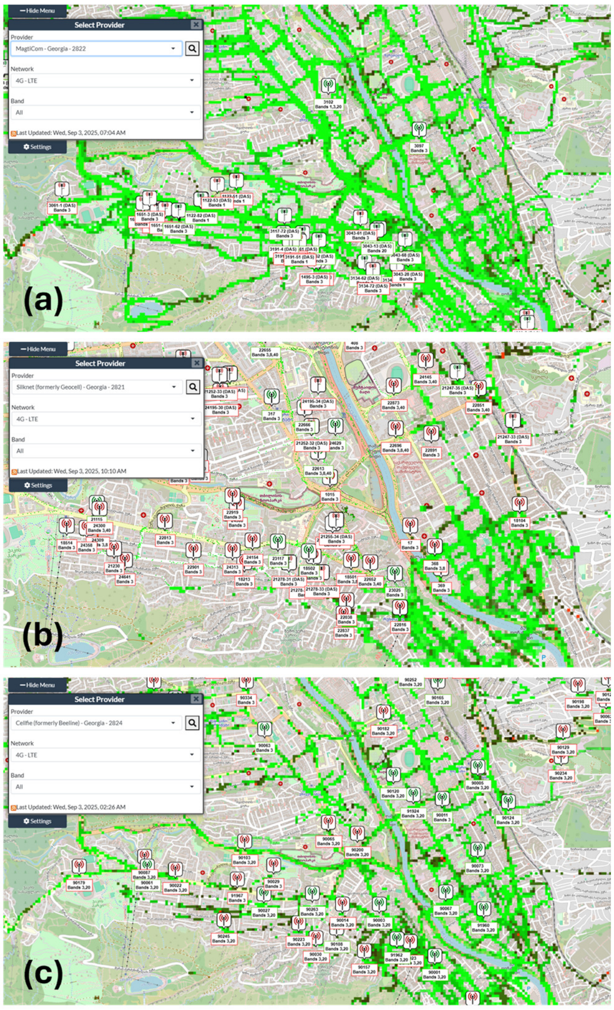

Fig. 1. Network coverage (Cell Towers) map by operators in Tbilisi, Georgia for: (a) MagtiCom, (b) Geocell (Silknet) and (c) Beeline (Cellfie) [24].

The public concern regarding EM pollution has intensified, largely due to the expansion of Global System for Mobile

Communications (GSM) networks and the emergence of new wireless communication technologies [23]. The proliferation of modern technological infrastructure has led to an increase in EM emissions from base stations, contributing to the unintended EM pollution of the environment.

The analysis of the data collected during the study period showed no significant differences between the measurements taken on weekends (Figure 2) and weekdays (Figure 3). This can be explained by the fact that the measurements were carried out along the outer perimeter of school buildings. It is assumed that more pronounced differences could have been observed as long as the measurements had been carried out inside the school premises.

As part of this study, measurements of EM field power density were conducted at various school locations throughout Tbilisi to assess the level of EM radiation in the urban environment. According to [25], a power density of up to 10 μW/cm² is considered safe. The study revealed that the EM field intensity at the measured locations ranged from 1mW/m² to 150 mW/m². Relatively high values were recorded near several schools (Figure 3), while the rest of the locations remained within the permissible limits set by both international and local standards [4, 11, 25]. In areas where the recorded values exceed the proposed thresholds, it is advisable to implement mitigation measures to reduce EM field intensity below the safe level.

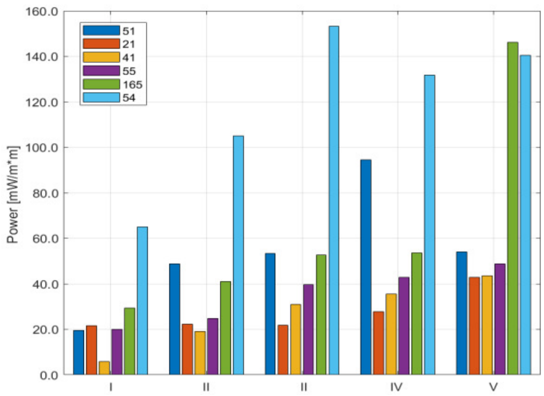

Fig. 2. Power density values for each selected public-school area measured on weekends.

