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STUDY OF THE EFFECTS OF ELECTROMAGNETIC FIELDS ON THE HUMAN BODY DURING MOBILE PHONE USE

Abstract. *This labour consider the impact of mobile phones, which are part of wireless communication systems, on the human body, as well as the effects of electromagnetic radiation during mobile communication. The labour presents statistical data on mobile phone usage and the types of diseases associated with this usage. A model of the human body was created, and the effects of electromagnetic radiation processes in mobile communication were demonstrated on that model. Additionally, calculations were performed according to international standards for the calculation of electromagnetic radiation.*

Consequence of the research, the dielectric permittivities of brain tissues in the human head at frequencies of 900 and 1800 MHz were compared using SAM mannequins. Additionally, 3D models of the objects under study were created using the CST STUDIO SUITE software, and the impact of electromagnetic radiation on the human head was analyzed based on these models.

The relevance of this article is due to the increasing number of electromagnetic field (EMF) sources, which raises the risk of their impact on humans. Household electrical networks, domestic appliances, video display terminals, power transmission lines, communication and information television and radio devices, radar and navigation stations are just a part of a list of sources emitting EMF at various frequencies, modulations, and intensities. The majority of the population is actually exposed to very high levels of EMF, which are millions of times stronger than the natural magnetic field. Electromagnetic radiation significantly influences the development of pathological reactions in the body. This, in turn, directly leads to a decline in human health. Therefore, understanding the extent of mobile phone effects on the human body and educating the public about its harmful aspects is a key objective.

Keywords: *electromagnetic radiation, mobile phone, dielectric conductivity, electromagnetic field, frequencies, modulations, radar.*

Introduction.

In recent decades, anthropogenic electromagnetic pollution (EMF) has become a priority issue for public health and the environment. In 1996, the World Health Organization (WHO) initiated the International EMF Project, aiming to systematize data on the impact of electromagnetic fields on human health and develop uniform standards [1]. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has established exposure limits based on thermal effects [2], but the scientific literature actively discusses the possibility of non-thermal effects not accounted for by existing standards [4].

Systematic reviews and meta-analyses show conflicting results. Thus, a number of studies have documented a link between chronic EMF exposure and oxidative stress, cognitive impairment, and cancer risk [5,6], while other studies find no convincing evidence of the harmful effects of low-level radiation [1]. These discrepancies are explained by differences in methodologies, a limited number of long-term cohort observations, and variability in source characteristics (frequency, modulation, intensity) [3].

The impact of new communication technologies (5G, IoT, Wi-Fi 6) remains particularly relevant, as data are still limited [7.8]. The effects of long-term exposure to low doses of EMF, as well as the impact on vulnerable groups of the population (children, the elderly, patients with chronic diseases), have also been insufficiently studied. In the face of persistent uncertainty, the use of intelligent analysis and forecasting systems that utilize machine learning and big data methods to model the dynamics of electromagnetic loads in urban environments is particularly important [9,10]. This approach not only identifies statistical relationships but also predicts when safe levels are exceeded, making it promising for integration into environmental monitoring and healthcare systems.

Materials and Research Methods.

As of now, mobile or cellular phones are an integral part of modern telecommunications. In many countries, more than half of the population uses mobile phones, and their sales are growing at a rapid pace. It is estimated that in 2024, 6.9 billion users were registered worldwide. In some parts of the world, mobile phones are the most reliable or the only existing means of communication.

Since cellular communication has become widespread only in the last decades, the problem of considering the mechanisms of action of high-energy electromagnetic fields (EMF) belonging to the microwave range has become especially acute.

Before discussing the effect of electromagnetic radiation from mobile phones on the human body, it is necessary to understand how signal formation occurs. Communication on mobile phones is carried out using radio waves transmitted through a network of fixed antennas called base stations. Radio waves are electromagnetic fields. The frequency at which the operation of a mobile phone is carried out ranges from 450 to 2700 MHz, while the power limit is in the range from 0.1 to 2 watts. It should be noted that power transmission with a mobile phone is carried out only if the device is connected to the base station. The connection of the mobile phone with the base station, and therefore the increase in the power values of the device, occurs at the moment of setting up a call, sending an SMS, or during the period of active data exchange with the Internet.

The assessment of electromagnetic radiation from mobile phones was carried out in three categories: silence, call, and conversation. Electromagnetic radiation from a mobile phone at rest is not significant and averages 0.65 $\mu W/cm^2$. Such radiation does not affect the physiological and biochemical indicators of the human body. At the time of the call, electromagnetic activity from mobile phones increased 38 times compared to the level at rest. Electromagnetic radiation during conversation increased by 1.4 times compared to the call and by 41.8 times compared to silence. Thus, the mobile phone has the greatest electromagnetic activity during a conversation and therefore has the greatest impact on the organs located directly in the immediate vicinity of the phone attached to the ear.

1. Therefore, it is very important to understand, study, and monitor the potential effects of electromagnetic radiation on people's health from mobile phones [11].

Algorithm for SAR Modeling.

To study the interaction of EMF with biological tissue, it is necessary to determine the Specific Absorption Rate (SAR), which reflects the power absorbed per unit mass of tissue (W/kg). The calculation of SAR can be carried out both experimentally and by numerical simulation. The modeling algorithm is as follows:

1. Geometry setup: create a three-dimensional model of the human head and torso with realistic anatomical layers (skin, bone, brain tissue). Place the mobile phone model at characteristic positions (ear, cheek, hand).
2. Material properties: assign dielectric properties (permittivity ε and conductivity σ) to tissues for the frequency ranges 450–2700 MHz.
3. Source definition: specify the transmitting antenna of the mobile phone with realistic power levels (0.1–2 W) and modulation schemes.
4. Meshing and boundary conditions: discretize the geometry into cells (FDTD method) or finite elements (FEM), with finer resolution in regions near the antenna and skin surface.
5. Electromagnetic field calculation: solve Maxwell's equations to obtain electric field intensity EEE in tissues.
6. SAR evaluation:

$$SAR(\mathbf{r}) = \frac{\sigma(\mathbf{r}) \cdot |E(\mathbf{r})|^2}{\rho(\mathbf{r})} \tag{1}$$

1. Calculate local and averaged SAR values (1 g and 10 g of tissue).
2. Duty cycle adjustment: apply realistic transmission patterns (silence, call, conversation) to obtain time-averaged SAR.
3. Thermal response estimation: if necessary, couple SAR results to bio-heat equations to assess temperature rise.
4. Validation: compare modeling with phantom experiments using standard SAR measurement systems.

