



## ELECTROMAGNETIC RADIATION INFLUENCE ON HUMAN HEALTH

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In 1926, V.I. Vernadsky, Academician, stated: «There are different kinds of radiation with different wavelengths all around us, inside us, everywhere, they flow continuously, changing each other, coinciding and colliding ... We have just started to realize their variety, understand that our ideas about the surrounding and penetrating into us radiation are fragmentary and insufficient, about its key ... role in the processes encircling us». Nowadays this idea became even more relevant since purposeful use of electromagnetic energy in various areas of human activity has resulted in the fact that existing electric and magnetic fields of the Earth, atmospheric electricity, solar and galaxy radio radiation were added by an artificial electromagnetic field. Its level considerably exceeds the level of natural electromagnetic background. Each ten years world energy resources are doubled and within this period specific gravity of electromagnetic field variables in power industry has thrice increased.

Electromagnetic radiation sources, which include overhead high-voltage and extra-high-voltage transmission lines, radio-broadcasting, TV, radio-relay and satellite communication equipment, radar and navigation systems, laser beacons and etc. have significantly influenced the natural electromagnetic background. Within rather wide areas and, in particular, near overhead high-voltage and extra-high-voltage transmission lines, radio and tele-centers and radar systems electric and magnetic fields strength has shown from two to five time increase, thus raising the real perils for humans, flora and fauna.

50 Hz industrial electric fields created by overhead transmission lines and sub-stations are of biological significance. Within location of overhead extra-high-voltage lines and sub-stations strength of industrial-frequency magnetic fields exceeds by 1-3 times the natural level of magnetic field of the Earth. High levels of electromagnetic radiation are observed within and often beyond the location of low-, medium- and high-frequency transmitting radio-centres.

Radio-transmitting communication equipment (car and portable radio sets and handsets, cordless telephones), television, radar, computer and household electrical equipment, as well as tram cars and electric trains "pollute" our environment in their own fashion.

Extra-low-frequency (0-10 Hz) and very low-frequency (10-1000 Hz) electromagnetic fields are created in the course of using electrified public and rail-road transport, transmitting lines and sub-stations and cable routing.

Broadcasting centers emitting particularly high-frequency and ultra-high-frequency ultra-short waves in the environment are widespread electromagnetic radiation sources in communities. At this, the highest levels of people's exposure to radiation and of its influence on the environment are observed within the location of broadcasting centers of "old construction" with an antenna support not higher than 180 m. Three- and six-storey very high frequency corner FM (as they are referred to in international practice) antennas most of all contribute to the accumulated exposure intensity.

Electromagnetic radiation influence of household electric devices on a human organism, which can be rather high, is also observed. For instance, within 3 cm magnetic induction of an operating hair drier is equal to 2 thousand microteslas and that of electric razor is 1.5 thousand microteslas (compare: natural geomagnetic background amounts to 30-61 microteslas). Being wide-



spread a cordless telephone as a transmitter of ultra-high frequency waves of high penetrating power, from time to time being dabbed to a temple poses a hazard not only for separate users but also for all surrounding people. Since 1970-s several millions of microwave cookers, which use ultra-high-frequency radiation energy have been manufactured.

Wide spread occurrence of electromagnetic radiation and their rush penetration in all spheres of human activity led to the appearance of a comparatively new set of pollutants, named “electromagnetic smog”, which means a totality of electromagnetic fields and various radiations, emerging in the course of operation of complex electromagnetic equipment.

The spectrum of electromagnetic radiation frequencies is very wide and covers wavelengths from tens and hundreds of kilometers to fractions of nanometers; from short-frequency radio waves to ionizing radiation in the form of space rays.

One of the conclusions of radiobiology, a recently emerged scientific branch, should be remembered – any, even a very small amount of ionizing radiation is harmful. The lowest limit of harm, i.e. natural radiation background, is a constant flow of high-energy particles where all living organisms exist. It is composed of space radiations, which share is 16.1 %, of terrestrial gamma rays— 21.9 %, internal transmitters — (i.e. living organisms, absorbing trace quantities of radioactive nuclides from the environment) — 19.5 %, as well as radium and thorium radiation (remaining part of the natural radiation background) — 42.5 %. For the Earth an average natural radiation background is equal to 0.011 mBer/h (in different regions of the world it is widely varied).