As shown in Figure 4, the green color indicates locations where the EM field power density does not exceed 50 mW/m². The yellow color represents areas where the field ranges between 50 mW/m² and 100 mW/m², while the red color highlights zones with values exceeding 100 mW/m². Mapping EM pollution is an essential tool for identifying areas with elevated radiation levels. Regular monitoring enables preventive action and ensures compliance with internationally recognized safety standards. It is crucial to regulate and maintain the EM field levels within safety limits.

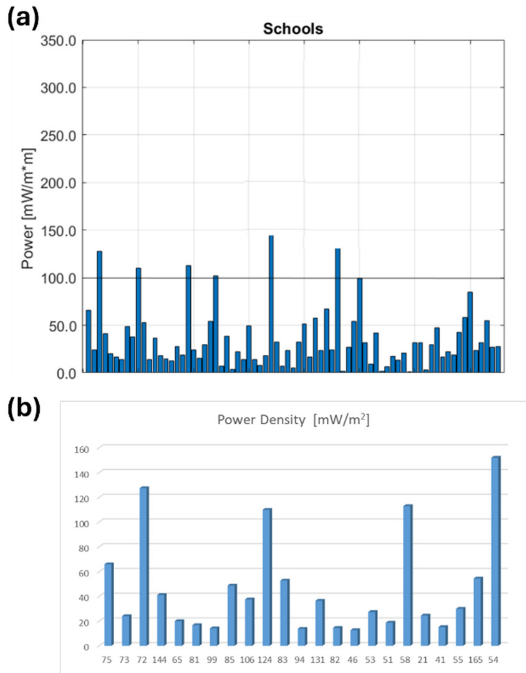

Fig. 3. Power density values for: (a) all selected public school locations and (b) specific locations measured on weekdays.

Furthermore, periodic monitoring and updates of EM background levels are necessary, as the number of electronic and communication devices has increased significantly. Special attention should be given to children, who are more sensitive to EMFs than adults. Children are still undergoing physiological and psychological development, and the bioelectrical characteristics of their nervous systems make them more vulnerable to EMF exposure [26-31]. Therefore, ensuring a safe environment is vital for protecting the health and well-being of future generations.

To ensure the consistency and reliability of the results, periodic measurements were conducted at locations previously identified as having relatively high EM field intensities. Measurements were performed under the same conditions, including season, time of day, and weather. The results confirmed that the EM field levels at these sites remained within the established safety limits.

The current study's results align closely with those of previous research conducted in Ramadi (Iraq), Crete (South Greece), Beijing (China), and Banja Luka (Bosnia and Herzegovina) [32-35]. The studies have shown that EMF exposure frequently exceeds the proposed safety thresholds, raising significant public health concerns. In all cases, the main sources of EMF were base stations, particularly those associated with newer technologies. These findings underscore the need for continuous monitoring, strict compliance with international safety standards, and careful planning of the antenna placement and operation to reduce exposure risks, especially in densely populated or sensitive environments.

