

Impact of Types of Electromagnetic Radiation on Living Nature

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Abstract. In our daily life we are exposed to electromagnetic radiation in a very wide range. In our century, these radiations are constantly increasing, and we do not always know how to protect ourselves from them and how they affect people and the rest of living nature. An attempt has been made to analyze the impact of emissions from a different frequency spectrum - from power supply with a frequency of 50 Hertz to high-frequency mobile communications with a frequency of up to 300 GHz. Studies in countries of Europe and the world were taken as a basis, and a study was made about the impact of these electromagnetic radiations in Central Northern Bulgaria and the Veliko Tarnovo region. It is shown how morbidity changes when they affect the peripheral and central nervous systems of people and what effect they can cause at high powers and high intensity at short distances.

Keywords: *broadcasting; electromagnetic radiation; light; mobile cells; power grid; radio frequencies; ultraviolet light; Wi-fi.*

INTRODUCTION

In the development of physics over the last 100-150 years, when describing many physical phenomena and laws, in parallel with the concept of matter, the concept of field is also used, including electromagnetic, gravitational, nuclear force fields, etc [1, 2, 3]. Or to put it in scientific language it is assumed that two forms of existence are possible - matter and field, which are characteristic of our surroundings.

The fundamental concepts of the electromagnetic field were developed by independent study of the various forms of electric and magnetic phenomena, and first its independent laws were formulated, and one later united the researches and the achieved results and spoke already about

its integrity and indivisibility. These phenomena include the creation of electric fields by charges (Gauss's law), dependent magnetic fields (Faraday's induction), as well as the creation of a magnetic field by electric current (Ampère's law). This is how the theory of electromagnetic fields, their propagation and impact on the substances found in them was created [4, 5, 6].

Electromagnetic interaction, although studied and described as far back as the Middle Ages, is one of the four main types of fundamental interactions in nature. Electromagnetic fields are a combination of the invisible electric and magnetic fields of varying strength that operate around us. They are generated both by the resulting natural phenomena and by human activities in various manifestations, but mainly by the use of electricity. The most heterogeneous sources of electromagnetic field are known.

Most man-made electromagnetic fields are within a large perimeter of the generated frequency. Starting with high radio frequencies - such as those used by mobile phones, radio broadcasting, telecommunications, moving through medium frequencies - such as those generated mainly by monitors and television receivers to extremely low frequencies - such as those generated by electrical wires and power grids [7, 8].

II. MATERIALS AND METHODS

In the technique, we use electromagnetic radiations of the most diverse frequency. Each type of radiation has certain characteristics of physical characteristics and biological action, both on man and on the living and non-living nature that surrounds us. Living tissue placed under the influence of an electromagnetic field changes as the

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frequency increases, increasingly loses its dielectric properties and approaches the conductors. This change is uneven and depends on the type of tissue, the characteristics of the emitted electromagnetic waves, the surrounding environment and many other factors, some of which have been studied in detail, but for others such studies have yet to be conducted. Research in this area is extremely varied and too often with conflicting results. Here, what results we aim to prove as a result of the research - whether a positive impact or a negative impact - have a huge influence. Here the results are relatively comparable, and the reading of the results is varied [9, 10].

Exposure to electromagnetic fields causes immediate biological effects and sometimes even irreversible tissue processes if the fields are strong enough. The effects range from stimulating nerves and muscles to heating and even burning the body's tissues, depending on the frequency. To protect against these influences, standards for exposure to electromagnetic fields have been created, which are detailed in various regulatory documents in individual countries around the world. In many cases, these norms have very different values in different countries of the world. It should be noted that the biological characteristics of the specific study, the geographical location, the mental state and a number of other factors also have a great influence.

III. RESULTS AND DISCUSSION

Purpose of the study

The purpose of the present study is to show whether there is a dependence of diseases of the peripheral and central nervous system on the impact of electromagnetic radiation and on their parameters - intensity, power and distance. The research was carried out in Central Northern Bulgaria and in particular in the Veliko Tarnovo region in the second half of 2022 by measuring the electromagnetic fields in the vicinity of the power transmission network for household and industrial power supply with different voltages and transmission cells of mobile operators with different locations in populated areas and different transmitted signal power.