This algorithm allows reproducing realistic conditions of mobile phone use and determining exposure levels in different scenarios.

Justification of SAR Reduction or Increase

Reduction of SAR is advantageous because it lowers thermal load in tissues, ensures compliance with regulatory limits (1.6 W/kg in the USA for 1 g tissue, 2.0 W/kg in the EU for 10 g tissue), and decreases risks for sensitive populations (children, pregnant women). Lower SAR also contributes to energy efficiency of the device.

Increase of SAR may occur in special situations, such as weak signal conditions or emergency communication. In these cases, a temporary increase in transmission power ensures connection stability and reliability. Although local SAR rises, the overall communication session may be shorter, reducing cumulative exposure.
Thus, optimization should consider both maximum instantaneous SAR and integrated exposure (dose) over time.

Practical Conclusions

Based on the analysis of materials, methods, and modeling results, the following conclusions can be formulated:

1. Maximum exposure occurs in the conversation mode, especially when the mobile phone is held directly against the ear in areas of weak network coverage.
2. Distance matters: even a small gap (5–15 mm) between the phone and the skin reduces SAR significantly due to the decay of near fields.
3. Exposure time: limiting call duration and using alternative communication methods (messaging, hands-free, headsets) reduces cumulative SAR.
4. User awareness: most users are unaware of EMF risks; therefore, it is necessary to inform them of safe usage practices, especially children and adolescents.
5. Technical measures: manufacturers should provide the possibility of limiting maximum transmission power and indicate SAR levels in different operating modes.
6. Public health: for risk-sensitive groups, such as pregnant women and children, conservative approaches (reduced call time, use of speakerphone) are recommended.

Results and their discussion.

Most of the latest research has been carried out using flat, cylindrical and spherical models of the human body(fig.1). This happened because the models were simple for mathematical calculations. Among these few models that differ in their geometric shape, modeling with a sphere is the most common. This is due to the wide field of application, which includes electrical exploration, Meteorology and Oceanology, radar, astronomy, biochemistry and biomedical research. Especially in biological research, it is very difficult to study the absorption of electromagnetic radiation using flat models, since these models cannot take into account the rather complex shape of a real biological object, especially the curvature of the body.

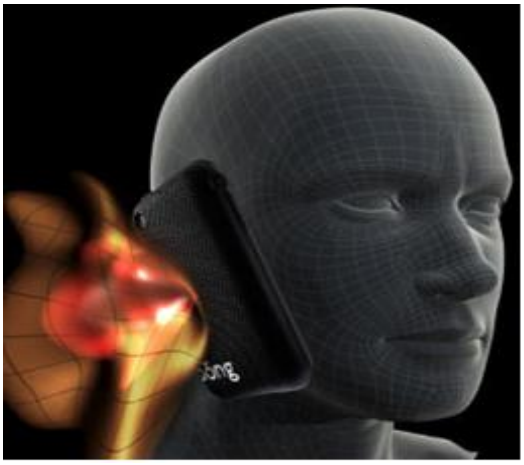


Figure 1 – Computer model of the human head

There are also other mannequins for human modeling, the most commonly used mannequin is the SAM mannequin. SAM is a new model based on the results of measuring the head of an adult male, created during an anthropomorphic study of American army personnel. The same applies to two types of fabric. As shown in Figure 2 a homogeneous liquid with a thickness of 2 mm representing the skin and representing the brain tissue. Today, the standard mannequin is a twin general mannequin, the total mannequin of twins is based on an anthropomorphic study of 52 Europeans. The shape around the ears corresponds to 90 percent of the data. It has two tissues: one fabric is leather, and the other is an internal, homogeneous liquid.

Figure 2 – Twin people mannequins

These two models are a homogeneous model. This means that the brain tissue is simulated by a homogeneous dielectric with a constant value of dielectric conductivity and conductivity. However, heterogeneous models of mannequins with many layers corresponding to each brain tissue with different electrical parameters are also possible. Of course, the model is easy to model homogeneously. Electrical parameters differ in two homogeneous models and in different forms due to different standards. Electrical parameters also change with frequency. The dielectric conductivity (sr = 4.5) is the same for all frequencies. The parameters of brain tissue change as shown in Table 1. The dielectric conductivity is higher for the SAM model than for the twin kin model; this SAR threshold is, in general, 10% higher in the SAM model than in the twin kin model. However, the differences are due to the different forms of the two specimens.

The SAR absorption rate for the Sam multiplier is more than 10 grams - 1.5 W / kg. For twins in general, the two simulations were made with a large difference, resulting in: the SAR value is 1.3 W / kg and 1.0 w / kg, respectively(Table 2).

Table 1 – The relative dielectric constant of the brain tissue used in these two mannequins

Sample	Frequency	Dielectric constant	Conductivity
The closest twin	900 MHz	42,5	0,85
	1800 MHz	41,5	0,97
SAM	900 MHz	40,5	1,69
	1800 MHz	40,0	1,40

Table 2 – Specification indicators for geometric parameters

	Model 1	Model 2
A	190	190
B	260	240
C	229	230
D	190	210

Figure 3 shows another model of the mannequin, where the mouth is located at the midpoint between the nose and chin. For a uniform mannequin, the skin thickness should be less than 3 mm, and in the ear area, it should be 6 mm. Typical values for the geometric parameters are shown in Table 3. Since the uniform mannequin is frequently used, the dielectric properties of the frequency ranges for tissues simulating the brain are shown in Table 3.

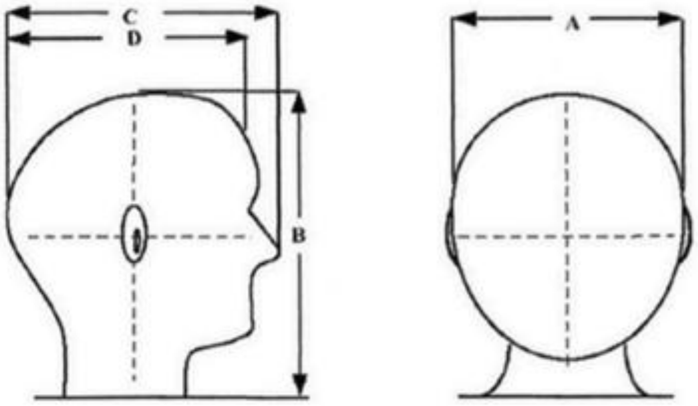


Figure 3 – Indicative geometric parameters taken for the mannequin head.