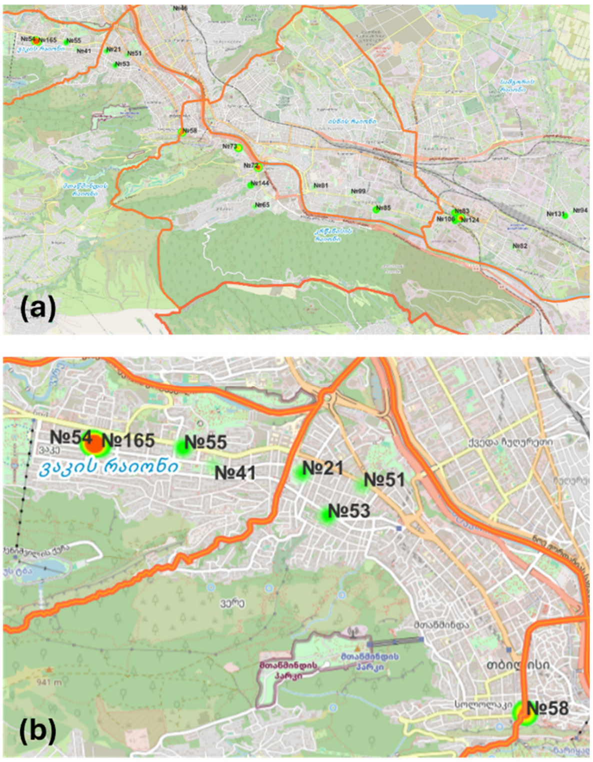

Fig. 4. Thematic map of selected schools in Tbilisi, based on measurements during: (a) weekdays, (b) weekends.

IV. CONCLUSIONS

A study of Electromagnetic (EM) background levels was conducted through direct measurements at some of the most sensitive locations, such as public schools in Tbilisi, Georgia. The collected data were analyzed, and a thematic map was created to identify school sites where the EM radiation levels are relatively elevated. After one-year, repeated measurements were conducted at sites previously identified as having comparatively elevated EM field levels. All data were collected under identical conditions with respect to season, time of day, and weather. The monitoring outcomes indicated that the EM field intensities at these locations remained within the established limits.

While numerous studies assessing Electromagnetic Field (EMF) exposure have been conducted internationally, research of this kind remains novel for Georgia. Most existing literature focuses on evaluating the EMF levels in urban school environments in other countries, where infrastructure, population density, and other environmental factors differ substantially from those in Georgia. The present study is, therefore, novel in its systematic evaluation of the EMF exposure around schools in Tbilisi. Furthermore, it aims, for the first time, to extend the research across multiple Georgian cities, towns, and villages, providing a comprehensive dataset reflecting the national conditions. By capturing EMF measurements across diverse school locations, the study generates baseline data essential for understanding potential exposure risks for children in local settings. These findings aim to minimize the EMF exposure and provide practical guidance for future school infrastructure planning, including the strategic placement of electrical and telecommunication equipment. Furthermore, the anticipated results from this research establish a foundation for region-specific studies and comparative analyses within Georgia. In this way, a clear and meaningful contribution is made, with relevance to public health at the country level.

Existing safety standards are primarily designed to protect against known short-term effects. However, even when the measured values fall within these limits, no definitive conclusions can be drawn regarding potential long-term impacts. It would be scientifically inaccurate to assume that the current standards offer complete protection against all health risks associated with the prolonged EM field exposure. Today, humans and other living organisms are constantly exposed to EM fields and/or EM radiation. It is, therefore, unsurprising that the potential effects of EM radiation are attracting increasing scientific attention. Many flora and fauna species are sensitive to artificial or human-made EM fields, which may be a contributing factor to species decline and extinction. EM fields can affect the health and viability of wildlife, and artificial EM fields might play a larger role in species reduction and extinction. This can trigger a cascading effect, since everything in nature is interconnected, and will inevitably impact human health and life quality.

Despite the extensive research, there is still no clear answer to whether EM pollution has negative effects on bio-species. Similarly, the question of whether EM radiation might sometimes have beneficial effects on living beings remains unanswered. Continued research is essential, as technology is advancing faster than the understanding of its long-term effects.

This study, together with existing research on this topic, highlights the widespread nature of the problem and reinforces the need for continuous monitoring, adherence to international safety standards, and careful planning of antenna placement and operation. The findings emphasize the importance of implementing mitigation strategies in sensitive environments, such as schools, to minimize exposure risks and protect vulnerable populations, especially children.