The natural radiation background represents a flow of ionizing particles and the energy of each particle, being absorbed by cell substance, is enough to cause any of its molecule decomposition and excitation. Within one hour in different regions of the Earth in human tissue cells from 200 mln to 6 billion of such microevents occur. Thus, all organisms, living on the Earth, continuously undergo high-energy terrestrial and space radiation from the moment of conception and on.

Scientific and technological progress used to be considered as a positive factor, stimulating high level of material and mental well-being and as a powerful accelerator of social progress. Though scientific and technological progress also represents a factor, which creates certain ecological problems. The same situation is also observed in case of electromagnetic radiation, which is accompanied with a range of negative consequences. It is mainly our fault that risk factors become malignant. It is the fact that people simple don't understand that they are responsible for everything happening on the Earth that is the seat of the problem. The biological world is indivisible, cell structures are almost similar and therefore microeffects are the same.

Nowadays, high level of electromagnetic fields biological activity is established; all living organisms are actually extremely sensitive to artificial electromagnetic fields if antropogenic origin. Some types of living organisms and plants are particularly sensitive to certain frequencies. Thus, fish endure frequency of 50Hz not well if field strength is rather high. Forest growth is slowed down if affected by ultra-high-frequency with 12, 25, 50 and 100 Hz modulation. Flowers response to acoustical frequencies. On a higher level of organization a variety comes into existence and sensibility to electromagnetic fields is differentiated.

Industrial fields are accompanied by different frequencies, parasite ultra-high-frequency radiations, harmful resonance phenomena, from which a human organism cannot yet protect itself. Regular electromagnetic field exposure may lead to performance, memory and attentiveness disorders. Electromagnetic fields increase the risk of cardio-vascular, endocrine and oncological diseases, decrease immune resistance and potency. According to World Health Organization specialists, today electromagnetic pollution of the environment is on a level typical for its current pollution by harmful chemical substances.

Organism's responses to strong influences are widely known. It is much more difficult to speak about weak influences, which result in potential so called remote genetic and cancerogenic effects. It is possible that in some time antropogenic electromagnetic fields will be established to belong to non-threshold irritants.

Review of the existing ideas about electromagnetic fields biological activity allows to distinguish two main approaches to this issue. The first one is related to the idea of energy interaction



and the second one with the analysis of informational interaction of electromagnetic fields with the elements of a biological system.

## ENERGY INTERACTION OF ELECTROMAGNETIC FIELDS WITH A HUMAN ORGANISM

### 1. Low-frequency electromagnetic field biological effect

With regard to low-frequency ( $<10^5$  Hz) electromagnetic fields a human body possesses a conductor's properties. Under an external field influence conduction current appears in tissues. The main representatives of free charges are ions. Length of low-frequency electromagnetic waves significantly exceeds the dimensions of a human body; as a result the whole organism undergoes such waves exposure. However, the effect on different tissues is not the same since both their electric properties and sensitivity to conduction current are different. It is the nervous system that is quite sensitive to it. Under the influence of an external electromagnetic field with a frequency of 10 Hz and strength of 10 vacuum meters<sup>-1</sup> in cerebral tissues a field, which is  $10^5$  weaker than the external one, is induced.

The induced conduction current passes mostly through extracellular fluids since their resistance is much less than that of the cell membranes. Approximately one thousandth of conduction current induced by the external electromagnetic field passes through neurons' plasmolemmas.

The threshold limit of conduction current, causing excitation, depends on electromagnetic field frequency. More than 3 kHz current applied to the skin of a man almost does not excite his nerves and muscles. With the nerves and muscles being directly influenced, this frequency limit is moved up to 200 kHz but with this frequency tissues are excited only by high current. Conduction current increase with electromagnetic field frequency growth is related first of all with ion channels' slow response. With frequencies, being higher than  $10^5$  Hz, their portal processes are not activated. Therefore, high-frequency electromagnetic fields are not able to excite organism's tissues.

Electromagnetic energy absorption by live tissues is accompanied by their temperature increase in case if the absorbed power exceeds heat energy diffusion power. The latter is governed by the emission of heat from the surface of a body through radiation, convection, thermal conductivity and water evaporation. Blood circulation secures abstracting thermal energy from deep tissues to the body surface. Heat emission mechanisms continuously operate in an organism since the constant high level of heat production in the course of metabolism is inherent to it. That is why a significant increase of living tissues temperature occurs only in case when an additional heating load (in particular, under electromagnetic field exposure) reaches not less than 70% of metabolic heat production (1-3 mW·g<sup>-1</sup>).