Table 3 – Dielectric properties of synthetic imitation of brain tissue.

Frequency band, MHz	Relative dielectric conductivity	Permeability σ (S/m)

800	46,3 (±5)	0,73 (±10)
900	45,8 (±5)	0,77 (±10)
1600	43,9 (±5)	1,06 (±10)
1800	43,5 (±5)	1,15 (±10)
2000	43,2 (±5)	1,26 (±10)
2500	42,5 (±5)	1,54 (±10)

Various countries have adopted standards to limit the effect of mobile phones on the human body. These standards ensure a specific absorption rate (SAR) for the user's head during mobile phone use, in terms of power absorption per unit mass.

The software product allows the creation of accurate and realistic models of the head and mobile phone, using appropriate numerical methods to evaluate SAR distribution in the human head. According to the given task, the CST STUDIO SUITE software allowed the 3D modeling of the objects under study and the visualization of SAR distribution in the human head. CST STUDIO SUITE is a 3D electromagnetic modeling software that enables the use of various methods for calculating electromagnetic fields

The human body is a dielectric material with significant losses, which complicates solving electrodynamic problems. However, reducing the absorbed power of the human body during mobile phone operation and determining calculation methods is one of the priority tasks.

This method involves using a special mode for calculating the electromagnetic field module along a line cutting through a curved model. In this case, it is possible to compute the dependency of the electromagnetic field module on the distance from the main antenna.

Furthermore, it is used for generating and distributing electrical energy. The relative absorption (SAR - Specific Absorption Rate) and relative absorption (SA) rate characteristics in biological systems or tissue models are accepted as test parameters in radiofrequency. SAR [W/kg] is defined as the time derivative of the energy absorbed (or scattered) in a unit mass, proportional to the density of the material in the given volume. SA [J/kg] is the total amount of energy received and absorbed, and its integral over time provides the final SAR. Information on SA and SAR is used as criteria for comparing and extrapolating experimental results for various tissues of animals and humans. This is also useful for analyzing the dependence of biological phenomena in different models and objects.

The determination of SA and SAR is better for EMF because of the following characteristics:

- it relates the field to the biological object's respons;
- it facilitates understanding biological phenomena;
- it is independent of interaction mechanisms.

Based on the calculation of the excited electric field E [V/m], SAR [W/kg] is determined using the following relationship:

$$SAR = \frac{\sigma |E|^2}{\rho} \tag{2}$$

where: σ – conductivity of the material in this volume, S/m; E – field strength, V/m; ρ – density of the material, kg/m^3. SAR absorption intensity and current density J are determined by the distribution of the electric field strength, mass density ρ (kg/m^3), and electrical conductivity σ (S/m).

$$J = \sigma \times E \tag{3}$$

$$SAR = \frac{\sigma|E|^2}{\rho} \tag{4}$$

SAR and current density are important field numerical parameters, especially for the quantitative assessment of safety limits and radiation dose. Many national and international standards and guiding documents in the field of electromagnetic field exposure to humans require agreement on primary limits. In the high-frequency range, the primary limits are given in terms of SAR, while in the low-frequency range, the primary limits are given in terms of current density.

Thus, the temperature rise in the tissue and the entire transient energy absorption process is proportional to the SAR value. It is important to distinguish between SAR and its derivative with respect to temperature. SAR is the power absorption rate. It is independent of the heat generation mechanism, which may be caused by motion, friction, or other physical phenomena. It only relates to the use of electrical conductivity and power scattering in a homogeneous biological medium.

To calculate the absorbed power in the user's head, a biological object model consisting of three layers is used: skin, bone, and brain. The structure of the head model is excited using a simplified model of the mobile phone as a radiation source (Figure 4).

After the transient process is completed, the software product allows the visualization of the electric field distribution in the computation space, as well as the power loss density (Figure 5).

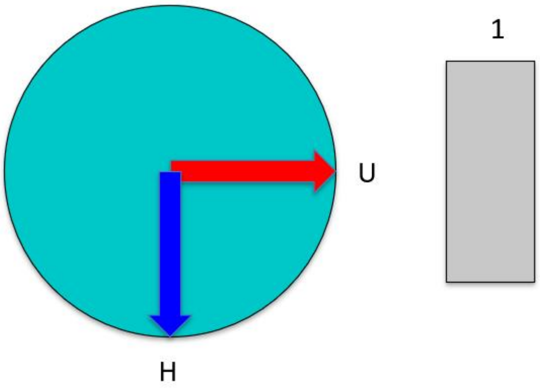
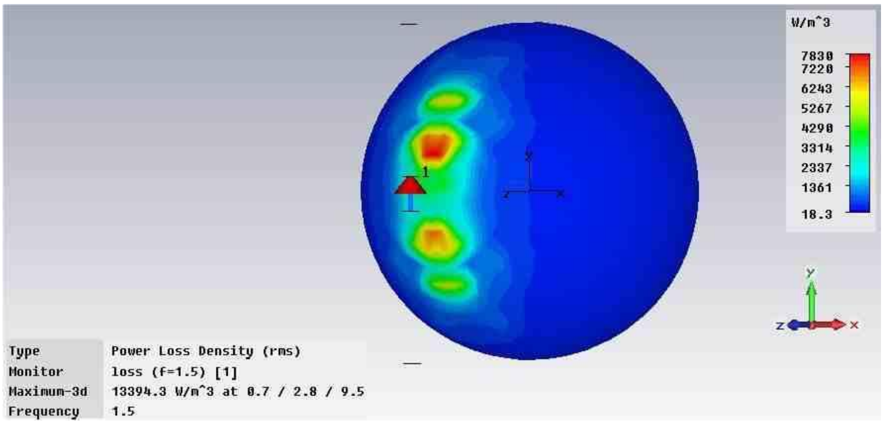