ACKNOWLEDGMENT

The present research is financially supported by Shota Rustaveli National Science Foundation of Georgia (SRNSFG) [grant number YS-23-131].

REFERENCES

[1] X. Wei, Y. Huang, and C. Sun, "A review of effects of electromagnetic fields on ageing and ageing dependent bioeffects of electromagnetic fields," *Science of The Total Environment*, vol. 963, Feb. 2025, Art. no. 178491, https://doi.org/10.1016/j.scitotenv.2025.178491.

[2] F. A.L, N. Hassan, and F. Ruzaik, "The Effect of Electromagnetic Radiation on Environmental and Human Safety: An Empirical Review," *in 2025 International Conference on Geography for Global Sustainability (ICGGS)*, Colombo, Sri Lanka, Mar. 2025, pp. 51-62.

[3] V. Nevezhin and A. Busygina, "Non-Thermal Effects of Electromagnetic Radiation on a Living Organism," in *2021 IEEE 22nd International Conference of Young Professionals in Electron Devices and Materials (EDM)*, Souzga, Russia, June 2021, pp. 403–406, https://doi.org/10.1109/EDM52169.2021.9507595.

[4] "IARC Classifies Radiofrequency Electromagnetic Fields as Possibly Carcinogenic to Humans," https://www.iarc.who.int/wp-content/uploads/2018/07/pr208_E.pdf.

[5] M. Abdul-Al *et al.*, "Wireless Electromagnetic Radiation Assessment Based on the Specific Absorption Rate (SAR): A Review Case Study," *Electronics*, vol. 11, no. 4, Feb. 2022, Art. no. 511, https://doi.org/10.3390/electronics11040511.

[6] G. C. Jagetia, "Genotoxic effects of electromagnetic field radiations from mobile phones," *Environmental Research*, vol. 212, Sept. 2022, Art. no. 113321, https://doi.org/10.1016/j.envres.2022.113321.

[7] J. Mydlová, I. Gálová, and M. Beňová, "Impact of Electromagnetic Fields in Transport on Active Implantable Medical Devices," *in Transportation Research Procedia*, Jan. 2019, vol. 40, pp. 1497–1503, https://doi.org/10.1016/j.trpro.2019.07.207.

[8] Z. Pšenáková, "Effects of 2.4 GHz radiofrequency radiation to pacemaker," *in 2015 Advanced Methods of Theory of Electrical Engineering*, Trebic, Czech Republic, Sept. 2025, pp. VII-3, https://dspace.zcu.cz/bitstreams/907458f6-3623-4fd0-b673-ed9d2a9dfbca/download.

[9] S. Driessen, A. Napp, K. Schmiedchen, T. Kraus, and D. Stunder, "Electromagnetic interference in cardiac electronic implants caused by novel electrical appliances emitting electromagnetic fields in the intermediate frequency range: a systematic review," *Ep Europace*, vol. 21, no. 2, pp. 219–229, 2019, https://academic.oup.com/europace/article-abstract/21/2/219/5050873.

[10] M. Mevissen *et al.*, "Effects of radiofrequency electromagnetic field exposure on cancer in laboratory animal studies, a systematic review," *Environment International*, vol. 199, May 2025, Art. no. 109482, https://doi.org/10.1016/j.envint.2025.109482.

[11] "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)." https://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf.

[12] B. B. Levitt, H. C. Lai, and A. M. Manville, "Effects of non-ionizing electromagnetic fields on flora and fauna, Part 2 impacts: how species interact with natural and man-made EMF," *Reviews on Environmental Health*, vol. 37, no. 3, pp. 327–406, 2022, https://doi.org/10.1515/reveh-2021-0050.

[13] A. Lázaro, A. Chroni, T. Tscheulin, J. Devalez, C. Matsoukas, and T. Petanidou, "Electromagnetic radiation of mobile telecommunication antennas affects the abundance and composition of wild pollinators," *Journal of Insect Conservation*, vol. 20, no. 2, pp. 315–324, Apr. 2016, https://doi.org/10.1007/s10841-016-9868-8.