Low-frequency electromagnetic fields influence on an organism does not lead to a marked tissues heating since thermal energy, which is absorbed by the tissues at this, is less than metabolic heat production. Electric burns of skin (flash-burns), appearing at the place of contact with high-voltage bare wire is an exception.

Studies of a range of authors prove common non-specific mechanisms of ultra-low-frequency electromagnetic field influence on an increase in pituitary-adrenal axis capacity, which in most examined is accompanied by reproductive and in some cases also pituitary-thyroid system enhancement (24,27).

A range of conducted studies have also shown positive coherence of low-frequency electromagnetic radiation and neoplasms development. However, this situation is not found in all of the studies. The most pronounce effect of electromagnetic fields is observed in the development of children leukemia, as well as leukemia and encephaloma of adults exposed to these fields radiation at work (7,8,16).

The influence of thermal intensity radio-frequency band on life span and neoplasms devel-



opment is not directed unambiguously. In different test conditions animals exposure gave opposite effects. Electromagnetic fields effects are multiple, they are not fully examined and are unpredictable. There are yet too many gaps and all kinds of uncertainties in this issue.

Ultra-low-frequency fields, as well as high-frequency and ultra-high-frequency detected fields with ultra-low-frequency harmful modulation, which release active free radicals, are particularly hazardous. They affect DNA and RNA as hard radiation and may cause extremely negative remote effects up to a genotype retrogression. These effects are rather difficult to be directly found (18,20).

## 2. High-frequency electromagnetic field biological effect

Unlike an organism's responses to low-frequency electromagnetic field, biological effect of high-frequency electromagnetic radiation depends mainly on thermal energy released in exposed tissues. Physiological mechanisms of heat emission do not make up for an organism's heat production, which is observed under high-frequency electromagnetic field influence.

Within the band of frequencies from 1.0 to 300 MHz the mechanisms of electromagnetic fields interaction with an organism are governed by conduction current, as well as by offset current, at this at a frequency of about 1 MHz it is conduction current that plays the leading role and on frequencies higher than 20 MHz it is offset current. Both kinds of current cause tissues heating. Thermal effect strengthens as an external field frequency grows. Unlike low-frequency current, high-frequency conduction current (with a frequency higher than  $10^5$  Hz) does not excite nerves and muscles. Offset current does not cause excitation, too.

On frequencies from 1.0 to 3000 MHz a wavelength exceeds the human body dimensions. Such fields may exert both local and overall influence on the organism. The nature of influence is governed by the fact if the whole body or its part is under field exposure. With higher frequencies (a frequency higher than 3000 MHz) a wavelength is less than the human body dimensions, which fact provides only local exposure of electromagnetic field. Moreover, the higher the frequency is, the lesser is the depth of electromagnetic oscillations penetration in an organism. Depth of electromagnetic radiation penetration in any medium refers to a distance where field amplitude decreases by  $e$  times ( $e = 2.718...$ ). Having penetrated so far, an electromagnetic wave reserves about 13% of its original intensity. The depth of penetration depends not only on an external electromagnetic field frequency but also on electric properties of tissues it penetrates. For fatty and bony tissues this value is by an order of magnitude greater than it is for muscular tissue.

The thermal effect of high-frequency fields is used as a remedy. Among the methods of high-frequency electrotherapy diathermy, short-wave diathermy, ultra-high-frequency therapy and microwave therapy are distinguished. In **diathermy** electromagnetic fields with a frequency of 0.5—2.0 MHz are applied. **Short-wave diathermy** method relies on applying electromagnetic fields with a frequency of 10—15 MHz. Biological effect (hyperthermia) is governed by a magnetic component of electromagnetic field generated by short-wave diathermy equipment. Under the influence of magnetic field in tissues eddy currents, heating a radiation object, appear. For **ultra-high-frequency therapy** electromagnetic fields with a frequency of 40—50 MHz are applied. Like in both previous methods a patient stays in the area of an unformed wave. Since electrodes have the shape of a plate the biological effect is governed by an electric component of electromagnetic field, at this heat is generated under exposure of both conduction current and offset current. In **microwave therapy** thermal effect is generated only by offset current, which appears in a human organism under ultra-high-frequency radiation influence. Their frequency band is from  $3 \cdot 10^8$  to  $3 \cdot 10^{11}$  Hz. For physiotherapeutic procedures waves with length of 12.7 cm are usually applied. They effect a human within the area of a formed wave. Therefore, thermal effect is determined by electromagnetic field strength. Since characteristic frequency of water relaxation appears to be within the frequency band of ultra-high-frequency radiation it is the water media of an organism that absorb the energy of ultra-high-frequency fields to the utmost. Since



ultra-high-frequency waves poorly interact with skin and fatty tissue and are intensively absorbed by muscles and internal, in microwave therapy muscles and internal are mostly heated. A lot of heat is released in liquids, filling various cavities.