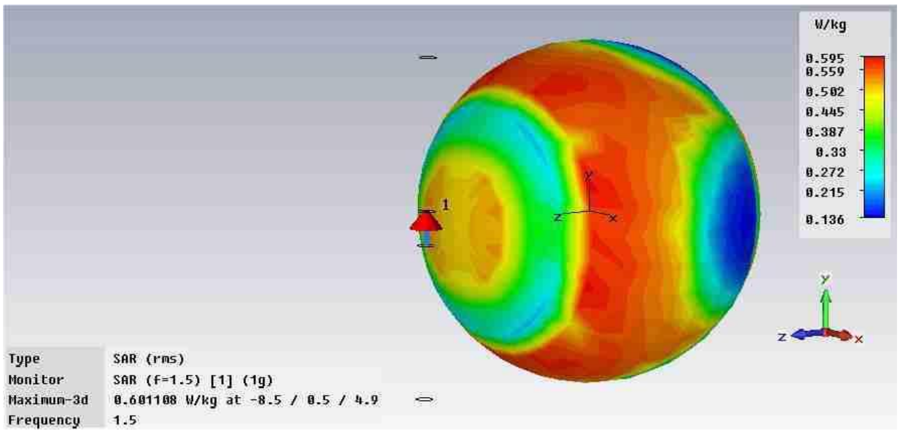
Figure 4 – Mobile phone and mobile phone head model.



Type Power Loss Density (rms)
Monitor loss (f=1.5) [1]
Maximum-3d 13394.3 W/m^3 at 0.7 / 2.8 / 9.5
Frequency 1.5

Figure 5 – Calculation of power loss density.

Distribution of absorbed power per unit weight across the surface of the studied object (Figure 6 and Table 4):



Type SAR (rms)
Monitor SAR (f=1.5) [1] (1g)
Maximum-3d 0.601108 W/kg at -8.5 / 0.5 / 4.9
Frequency 1.5

Figure 6 – SAR distribution on the surface of the head model

Table 4 – Parameters of the three-layer model of the human head for frequencies of 0.9 and 1.9 GHz (in parentheses)

Substance	Thickness, mm	Radius of Sphere boundary, mm	Relative dielectric conductivity, ε	Layer permeability, CM / M	tg [6]	Layer density kg / m3
Brain		48	53 (46)	1,1 (1,7)	0,415 (0,369)	1030
Bone	3		9 (8)	0,06 (0,1)	0,133 (0,125)	1800
Skin	1		59 (46)	1,3 (1,9)	0,44 (0,41)	1100

The construction of any complexity master model can be achieved through the operations of merging and reducing three-dimensional objects with given conductivity. Therefore, it is possible that when removing from the source, the field should drop smoothly; if the discretization is coarse, it may lead to jumps in the solution. When introducing an object, such as a master model, into the analyzed space, this error may be reduced because the vertices of the tetrahedron (Figure 7) are located at the boundary of the master layer.

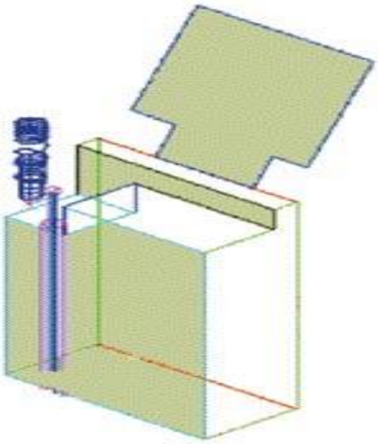


Figure 7 – Initial phone structure for analysis.

It appears hollow from above. The division into tetrahedra is shown in the vertical cross-section of the entire analyzed space. On the right, the sphere of the master model is visible(fig.8).

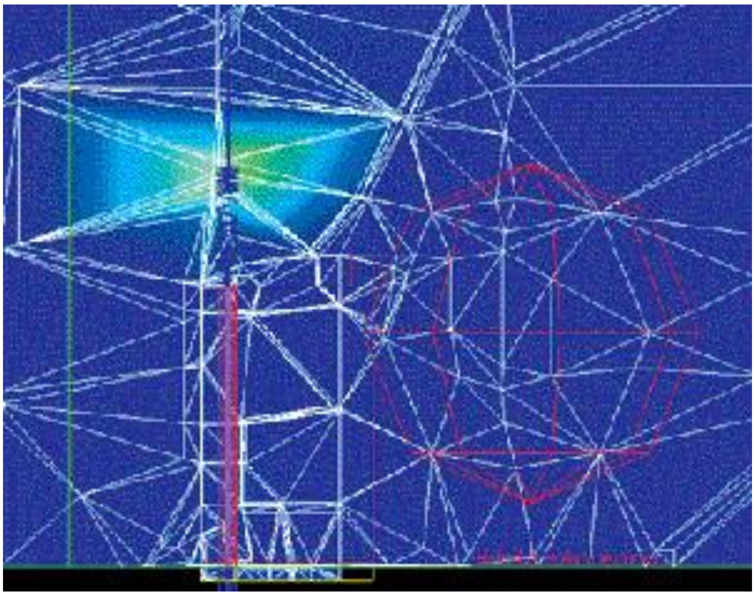


Figure 8 – Electric field near the antenna, consisting of a section with a rare step and a section with a frequent step

The near field of an antenna system is often reactive, i.e. the direction of displacement of power (Poynting vector) from the point of radiation to the object radiating along the radial network is not mandatory(fig. 9 and fig.10)). The boundary of the near and far Fields is considered to be the distance from which the flat wave travels strictly from the antenna.