[14] O. J. Adelaja, A. T. Ande, G. D. Abdulraheem, I. A. Oluwakorode, O. A. Oladipo, and A. O. Oluwajobi, "Distribution, diversity and abundance of some insects around a telecommunication mast in Ilorin, Kwara State, Nigeria," *Bulletin of the National Research Centre*, vol. 45, no. 1, Dec. 2021, Art. no. 222, https://doi.org/10.1186/s42269-021-00683-y.

[15] C. A. Hallmann et al., "More than 75 percent decline over 27 years in total flying insect biomass in protected areas," *PLOS ONE*, vol. 12, no. 10, Art. no. e0185809, Oct. 2017, https://doi.org/10.1371/journal.pone.0185809.

[16] J. H. Kim, J.-K. Lee, H.-G. Kim, K.-B. Kim, and H. R. Kim, "Possible Effects of Radiofrequency Electromagnetic Field Exposure on Central Nerve System," *Biomolecules & Therapeutics*, vol. 27, no. 3, pp. 265–275, 2019, https://doi.org/10.4062/biomolther.2018.152.

[17] Z. A. Kashani et al., "Electromagnetic fields exposure on fetal and childhood abnormalities: Systematic review and meta-analysis," *Open Medicine*, vol. 18, no. 1, May 2023, https://doi.org/10.1515/med-2023-0697.

[18] B. Samaila, A. Abdullahi, M. Yahaya, and N. Abubakar, "Residential exposure to non-ionizing electromagnetic radiation from mobile base stations: a systematic review on biological effects assessment," *Material Science & Engineering International Journal*, vol. 7, no. 2, pp. 44–52, Apr. 2023, https://doi.org/10.15406/mseij.2023.07.00203.

[19] A. Asghari, A. A. Khaki, A. Rajabzadeh, and A. Khaki, "A review on Electromagnetic fields (EMFs) and the reproductive system," *Electronic Physician*, vol. 8, no. 7, pp. 2655–2662, July 2016, https://doi.org/10.19082/2655.

[20] N. As, B. Dilek, M. E. Şahin, and Y. Karan, "Electromagnetic pollution measurement in the RTE university campus area," *Global Journal on Advances in Pure & Applied Sciences*, vol. 3, pp. 65–72, March 2014.

[21] J. F. Bakker, M. M. Paulides, A. Christ, N. Kuster, and G. C. van Rhoon, "Assessment of induced SAR in children exposed to electromagnetic plane waves between 10 MHz and 5.6 GHz," *Physics in Medicine & Biology*, vol. 55, no. 11, Art. no. 3115, May 2010, https://doi.org/10.1088/0031-9155/55/11/009.

[22] J. Dikun, V. Jankunas, E. Guseinoviene, L. Galdikas, and T. C. Akinci, "Effects of weather conditions on electromagnetic field parameters," in 2015 Tenth International Conference on Ecological Vehicles and Renewable Energies (EVER), Monte-Carlo, Monaco, Mar. 2015, pp. 1–7, https://doi.org/10.1109/EVER.2015.7112935.

[23] F. U. Rashidi, M. H. Mohsini, and C. Ambele, "Investigations of Cell Tower Antennas Parameters on Reduction of Radio Frequency Radiation Levels from Radio Base Stations," Tanzania Journal of Engineering and Technology, vol. 43, no. 2, pp. 223–241, Aug. 2024, https://doi.org/10.52339/tjet.v43i2.1032.

[24] "Cellular Tower and Signal Map." https://www.cellmapper.net.

[25] "Order No 297/N of 2001 of Minister of Labor, Health and Social Affairs of Georgia on Environmental Quality Requirements." https://ampeid.org/documents/georgia/order-no-297-n-of-2001-of-minister-of-labor-health-and-social-affairs-of-georgia-on-environmental-quality-requirements/.