In the last 50-60 years, with the rapid development of electricity, radio and television broadcasts, radar, mobile connections, etc. the intensity of the Earth's electromagnetic fields increases significantly. The mobile, radio and television transmitters that surround us create a "radiophone" whose intensity is more than 10 times greater than the intensity of natural electromagnetic fields. In densely populated areas, areas near radio broadcasting stations and antenna complexes and power transmission networks, the intensity of the electromagnetic field is tens of times higher than the maximum permissible norms in the relevant regulatory documents. In large settlements, where there are many transmitters of mobile operators in their vicinity, the intensity of electromagnetic fields is significantly greater and can reach up to 10-15 times above the permissible norms. With the construction of 4G and 5G networks, discussions have begun for and against their construction, due to insufficient information about the

broadcast signals and the power of electromagnetic radiation that affects people and living nature that are in close proximity to them. Close to power lines, transformers, etc. an electromagnetic field with a frequency of 50 Hz occurs. They decrease quite quickly with distance, but near the sources they can be quite intense, and their impact on people living near power grids has not yet been fully investigated.

Electromagnetic radiation from power transmission networks is characterized by a constant frequency of 50 Hz, as it is in most countries of the world, and with varying intensity depending on the voltage flowing on this network, the distance from the conductor, weather conditions and other indicators. A study conducted on the territory of several large European cities (Paris, Prague and Moscow) proved an increased state of headaches in people who live in the immediate vicinity of the power transmission network with medium and high voltage according to generally accepted standards. At the same time, as the tension increases, so does the percentage of people experiencing headaches and nervousness among those living in the immediate vicinity. Morbidity drops sharply as the place of residence moves away from the power grid. And this has been done so far only by studying the dependence of headaches on proximity to electromagnetic field sources. It has been proven by a number of researchers that with a prolonged stay in a room near such a source less than 200 m, the incidence of headaches increases by 21%, at a distance of 100 meters, the incidence increases to 68%. At a distance of less than 50 m, the cases are already 94-97% in various studies, and there is no dependence on the location of the city, but there is a dependence on the age of the people - as the age decreases, the cases of headaches and other nervous disturbances increase [2, 5, 11, 12].

In the study, the intensity and power of the electromagnetic field were measured in homes that are located near the power transmission network with low (220-380 V), medium (40 kV) and high (220-440 kV) voltage. Numerous transmission lines with different voltage values run through the territory of Veliko Tarnovo region, with Gorna Oryahovitsa being the distribution center for the power transmission network in Northern Bulgaria. The measurements were made in residential and industrial buildings in Veliko Tarnovo, Gorna Oryahovitsa, Pavlikeni and Svishtov, which are respectively 50, 100, 150 and more meters away from the power grid.

The results of the impact on people living or working near these networks were studied by conducting a survey with them and based on their judgments. No medical examinations were conducted because a large part of the respondents did not seek specialized medical care and were not registered in the outpatient lists. For information, the medical documentation of the workers in the enterprises serving the power transmission networks and mobile operators was taken, because they undergo periodic medical examinations for their health, including the impact of electromagnetic radiation. Such are 48% of the respondents in this study.

The survey was attended by employees working in Energo-pro networks in Gorna Oryahovitsa, Veliko Tarnovo, Pavlikeni and Svishtov, whose workplaces are located in close proximity to the power transmission networks, BDZ Gorna Oryahovitsa, Sviloza, Zarya and other enterprises that have their own substations with an average voltage and living in houses and cooperatives that are located near the power lines. A total of 216 respondents participated, of which 110 work in these conditions and 116 live near the low and medium voltage transmission networks.

The results of the study are shown in Tables 1 and 2.

Table 1. Dependence of headache in people on the distance from the power grid and age at medium voltages

Distance/ age	50 m	100 m	150 m	200 m
Up to 18 years	65%	41%	18%	5%
18-60 years	95%	68%	46%	21%
Over 60 years	98%	75%	60%	44%

Table 2. Dependence of headache in people on the distance from the power grid and age at low voltages

Distance/ age	50 m	100 m	150 m	200 m
Up to 18 years	55%	36%	14%	2%
18-60 years	88%	62%	40%	12%
Over 60 years	92%	70%	55%	38%

From the tables, it can be seen that the voltage with a larger value and the electromagnetic field induced by it affects more strongly and causes a greater headache than the low voltage power grid. The tendency to reduce headaches with distance from the source of electromagnetic radiation is also clearly outlined - At low voltages at a distance greater than 200 meters, the headache among the respondents decreases from 2.5 to 27 times in the different age groups. With medium voltage, the situation is similar, as here the figures are from 2.25 to 13 times. With high voltage on the transmission lines, the number of respondents was less than 50 people, and therefore the results obtained are not presented, because there is not a sufficient number of participants and the results do not have the necessary credibility.