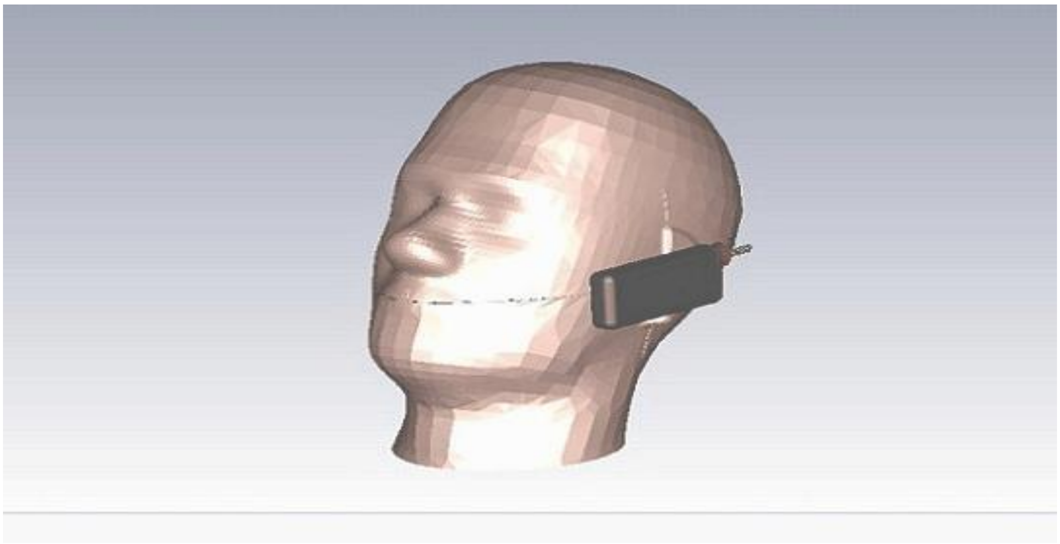


Figure 9 – Standard model of the human head

- **Type:** Farfield
- **Approximation:** manable (NR >> 1) ← скорее всего *"manageable (NR >> 1)"*
- **Monitor:** Farfield (r=1.0) [1]
- **Component:** Abs
- **Output:** Directivity
- **Frequency:** 1.0
- **Rad. effic.:** –1.547 dB
- **Tot. effic.:** –11.158 dB
- **Max. dir.:** 5.508 dBi

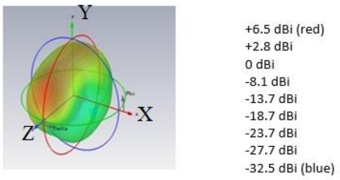


Figure 10 – Distribution of per person and mobile phone models in the SAR system

Consider the level of specific absorption power (SAR) depending on the location of the radiation device. There is a situation when the phone fits snugly to the head(fig.11).

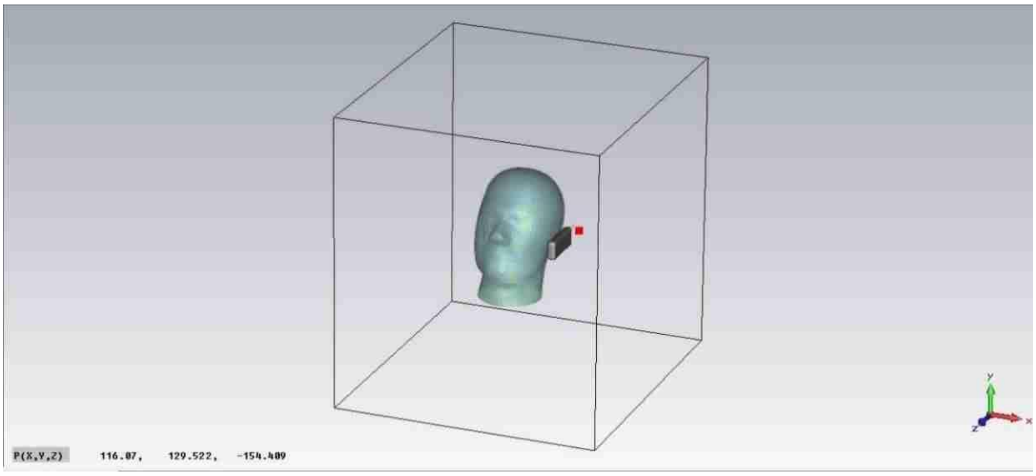

P(X,Y,Z) 116.07, 129.522, -154.409

Figure 11 – Location of the Illuminator (phone)

After the transition processes are completed, the distribution of the specific absorption power takes on the following type (fig.12):

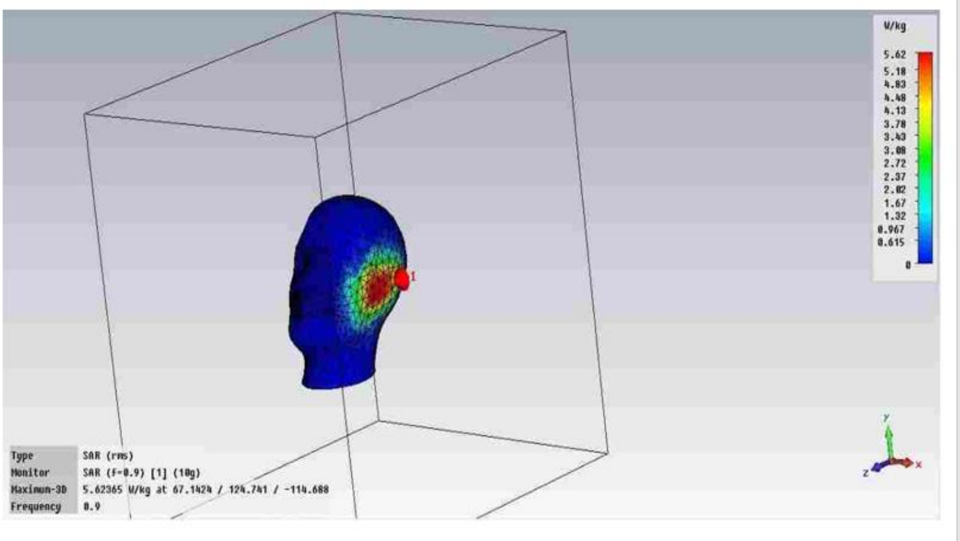

Type SAR (rms)
Monitor SAR (f=0.9) [1] (10g)
Maximum-3D 5.62365 W/kg at 67.1424 / 124.741 / -114.688
Frequency 0.9

Figure 12 – Distribution of SAR by the surface of the head model

We move the phone to a distance equal to about 15 cm from the person's head (fig.13):

