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HYGIENIC CHARACTERISTIC OF THE ELECTROMAGNETIC SITUATION CREATED BY THE ELECTROMAGNETIC RADIATION OF THE ANTENNAS OF MOBILE BASE STATIONS IN CHERKASY REGION BEFORE AND AFTER THE INTRODUCTION OF 4G TECHNOLOGY

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Ключевые слова: *электромагнитное излучение, базовые станции мобильной связи, 4G, 5G*

Abstract. Hygienic characteristic of the electromagnetic situation created by the electromagnetic radiation of the antennas of mobile base stations in Cherkasy region before and after the introduction of 4G technology. Halak S.S., Dumansky V.Yu., Nikitina N.G., Bitkin S.V., Bezverkha A.P. *This work is part of our researches to study the distribution of electromagnetic radiation from mobile base stations in populated areas. The aim of this work was to study and analyze the electromagnetic situation before and after the introduction of fourth generation 4G technology at mobile base stations. We analyzed the maximum and average levels of electromagnetic radiation from mobile base stations located in Cherkasy region. The electromagnetic situation was studied both in urban areas and in rural areas. It was found that after the introduction of the fourth generation 4G technology at the mobile base stations, the levels of electromagnetic radiation in Cherkasy region increased significantly. The median of maximum levels of electromagnetic radiation increased by 155.6% (in particular, in urban areas by 194.1%), and the median of average levels - by 75.2% (in particular, in urban areas by 141.1%). No significant changes in electromagnetic radiation levels were detected before and after the modernization of mobile base stations in rural areas. It has been proven that there are no prerequisites for increasing the maximum permissible level to 100 μW/cm^2 when implementing 4G and 5G technologies at mobile base stations.*

Реферат. Гигиеническая характеристика электромагнитной обстановки, создаваемой электромагнитным излучением антенн базовых станций мобильной связи в Черкасской области, до и после внедрения технологии 4G. Галак С.С., Думанский В.Ю., Никитина Н.Г., Биткин С.В., Безверхая А.П. *Эта работа является частью наших исследований по изучению распределения электромагнитного излучения от базовых станций мобильной связи в населенных местах. Целью данной работы было изучение и анализ электромагнитной обстановки до и после внедрения на базовых станциях мобильной связи технологии четвертого поколения 4G. Нами были проанализированы максимальные и средние уровни электромагнитного излучения от базовых станций мобильной связи, расположенных в Черкасской области. Исследовалась электромагнитная обстановка как на территории городов, так и в сельской местности. Установлено, что после внедрения на базовых станциях мобильной связи технологии четвертого поколения 4G в Черкасской области значительно выросли уровни электромагнитного излучения. Медиана максимальных уровней электромагнитного излучения увеличилась на 155,6% (в частности, на территории городов на 194,1%), а средних – на 75,2% (в частности, на территории городов на 141,1%). Не было выявлено достоверных изменений уровней электромагнитного излучения до и после модернизации базовых станций мобильной связи в сельской местности. Доказано, что не существует предпосылок для увеличения предельно допустимого уровня до 100 мкВт/см^2 при внедрении на базовых станциях мобильной связи технологий 4G и 5G.*

Due to the fact that Ukraine plans to introduce 5G mobile technology and is actively implementing 4G technology, we conducted research on the levels of electromagnetic radiation (EMR) from the antennas of mobile base stations before and after the introduction of technology 4G.

Electromagnetic radiation from mobile devices, including 4G and 5G standards is a dangerous factor. The International Agency for Research on Cancer (IARC) classifies non-ionizing electromagnetic radiation from the antennas of mobile base stations to Group 2B as a "potentially human carcinogen" factor. Animal studies have shown that EMR affects the physiological, biochemical, cytological, embryological parameters of the body of experimental animals, and leads to the development of malignant tumors [6, 7, 8, 9].

In addition to the risk of cancer from electromagnetic radiation, several studies have shown other possible adverse effects on the health of people living near mobile base stations. Symptoms such as fatigue, sleep disturbances, headache, dizziness, cardiovascular symptoms, depression and difficulty concentrating and remembering have been reported [4, 5]. The study [10] found an increase in cancer incidence among the population living near mobile base stations, and found a correlation between cancer mortality rates and capacity of mobile base stations.

The aim of the work was to study and analyze the electromagnetic environment created by electromagnetic radiation of antennas of mobile base stations in Cherkasy region before and after the introduction of 4G technology.