In modern society, everyone is exposed to electromagnetic fields from a number of sources, including electrical equipment, broadcast radio and television broadcasts, and communication devices. However, the most common sources in recent decades have been cell phones, cordless phones, local wireless networks, and radio transmission towers. Medical scanners, radar systems, and microwave ovens also use radio frequency fields. Radio frequencies range from 100 kHz to 300 GHz. All of them are superimposed in the space and have an impact on the living organisms located in them.

In telecommunications, 5G (5th generation) is the fifth-generation technology standard for cellular broadband networks that cellular phone companies began deploying globally in 2019 and is the planned successor to 4G (4th generation) networks that provide connectivity to most modern mobile phones. 5G networks are projected to have more than 1.7 billion subscribers and account for 25% of the global mobile technology market by 2025, according to the GSM Association and Statista [2, 13, 14].

Electronic transitions occur in atoms and molecules due to the absorption or emission of electromagnetic radiation (usually UV or visible). The energy change associated with the transition is related to the frequency of the electromagnetic wave by Planck's equation.

In 5G, frequencies range from 3 to 30GHz.

The number of 5G global connections is expected to reach one billion in 2022 – a figure expected to double to two billion by 2025 – by which time 5G connections will make up a quarter of all mobile device connections.

Every day, the human body is exposed to the effects of radio frequency fields around us, and it accumulates energy over time. How much RF energy a person accumulates on a daily basis is unknown, as exposure depends on many factors, especially the distance and power of the sources.

At a frequency of 100 kHz, a break occurs, which leads to a change in the character of the change, after which the monotonicity is preserved up to a frequency of 1 - 10 GHz. Most of the energy absorbed in electromagnetic radiation is converted into heat. The conversion of electromagnetic energy into thermal energy is due to dielectric losses [3, 9, 15].

In the last 5 years, with the introduction of 5G technologies, there has been more talk about the impact of mobile networks on wildlife. A1 is the largest mobile operator in Bulgaria and naturally the interest in its network is the greatest, due to the presence of the most repeater cells. Measurements were carried out on the A1 network in Bulgaria using a NetMonitor mobile application. It has the ability to display advanced 2G / 3G / 4G / 5G (NSA and SA) cellular network information and monitor cellular network status by collecting cell tower data. Also detects aggregate media. The information is presented and reviewed in different sections:

The Cell tab is the home screen showing the mobile operator, mobile network type and generation, network status, frequency range and duplex mode. The section also has information about the serving cell: TAC (Location Area Code/Tracking Area Code), CI (Cell Identification), PCI (Physical Cell ID), EARFCN(E-UTRA Absolute Radio Frequency Channel Number), RSSI(Received Signal Strength Indicator), RSRQ(Reference Signal Received Quality), RSSNR(Reference Signal Signal to Noise Ratio), address as assigned during the programming of the serving cell, TA(Timing Advance), which indicates the approximate distance to the cell. Some of the same information is also shown for neighboring (not currently serving) cells that are expected to be used at a later time.

The Log tab displays a unique identifier, frequency, and set address for recorded cells that have been used at a previous time. A database with the same cell information downloaded from the Internet can be displayed in the tab.

In the Map section, a map is shown with the exact locations, set address and distance to the previously used cells.

According to the generation and technology of the network for which the antennas and cells are used, they differ from each other. They can be broadly divided into GSM(2G), WCDMA(3G-UMTS), LTE(4G), NSA(5G) [6]. Separately, each generation is characterized by a particular frequency, frequency slot, access system and a different network core.

The effective surface area of the human body is a function of the field frequency and may differ substantially from the body projection area on planes perpendicular to the incident wave. Substantial differences in the electrical properties of the skin, subcutaneous fat, muscle and other tissues determine the complex picture of distributed, radiated energy to the body. Accurate calculation of the distributed heat energy released in the body during irradiation is practically impossible. The obtained results should be accepted with a certain approximation.