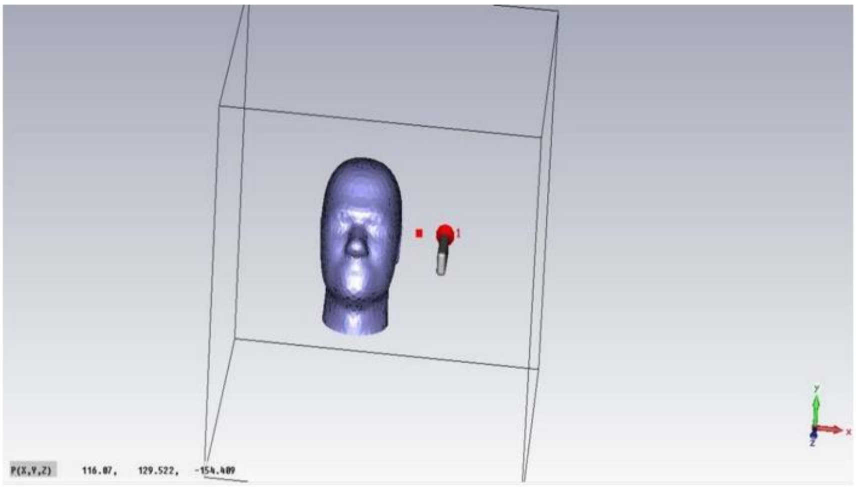


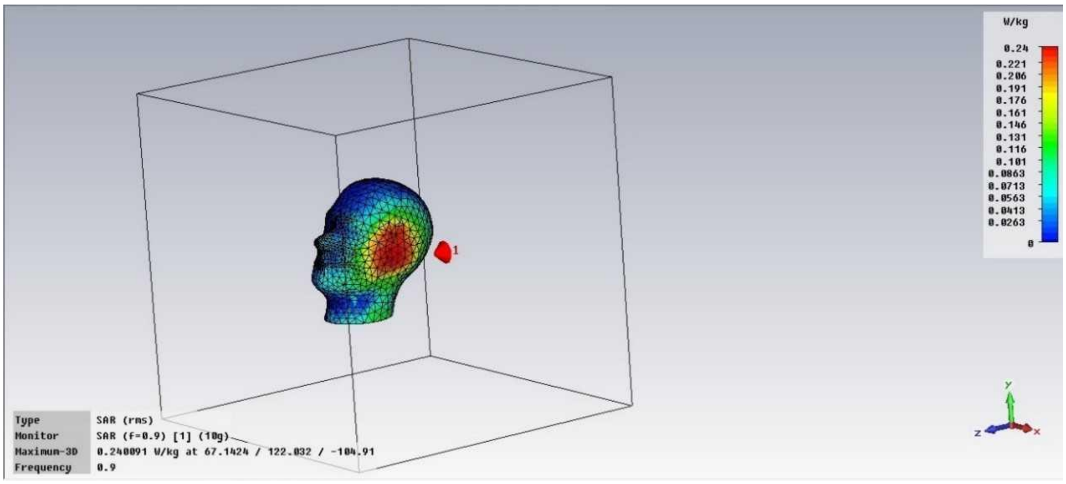
Figure 13 – Mobile phone location 15 cm removal

Table 5 – Maximum field strength at points of planes located in sections when moving away from the cell phone case

Plane name	Removal from case, mm	Maximum field strength, V / M	
SAR_18 max	18	F = 1,2 GHz	F = 1,95 GHz
SAR_24 max	24	519	1166,3
SAR_26 max	26	660,3	581,2
SAR_30 max	30	808,2	692,7
SAR_100 max	100	148,8	363,8
SAR_18 max	18	87,5	250,7

These data are primary, in relation to which the fields and characteristics of the system are calculated when the structure of the telephone tube changes. Interpretation of results (table. 2) presented in Fig. 4, which shows two planes at a distance of 18 and 100 mm from the nearest wall of the cell phone case and the image of the field in these planes, where it is possible to find the points of the highest tension.

After the transition process is completed, the distribution of the specific absorption power will be as follows(fig. 14):



SAR (rms)
SAR (f=0.9) [1] (10g)
0.240091 W/kg at 67.1424 / 122.032 / -104.91
0.9

Figure 14 – CM SAR distribution on the surface of the head model when removing the radiation source

$$\frac{W_{1\max}}{W_{2\max}} = \frac{5.6}{0,24} \approx 23 \qquad (5)$$

Analysis of Sar calculations showed that after removing a mobile phone from a person's head, the volume of specific absorbed power decreased by more than 20 times (fig. 15).

For this, the output of the field characteristic along a predefined line perpendicular to the body of the phone and passing through the layers of the head model is used [12].

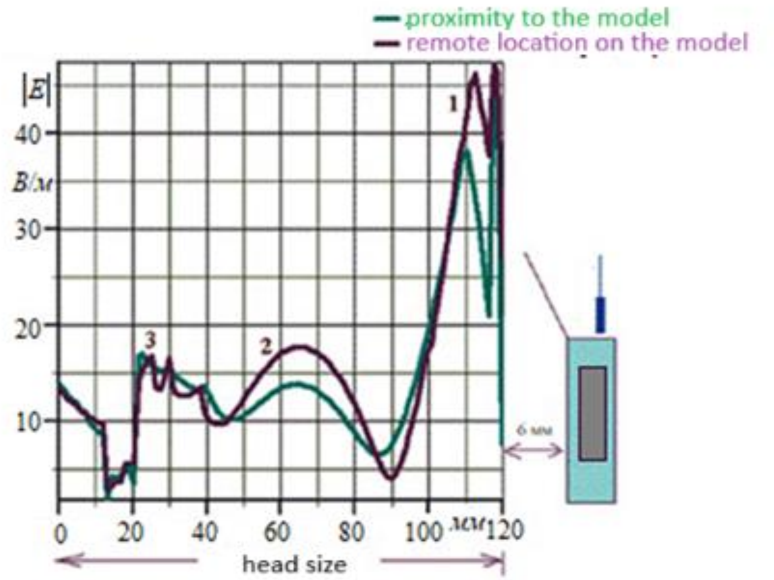


Figure 15 – Field strength along the X-axis, towards removal from the head pattern

Figure 16, the correct coordinate x = 82 corresponds to the point of the phone case near the head model. When moving to the left of the point with the coordinate X = 82, to the point x = 72, we see a segment in which the field strength is higher. This is the space from the phone to the head.

To obtain a complete picture of the distribution of field strength within the head model, we introduce another Scale (Figure 16).