MATERIALS AND METHODS OF RESEARCH

This study analyzed the results of calculations of the distribution of electromagnetic radiation from the antennas of mobile base stations located in the Cherkasy region before (2016-2017) and after (2019-2020) the introduction of 4G technology.

The results of the calculations were taken from the section "Environmental Impact Assessment" of projects for the construction and / or modernization of mobile base stations.

Calculations of electromagnetic radiation distribution were performed in accordance with the requirements of the State Sanitary Norms and Rules for Protection of the Population from Electromagnetic Radiation (Order of the Ministry of Health of Ukraine of August 1, 1996 № 239) [2] according to the methodology approved by the Ministry of Health of Ukraine [3].

We analyzed data from 106 projects for the construction and modernization of 53 base stations of mobile communications which are located in the Cherkasy region. The same base stations before and after the modernization were considered.

The results of calculations of EMR levels from base stations both in urban areas (31 base stations) and in rural areas (22 base stations) were analyzed. We considered urban-type settlements as rural areas.

The following indicators were studied (before and after modernization): the maximum level of EMR at a height of 2 m from the ground surface; average level of EMR (average value of maximum levels of EMR in the directions of maximum radiation of panel antennas of base stations) at a height of 2 m from the ground surface.

The following statistical methods were used in data analysis: finding the average; finding the median; Kolmogorov-Smirnov criterion; Shapiro-Wilk criterion; Wilcoxon T-test [1].

The lack of normal data distribution was found in the statistical analysis, so further analysis of the results and conclusions were made on the basis of Wilcoxon's T-test and the median EMR levels.

STATISTICA 10 (licensed No. STA999K347156-W) was used for statistical analysis and calculations.

RESULTS AND DISCUSSION

The results of the study were based on the analysis of projects for the construction and / or modernization of 53 mobile base stations before and after the introduction of 4G technology. The generalized results of this analysis are shown in Tables 1-3.

Statistical analysis of the results showed a significant increase in the median of both maximum and average levels of EMR from mobile base stations in Cherkasy region after their modernization.

Significant changes (increase in median) of maximum and average levels of EMR from base stations in the urban area of Cherkasy region were revealed. No significant changes in EMR levels before and after modernization were found in rural areas.

After the introduction of 4G technologies at the base stations of mobile communication in Cherkasy region, the median maximum levels of EMR increased by 155.6% (in particular, in urban areas by 194.1%), and average – by 75.2% (in particular, on the territory of cities – by 141.1%).

After analyzing the above results, we found that the increase in EMR levels around mobile base stations occurs mainly in cities.

Table 1

The results of the distribution of EMR levels from mobile base stations, located in Cherkasy region (53 base stations)

Value	Mean	Median	Min	Max
Maximum level before modernization	**0.6309**	**0.4269**	**0.0020**	**2.4187**
Maximum level after modernization	**1.3851**	**1.0910**	**0.0520**	**6.2280**
Average level before modernization	**0.5455**	**0.3500**	**0.0010**	**2.4187**
Average level after modernization	**0.9194**	**0.6131**	**0.0493**	**3.9410**

Notes: Mean – average value of EMR levels, μW/cm^2; Median – median EMR levels, μW/cm^2; Min – minimum value of EMR levels, μW/cm^2; Max – maximum value of EMR levels, μW/cm^2

Table 2

The results of the distribution of EMR levels from mobile base stations, located in the cities of Cherkasy region (31 base stations)

Value	Mean	Median	Min	Max
Maximum level before modernization	**0.8058**	**0.5975**	**0.1650**	**2.4187**
Maximum level after modernization	**1.9872**	**1.7570**	**0.1670**	**6.2280**
Intermediate level befor modernization	**0.7171**	**0.4913**	**0.1392**	**2.4187**
Average level after modernization	**1.3260**	**1.1847**	**0.1317**	**3.9410**

Notes: Mean – average value of EMR levels, μW/cm^2; Median – median EMR levels, μW/cm^2; Min – minimum value of EMR levels, μW/cm^2; Max – maximum value of EMR levels, μW/cm^2;

Table 3

The results of the distribution of EMR levels from mobile base stations, located in the countryside of Cherkasy region (22 base stations)

Value	Mean	Median	Min	Max
Maximum level before modernization	**0.3843**	**0.3072**	**0.0020**	**1.3038**
Maximum level after modernization	**0.5366**	**0.3320**	**0.0520**	**2.7400**
Average level before modernization	**0.3037**	**0.2690**	**0.0010**	**0.7732**
Average level after modernization	**0.3465**	**0.2112**	**0.0493**	**1.1873**

Notes: Mean – average value of EMR levels, μW/cm^2; Median – median EMR levels, μW/cm^2; Min – minimum value of EMR levels, μW/cm^2; Max – maximum value of EMR levels, μW/cm^2.