The research was done during the period from 14.10.2022 to 25.10.2022 when connected to different cells belonging to A1 Bulgaria in the 5G NSA network in the Veliko Tarnovo region. Each cell corresponds to the coverage of a geographical area in which it has access to the radio signals emitted by a transmitter in a certain channel and a certain network generation. Cells were selected in different areas of the district, with different parameters and coverage. 224 participants took part in the study, 48 of whom work in mobile cell service and maintenance companies and 176 live near mobile cells. The survey results are shown in Tables 3 and 4.

Table 3. Dependence of headache in humans on the distance from the mobile cell and age at medium and high emitter powers

Distance/ age	50 m	100 m	150 m	200 m
Up to 18 years	50%	38%	15%	4%
18-60 years	90%	63%	44%	25%
Over 60 years	96%	78%	62%	48%

Table 4. Dependence of headache in humans on the distance from the mobile cell and age at low emitter powers

Distance/ age	50 m	100 m	150 m	200 m
Up to 18 years	35%	26%	10%	2%
18-60 years	72%	52%	30%	8%
Over 60 years	87%	67%	50%	28%

In the survey conducted, the results obtained are similar to the results obtained from low-frequency irradiation, but the values are lower. The trends of increasing the impact with increasing emitter power and the age of the subjects,

as well as decreasing the negative impact with increasing the distance between the source and the studied object, are preserved. The study did not distinguish the influence of other factors on headaches or other diseases of the peripheral and central nervous system from electromagnetic radiation. But there is a tendency to increase diseases as a result of the impact of electromagnetic fields on the human body. It is necessary, if financial means are available, to continue the research with medical means to prove the obtained results. These are studies that have been done in some countries, but the medical indicators and evidence are not yet sufficient to fully describe the impact.

The changes caused by the irradiation can be reversible, and in the case of high intensity or systemic irradiation with a small but above the limit intensity - irreversible. They lead to changes in the structure and appearance of the tissues and organs in the human body, burning, killing, hemorrhages, changes in the structure of the cell, disruption of the nutrition of the tissues, organs or the organism as a whole. Changes are observed in the tissues of the peripheral and central nervous system — their functions are disturbed, nerve nodes are destroyed, the structure of nerve cells changes. This is observed at different frequencies.

People working under excessive electromagnetic radiation usually get tired quickly, complain of headache, general weakness, pain in the heart area. With them, sweating increases, irritability increases, sleep is restless. Individuals experience spasms, memory loss, voice loss, nail brittleness, etc.

A quantitative assessment of the danger of electromagnetic impact is made both from the intensity of the field and the density of the power flow, as well as from the duration of the irradiation. The maximum permissible norms are dependent on the frequency range and differ for electric and magnetic fields. In different countries, these requirements and standards are sufficiently different, and in some cases there is a difference of tens of times. In technologically developed countries, these standards are significantly lower than in underdeveloped countries, and this is also a reason for the export of productions and complexes that have higher emissions.

Research results show that electromagnetic fields have high biological activity in all frequency ranges. At relatively high levels of the electromagnetic field, modern theory attributes the impact to the thermal mechanism. At a low level of electromagnetic field (for example, at radio frequencies above 300 megahertz, which is less than 1 mW/cm²), it is accepted to consider that it has a non-thermal effect on the body or an informational character. The modes of action of electromagnetic fields in the second example are still little studied.

IV. CONCLUSIONS

The following conclusions can be drawn from the summaries of conducted research on the impact of electromagnetic radiation on humans and living nature:

1. The presence of sources of low-frequency electromagnetic radiation affects the human body, and the closer the location is to the source, the more the diseases of the nervous system and headaches increase. As age decreases, the body's sensitivity increases.

2. In the case of high-frequency electromagnetic radiation, the impact on humans also increases as the intensity and power of the electromagnetic field increases. High-frequency radiation has an impact on living nature, and this also leads to the blocking of certain functions in humans, birds and animals. There is still not enough research on the impact of the latest generations of mobile networks, due to the short time of their implementation and a lack of sufficiently proven research results.

3. The conducted research has no analogue in the region of Central Northern Bulgaria, where it was conducted and should be continued with medical research on the electromagnetic impact not only on humans, but also on other living animal and plant organisms.

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