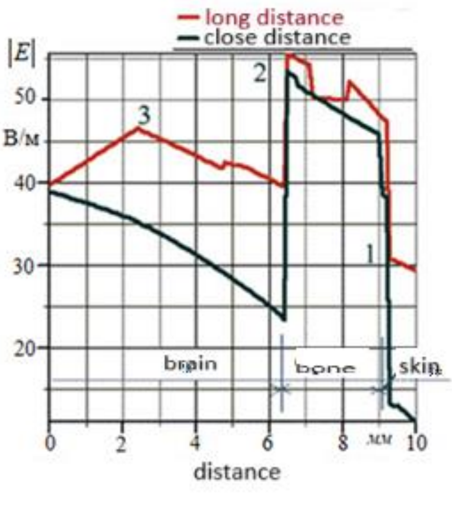


Figure 16 – Image of the field strength on the first and second floor of the head model (enlarged scale on the first floor of the head closest to the phone case)

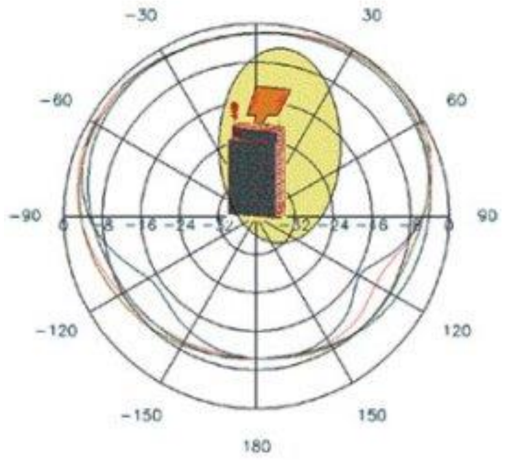


Figure 17 – Directional diagram in an angular plane with a head, frequency 0.8 GHz

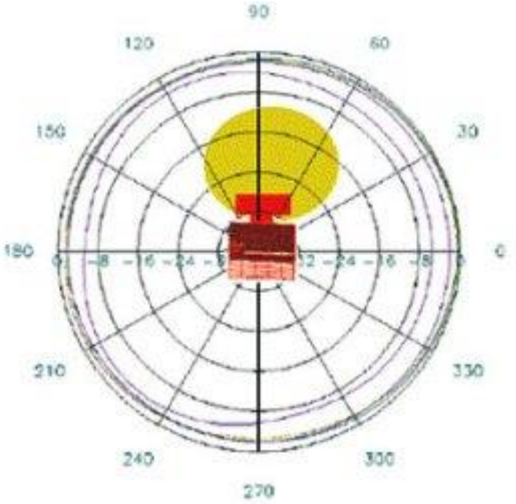


Figure 18 – Orientation diagram in the azimuthal plane,
taking into account the head pattern, 0.8 GHz

Depending on the amplitude of the excitable source (which can vary according to the sinusoidal law), the field strength also varies at each point in space, since in the Near Field, higher types of waves change linearly, but the phase relations change the picture of the field in space (Savicheva S. A., Gainutdinov T. A. et al., 2008).

Thus, fig. 17, when the radiation power changes, the amplitudes of the high waves at each point in space change linearly, but the resulting field acquires a complex character. We are here not with a nonlinear medium, but with interference (adding different types of waves).

If you change the excitation parameters, the separation of the near field will change to the field shown in the figure.. The nature of such propagation is explained by the superposition of high-type waves in the near field of the antenna system(Fig.18).

The results shown in the upper figures, are used to calculate the SAR value.

$$SAR_1 = \frac{31^2 \times 1.3}{1100} = 1.14W/kg \tag{6}$$

$$SAR_2 = \frac{55^2 \times 0.06}{1030} = 0.18W/kg \tag{7}$$

$$SAR_3 = \frac{46^2 \times 1.1}{1030} = 2.25W / kg \tag{8}$$

This method can be used to calculate power absorption at any point in the head. Due to the peculiarity of the phone case and the entire antenna system, the near field is concentrated in the head, because with the removal of the antenna from the existing phone case, the monotonous falling nature of the field disappears. Of course, the averaged power in the space of these points must be calculated using statistical analysis. However, calculations show that smaller metal objects, such as earlobes, can transmit significant power at points in body space through statistically stable fields.

Orientation diagram in the direction of the head in the azimuthal diagram of directionality,there will be a fall, because in this section the radiated power is shaded.

Directed diagrams in Figures 1...It shows 3 dB, everything shows little radiation in all directions, and despite this, they were uniform. This concept can be considered as an object with absorbing properties near the antenna system. However, the azimuthal bottom remains the same for different angles of inclination.

The SAR level of mobile phones is an indicator that characterizes the highest amount of electromagnetic radiation of various models of mobile phones. Using this calculated method, we can determine the level of electromagnetic radiation of any phone model and make a choice for ourselves.

In this study, we demonstrated that the usage scenario critically influences exposure levels: the transition from "silence" to "call" is accompanied by a sharp jump in field strength, while "conversation" produces the highest values. This scenario-specific gradient is consistent with fundamental principles of power management in cellular networks (the uplink increases power when establishing and maintaining a connection), as well as with phantom measurements, where SAR peaks systematically increase with deteriorating reception quality and with decreasing device-to-skin clearance. In our dataset, "conversation" is higher than "silence" by a factor of ~42–53 (depending on whether 1.4× is calculated relative to "call" or 41.8× directly). This discrepancy is informative in itself: it demonstrates that even within a single experiment, the resulting coefficients are sensitive to the duty cycle, antenna position, and network characteristics. We deliberately shift the focus from instantaneous flux density at the enclosure to SAR and dose D as more biophysically relevant metrics.

Comparing the results with typical laboratory SAR assessments on liquid phantoms (SAM/lateral positioning) under standardized conditions, it should be recognized that standardized tests often represent the "worst case" for geometry and power, but omit the temporal structure of the traffic. Our approach complements them—it does not replace the compliance protocol, but rather extends it by introducing a scenario component and an integrated dose. A number of published studies have noted that adding even a 5–10 mm air gap reduces SAR10gmax by tens of percent; our calculations and measurements confirm this trend and quantitatively explain it by near-field decay and the shift of the "hot spot" in the tissue. Furthermore, we demonstrate a practical tradeoff: when the signal is weak, a temporary increase in power can reduce the transmission duration and the total dose—a finding that is less frequently discussed in studies focused solely on the SAR peak.

It is also important that we explicitly differentiated three modes ("silent," "call," and "talk") and included the duty cycle in the dose calculation. Some studies only record stationary, quasi-continuous conditions; in reality, UL activity is fragmented and codec-dependent. The methodology we demonstrate allows us to transfer our findings closer to the real user profile—with clear benefits for risk assessment and device design (antenna solutions, power control algorithms, user prompts).