[26] H. Lim, J. Choi, H. Joo, and M. Ha, "Exposures to radio-frequency electromagnetic fields and their impacts on children's health – What the science knows?," *Current Opinion in Environmental Science & Health*, vol. 32, Art no. 100456, Apr. 2023, https://doi.org/10.1016/j.coesh.2023.100456.

[27] T. Nozadze, V. Jeladze, M. Tsverava, V. Tabatadze, M. Prishvin, and R. Zaridze, "EM exposure study on an inhomogeneous child model considering hand effect," *in 2017 IEEE First Ukraine Conference on Electrical and Computer Engineering (UKRCON)*, Kyiv, Ukraine, May. 2017, pp. 51–54, https://doi.org/10.1109/UKRCON.2017.8100484.

[28] T. Nozadze, V. Jeladze, and R. Zaridze, "Mobile Antenna Matching Study Considering Different Holding Positions at 2100 MHz Frequency," *in 2020 IEEE XXVth International Seminar/Workshop Direct and Inverse Problems of Electromagnetic and Acoustic Wave Theory (DIPED),* Tbilisi, Georgia, Sept. 2020, pp. 121–125, https://doi.org/10.1109/DIPED49797.2020.9273363.

[29] T. Nozadze, K. Henke, M. Kurtsikidze, V. Jeladze, G. Ghvedashvili, and R. Zaridze, "Study How the Hand Affects on the Mobile Phone Dipole Antenna Matching Conditions to the Free Space at 3700 MHz Frequency," *in 2022 IEEE 2nd Ukrainian Microwave Week (UkrMW)*, Online, Nov. 2022, pp. 439–443, https://doi.org/10.1109/UkrMW58013.2022.10037056.

[30] D. B. Deaconescu, A. M. Buda, D. Vatamanu, and S. Miclaus, "The Dynamics of the Radiated Field Near a Mobile Phone Connected to a 4G or 5G Network," *Engineering, Technology & Applied Science Research*, vol. 12, no. 1, pp. 8101–8106, Feb. 2022, https://doi.org/10.48084/etasr.4670.

[31] T. Nozadze, D. Kharshiladze, V. Jeladze, G. Ghvedashvili, and R. Zaridze, "Assessment of the EM Radiation Level in Tbilisi School Locations," *in 2024 IEEE 29th International Seminar/Workshop on Direct and Inverse Problems of Electromagnetic and Acoustic Wave Theory (DIPED)*, Tbilisi, Georgia, Sept. 2024, vol. 1, pp. 175–179, https://doi.org/10.1109/DIPED63529.2024.10706051.

[32] M. S. Zidan, M. Q. Taha, L. A. Yaseen, N. D. Hameed, and Q. N. Abid, "Measurement and assessment of mobile network electromagnetic radiation pollution in Ramadi, Iraq," *Bulletin of Electrical Engineering and Informatics*, vol. 11, no. 5, pp. 2679–2686, Oct. 2022, https://doi.org/10.11591/eei.v11i5.3938.

[33] J. Liu, M. Wei, H. Li, X. Wang, X. Wang, and S. Shi, "Measurement and mapping of the electromagnetic radiation in the urban environment," *Electromagnetic Biology and Medicine*, vol. 39, no. 1, pp. 38–43, 2020, https://doi.org/10.1080/15368378.2019.1685540.

[34] T. N. Kapetanakis et al., "Assessment of Radiofrequency Exposure in the Vicinity of School Environments in Crete Island, South Greece,"

Applied Sciences, vol. 12, no. 9, Art. no. 4701, May 2022, https://doi.org/10.3390/app12094701.

[35] Z. Popović, P. Ilić, S. Gotovac Atlagić, S. Rikić, and B. Radović, "Examination along with Precise Mapping of Radio Frequency Pollution over Environment of Elementary School in Banja Luka.," *Polish Journal of Environmental Studies*, vol. 30, no. 6, pp. 5203-5209, Aug. 2021, https://doi.org/10.15244/pjoes/135140.