It should be noted that in Ukraine during our study, the maximum allowable level (MAL) of electromagnetic radiation from mobile base stations varied and was:

- until May 16, 2017 – 2.5 μW/cm^2 (Order of the Ministry of Health No. 239 of 01.08.1996. Registered with the Ministry of Justice of Ukraine on August 29, 1996, No. 488/1513);

- from May 16, 2017 to January 8, 2021 – 10 μW/cm^2 (Order of the Ministry of Health No. 266 of March 13, 2017. Registered with the Ministry of Justice of Ukraine on May 16, 2017 No. 625/30493);

- from January 8, 2021 – 100 μW/cm^2 (Order of the Ministry of Health No. 2760, 30.11.2020. Registered in the Ministry of Justice of Ukraine on January 08, 2021, No. 26/35648).

As can be seen from the results of the study, no case of exceeding the maximum allowable level was detected, which before modernization (2016-2017) was 2.5 μW/cm^2, and after modernization – 10 μW/cm^2. However, after the modernization of base stations, the maximum levels of EMR in 18.9% of cases (10 out of 53), and the average levels of EMR in 5.7% of cases (3 out of 53) exceeded the "old" maximum allowable level – 2.5 μW/cm^2.

It was found that the median value of the maximum levels of EMR before modernization was 0.4269 μW/cm^2 (17.08% of MAL – 2.5 μW/cm^2), and after modernization – 1.0910 μW/cm^2 (10.91% of MAL – 10 μW/cm^2).

These results show that there are no technical prerequisites for increasing the maximum permissible level to 100 μW/cm^2 when implementing 4G and 5G technologies at mobile base stations.

CONCLUSIONS

1. It is established that after the introduction of 4G technology at the base stations of mobile communication in the Cherkasy region, the median of the maximum levels of EMR increased by 155.6% (in particular, in the cities by 194.1%), and average – by 75.2% (in particular, in urban areas by 141.1%).
2. It is shown that the increase in EMR levels occurs mainly in the cities of Cherkasy region. No significant changes in EMR levels were observed before or after the modernization of mobile base stations in rural areas.
3. No cases of exceeding the maximum permissible levels of EMR were detected both before and after the modernization of base stations.
4. It was found that after the modernization of base stations, the maximum levels of EMR in 18.9% of cases, and the average levels of EMR in 5.7% of cases exceeded the "old" maximum allowable level – 2.5 μW/cm2.
5. It is proved that there are no prerequisites for increasing the maximum allowable level to 100 μW/cm^2 when implementing 4G and 5G technologies at mobile base stations.

Conflict of interest. The authors declare no conflict of interest.

REFERENCES

1. Antomonov MYu. [Mathematical processing and analysis of medical and biological data. 2nd ed.]. Kyiv: MYCz "Medynform". 2018. p. 579. Russian.
2. [Order of MH Ukraine from 01.08.1996 N 239. State sanitary norms and rules of protection of the population from influence of electromagnetic radiation]. Kyiv; 1996. Ukrainian. Available from: https://zakon.rada.gov.ua/laws/show/z0488-96#Text
3. [Order of MH Ukraine from 29.11.2013 N 1040. Method of calculating the distribution of electromagnetic field levels]. Kyiv; 2013. Ukrainian. Available from: https://zakon.rada.gov.ua/laws/show/z2130-13#Text
4. Singh K, Nagaraj A, Yousuf A, Ganta S, Pareek S, Vishnani P. Effect of electromagnetic radiations from mobile phone base stations on general health and salivary function. J Int Soc Prev Community Dent. 2016;6:54-9. doi: https://doi.org/10.4103/2231-0762.175413
5. Bogers R, van Gils A, Clahsen S, Vercruijsse W, van Kamp I, Baliatsas C et al. Individual variation in temporal relationships between exposure to radiofrequency electromagnetic fields and non-specific physical symptoms: A new approach in studying electrosensitivity'. Environment International. 2018;121:297-307. doi: https://doi.org/10.1016/j.envint.2018.08.064
6. National Toxicology Program: NTP technical report on the toxicology and carcinogenesis studies in B6C3F1/N mice exposed to whole-body radio frequency radiation at a frequency (1,900 MHz) and modulations (GSM and CDMA) used by cell phones. NTP TR 596. 2018 March 26-28. doi: https://doi.org/10.22427/NTP-TR-596
7. National Toxicology Program: NTP technical report on the toxicology and carcinogenesis studies in Hsd: Sprague Dawley sd rats exposed to whole-body radio frequency radiation at a frequency (900 MHz) and modulations (GSM and CDMA) used by cell phones. NTP TR 595. 2018 March 26-28. doi: https://doi.org/10.22427/NTP-TR-595
8. Falcioni L, Bua L, Tibaldi E, Lauriola M, De Angelis L, Gnudi F, Mandrioli D, Manservigi M, Manservisi F, Manzoli I, et al. Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission. Environ Res. 2018;165:496-503. doi: https://doi.org/10.1016/j.envres.2018.01.037
9. Wyde M, Cesta M, Blystone C, Bucher J, Elmore S, Foster P, Hooth M, Kissling G, Malarkey D, Sills R, et al. Report of partial findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley SD rats (Whole Body Exposures). 2018. doi: https://doi.org/10.1101/055699
10. Rodrigues NCP, Dode AC, de Noronha Andrade MK, O'Dwyer G, Monteiro DLM, Reis INC, et al.