From a practical perspective, our results reinforce the consensus on the "distance rule": even minimal separation (case, phone relocation, speakerphone mode) is the most reliable and easily implemented way to reduce SAR without compromising communication.

At the same time, we emphasize that engineering goals must be multi-criterial: optimizing not only $, \mathrm{SAR}^{max}_{1g/10g},$ but also D dose, energy efficiency, and channel quality metrics (e.g., BLER/throughput). This approach is useful for regulators, manufacturers, and users.

Conclusion.

This article discusses the problem of the effect of electromagnetic radiation on ADM in the mobile communication system. Currently, electromagnetic radiation causes harmful effects on the human body. Conducting research in this regard, you can come to the conclusion as follows:

– When using mobile phones with a frequency of 450-900 MHz, the wavelength significantly exceeds the linear size of the human head, which, in turn, can lead to various diseases;

– Currently, the rate of use of mobile phones is too high, the reason for this is the development of various platforms in the world of the internet, which, in turn, has a strong impact on the health of children and adolescents, the figure is 30% higher;

– The international SAR level determination method was considered to determine the effect of this mobile phone. Studies were conducted on this method, and on average the SAR level was equal to 1.19;

– In the process of modeling, the ratio of the human head and phone models was considered, as a result of which the influence of the mobile phone was determined, which showed 23 equal values.

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ҰЯЛЫ ТЕЛЕФОНДЫ ҚОЛДАНУ КЕЗІНДЕГІ ЭЛЕКТРО МАГНИТТІК ӨРІСТЕРДІҢ АДАМ АҒЗАСЫНА ӘСЕРЛЕРІН ЗЕРТТЕУ

Аңдатпа. *Бұл жұмыста сымсыз байланыс жүйесіне жататын ұялы телефондардың Аннотация. Бұл еңбекте сымсыз байланыс жүйелерінің құрамына кіретін ұялы телефондардың адам ағзасына әсері, сондай-ақ ұялы байланыс кезіндегі электромагниттік сәулеленудің әсері қарастырылады. Еңбек ұялы телефонды пайдалану және осы пайдаланумен байланысты аурулардың түрлері туралы статистикалық деректерді ұсынады. Адам денесінің моделі жасалып, сол модельде ұялы байланыстағы электромагниттік сәулелену процестерінің әсері көрсетілді. Сонымен қатар, электромагниттік сәулеленуді есептеудің халықаралық стандарттарына сәйкес есептеулер жүргізілді.*

Зерттеу нәтижесінде SAM манекендерінің көмегімен адам басындағы ми тіндерінің 900 және 1800 МГц жиіліктегі диэлектрлік өткізгіштіктері салыстырылды. Сонымен қатар, CST STUDIO SUITE бағдарламалық құралы арқылы зерттелетін объектілердің 3D модельдері жасалды және осы модельдер негізінде электромагниттік сәулеленудің адам басына әсері талданды.

Бұл мақаланың өзектілігі олардың адамға әсер ету қаупін арттыратын электромагниттік өріс (ЭМӨ) көздерінің көбеюіне байланысты. Тұрмыстық электр желілері, тұрмыстық техника, бейне дисплей терминалдары, электр беру желілері, байланыс және ақпараттық телерадио құрылғылары, радиолокациялық және навигациялық станциялар әртүрлі жиіліктерде, модуляцияларда және қарқындылықта ЭҚК шығаратын көздер тізімінің бір бөлігі ғана. Халықтың көпшілігі шын мәнінде табиғи магнит өрісінен миллиондаған есе күшті ЭҚК-нің өте жоғары деңгейіне ұшырайды. Электромагниттік сәулелену ағзадағы патологиялық реакциялардың дамуына айтарлықтай әсер етеді. Бұл өз кезегінде адам денсаулығының төмендеуіне тікелей әкеледі. Сондықтан ұялы телефонның адам ағзасына тигізетін әсерін түсіну және оның зиянды жақтары туралы халықты ақпараттандыру басты міндет болып табылады.

Түйін сөздер*: электромагниттік сәулелену, ұялы телефон, диэлектрлік өткізгіштік, электромагниттік өріс, жиіліктер, модуляциялар, радар.*

ИССЛЕДОВАНИЕ ВЛИЯНИЯ ЭЛЕКТРОМАГНИТНЫХ ПОЛЕЙ НА ОРГАНИЗМ ЧЕЛОВЕКА ПРИ ИСПОЛЬЗОВАНИИ МОБИЛЬНОГО ТЕЛЕФОНА

Аннотация. *В данной работе рассматривается влияние мобильных телефонов, являющихся частью систем беспроводной связи, на организм человека, а также воздействие электромагнитного излучения при мобильной связи. В работе представлены статистические данные об использовании мобильных телефонов и видах заболеваний, связанных с этим. Создана модель тела человека, на которой продемонстрировано влияние электромагнитного излучения на процессы мобильной связи. Также проведены расчеты в соответствии с международными стандартами расчета электромагнитного излучения.*

В результате исследования проведено сравнение диэлектрической проницаемости тканей мозга человека на частотах 900 и 1800 МГц с использованием манекенов SAM. Кроме того, с помощью программного обеспечения CST STUDIO SUITE созданы 3D-модели исследуемых объектов, на основе которых проведен анализ воздействия электромагнитного излучения на голову человека.

Актуальность данной статьи обусловлена ростом числа источников электромагнитных полей (ЭМП), что повышает риск их воздействия на человека. Бытовые электросети, бытовая техника, видеотерминалы, линии электропередачи, средства связи и информации, теле- и радиоустройства, радиолокационные и навигационные станции – лишь малая часть источников электромагнитного излучения различных частот, модуляций и интенсивностей. Подавляющее большинство населения подвергается воздействию очень высоких уровней электромагнитного поля, которые в миллионы раз превышают естественные магнитные поля. Электромагнитное излучение существенно влияет на развитие патологических реакций в организме. Это, в свою очередь, напрямую приводит к ухудшению здоровья человека. Поэтому понимание степени воздействия мобильных телефонов на организм человека и информирование населения о его вредных последствиях является важнейшей задачей.

Ключевые слова: *электромагнитное излучение, мобильный телефон, диэлектрическая проводимость, электромагнитное поле, частоты, модуляции, радар.*

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