Not only in a physiotherapeutic cabinet one has to deal with ultra-high-frequency radiation. They are widely used in radiolocation. When working at radar platforms, violation of safety measures may significantly affect health.

Works, concerning studying the influence of low-density ultra-high-density fields modulated within a frequency band of personal biological rhythms of a bioobject on the central nervous system are of particular interest. It is determined that threshold intensities of microwave radiations modulated within this band are considerably lower than those typical for pulse or continuous radiations (16,17,19).

Low-energy ultra-high-frequency fields modulated within the rhythms of individual frequencies of a brain have a marked cardiotropic effect. Having exposed the cerebral (neural) tissue to electromagnetic field modulated with the brain's own biorhythms frequency the amplification of the electromagnetic field's biological effect may be attained due to the resonance phenomena.

Resonance processes related with biological rhythms of a man play significant role. Resonance amplification or decay of these rhythms, harmonics and subharmonics appearance, as well as the results of cross-modulation in cell non-linear elements may cause various psychophysiological effects with negative consequences.

Among a great number of electromagnetic phenomena microwave radiations are worthy of special notice; at this, radar and radio-relay stations, as well as other objects, which operation is based on the generation of ultra-high-frequency electromagnetic radiation, considerably contribute to microwave pollution of the environment. People working at troposphere, satellite, radio and radio-relay stations start to feel headaches, irritation, sleepiness, memory weakening and etc.

According to a doze and nature of exposure, acute and chronic microwave radiation affections are distinguished (Table 1). Abnormalities, resulting from a short-term influence of microwaves, which energy flow density causes thermogenic effect, refer to the acute affections. A chronic affection is a result of a long-term influence of microwave radiation with subthermal energy flow density.



Table 1  
Clinical manifestation of microwave influence on a human organism with different radiation intensity (B.A. Minin's modification with data addition, 1974)

| Microwaves' intensity, mW/sm <sup>2</sup> | Changes observed  |
|---|---|
| 1   | 2   |
| 600                                       | Painful sensations during exposure*   |
| 200                                       | Tissues redox processes depression*   |
| 100                                       | Blood pressure increase followed by its decrease, in case of chronic exposure – stable hypotension. Double-sided cataract.  |
| 40  | Warmth sensation. Vessels dilation. During exposure blood pressure increases by 20-30 mm of mercury.*   |
| 20  | Tissues redox processes stimulation   |
| 10  | After 15-minute exposure asthenisation and change in brain bioelectric activity are observed  |
| 8   | General radiation period being 150 hours, vague shifts with regard to blood and changes in coagulability are observed   |
| 6   | Electrocardiographic changes and changes in receptor system   |
| 4-5                                       | Changes in blood pressure in case of multiple exposure, Short-term leukopenia, erythropenia   |
| 3-4                                       | Vagotonic response with bradycardia symptoms, heart conductivity slowing-down   |
| 2-3                                       | Marked blood pressure lowering, more rapid pulse, heart blood volume fluctuations   |
| 1   | Blood pressure lowering, rapid pulse trend, insignificant heart blood volume fluctuations. If exposure exists every day within 3.5 months intraocular pressure reduces. |
| 0.4                                       | Under pulse electromagnetic radiation exposure acoustic effect is observed  |
| 0.3                                       | Some changes in the nervous system under chronic exposure within 5-10 years   |
| 0.1                                       | Electrocardiographic changes  |
| До 0.05                                   | Blood pressure lowering trend under chronic exposure*   |

\* - intensity values are the lowest among values mentioned in publications.