The Effect of Continuous Low-Intensity Exposure to Electromagnetic Fields from Radio Base Stations to Cancer Mortality in Brazil. International Journal of Environmental Research and Public Health [Internet]. MDPI AG; 2021 Jan 29;18(3):1229.
doi: http://dx.doi.org/10.3390/ijerph18031229

СПИСОК ЛІТЕРАТУРИ

1. Антомонов М. Ю. Математическая обработка и анализ медико-биологических данных. 2-е изд. Киев: МИЦ "Мединформ", 2018. 579 с.

2. Державні санітарні норми і правила захисту населення від впливу електромагнітних випромінювань: наказ МОЗ України від 01.09.1996 р. № 239. URL: https://zakon.rada.gov.ua/laws/show/z0488-96#Text

3. Методика розрахунку розподілу рівнів електромагнітного поля: наказ Міністерства охорони здоров'я України від 29.11.2013 № 1040. URL: https://zakon.rada.gov.ua/laws/show/z2130-13#Text

4. Effect of electromagnetic radiations from mobile phone base stations on general health and salivary function / K. Singh et al. *J Int Soc Prev Community Dent* 2016. Vol. 6, No. 3. P. 54-59.
DOI: https://doi.org/10.4103/2231-0762.175413

5. Individual variation in temporal relationships between exposure to radiofrequency electromagnetic fields and non-specific physical symptoms: A new approach in studying 'electrosensitivity' / R. P. Bogers et al. *Environment International.* 2018. Vol. 121, Part 1. P. 297-307.
DOI: https://doi.org/10.1016/j.envint.2018.08.064

6. National Toxicology Program: NTP technical report on the toxicology and carcinogenesis studies in B6C3F1/N mice exposed to whole-body radio frequency radiation at a frequency (1,900 MHz) and modulations (GSM and CDMA) used by cell phones. *NTP TR 596*. 2018. 26-28 March.
DOI: https://doi.org/10.22427/NTP-TR-596

7. National Toxicology Program: NTP technical report on the toxicology and carcinogenesis studies in Hsd: Sprague Dawley sd rats exposed to whole-body radio frequency radiation at a frequency (900 MHz) and modulations (GSM and CDMA) used by cell phones. *NTP TR 595.* 2018. 26-28 March.
DOI: https://doi.org/10.22427/NTP-TR-595

8. Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission / L. Falcioni et al. *Environ Res*. 2018. Vol. 165. P. 496-503.
DOI: https://doi.org/10.1016/j.envres.2018.01.037

9. Report of partial findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley SD rats (Whole Body Exposures) / M. Wyde et al. (Preprint/bioRxiv 055699). 2018.
DOI: https://doi.org/10.1101/055699

10. The Effect of Continuous Low-Intensity Exposure to Electromagnetic Fields from Radio Base Stations to Cancer Mortality in Brazil / N. C. P. Rodrigues et al. *Int. J. Environ. Res. Public Health*. 2021. Vol. 18, No. 3. P. 1229.
DOI: https://doi.org/10.3390/ijerph18031229

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