With regard to the cardiovascular system hypertensive neurocirculatory dystonia, myocardiosystrophy accompanied by rapidly progressing coronary insufficiency have been observed. Leucopenia and thrombocytopenia have been typical of peripheral blood. Changes in peripheral circulation system of specialists, maintaining electromagnetic devices, appears to have phase nature. Within the initial stage a moderate reduction of hemoglobin and erythrocytes value may be noted. Further on these values increase and sometimes considerably exceed standards. At first the number of leukocytes tends to increase in comparison with the standard. After seven-nine years of contact leu-



kocytes tend to decrease. People with 7-12-year experience may have persistent leucopenia. Coagulability rate of some people changes.

Biological studies have proven that it is the central nervous system, eyes and gonads (1,3) that are the most sensitive to electromagnetic radiation exposure. At this, disorders in cardiovascular, neuroendocrine, hemopoietic and immune systems activity and in metabolic processes may occur. Studies have shown that human reproductive system is very sensitive to electromagnetic radiation exposure. At this, among men rather high percentage of impotency and blood testosterone value reduction have been detected. Disorders in women's genital function (toxicosis of pregnancy, spontaneous abortion and partus pathology) may be observed).

A human organism is not indifferent to electromagnetic energy localizing at certain organs (it is head, when using hand cordless phones, loin or back, when using portable radio transmitters). Evident dependence of bioeffects on field intensity, waves polarization and direction, correlation of human organs and body dimensions and electromagnetic wave length is noted. The difficulty is represented by the fact that it is necessary to consider the whole variety of factors, governing the amount of absorbed electromagnetic energy, tissues dielectric properties, bioobject's geometry, mass and orientation, electromagnetic field polarization, source's configuration and characteristics, radiation intensity and frequency, as well as all features of ultra-high-frequency electromagnetic radiation generation and expansion (10,11).

900 MHz radiation allowed for cellular cordless phones has particularly high permittivity, at this, resonance effect in a man's head is not rare. Actually there are considerable differences in individual sensitivity. There are variety of models and modifications of cordless phones and they considerably differ in view of wave power and length. Therefore, it is possible to speak of a certain effect of this or that device only after the relevant certification.

It is a molecule, possessing of electromagnetic properties, that is the target of ultra-high-frequency radiation. First of all it is a water molecule. A living human organism mostly consists of water (by 95% of water at a very young age and by 60% at old age). Being dissolved in water all substances form hydrate membranes. Weak low-frequency electromagnetic fields change metastable structures of water, thus drastically reducing potassium ions concentration and leading to active free radicals origination (23,25).

Electromagnetic energy of ultra-high-frequency radiation and of exposure on water converts into thermal energy and subsequent bioeffects in cells and tissues are related with local increase in their temperature and then the whole organism heating. The more the value of ultra-high-frequency wave is, the deeper is a thermal burn of tissues. Temperature increase causes thermoreceptors excitation. Mechanoreceptors in the lesion focus are also irritated due to the bulk effect of heated interstitial fluid.

Along with the thermal effect the resonance effect becomes apparent by destructing DNA and ATP molecules and decreasing the extent of  $K^+$ ,  $Ca^{2+}$  and other ions binding. With regard to  $K^+$  and  $Na^+$ , membranes permeability changes. It is proven that the main mechanism of low-frequency electromagnetic radiation influence on biological objects is governed by the fact that  $E$ , being equal to 30 kW/m, each second  $10^4$  of  $K^+$  ions are introduced into a cell and the same amount of  $K^+$  ions is removed that requires an increased energy consumption (11,12).

With frequencies of 1GHz, the share of ultra-high-frequency energy consumed by water constitutes 50 %, 10 GHz — 90 %, and 98 % - 30 GHz. The effect of ultra-high-frequency energy consumption by cells and tissues is represented by thermal and non-thermal action. Structure and functions of a nerve cell, erythrocyte and other cells are affected. These are organs, which do not contain blood vessels (lens, testicles, ovaries and etc.) that are overheated intensively. In this sense these are eyes, gonads and spermatozoons that are the targets for ultra-high-frequency radiation.

Thermal exposure is spread on the central nervous system, exciting and overexciting it. The central nervous system is damaged very early due to direct and indirect exposure of ultra-high-frequency radiation through the efferent system. Endocrine, immune, cardiovascular and respiratory systems are also subject to damage. At later stages features of energy exhaustion and brain centres depression are observed.(2,22,11)



Under chronic ultra-high-frequency radiation influence radio wave disease accompanied by all regulatory systems functions upsetting onsets. As a result a man's performance drastically decreases and mental disorders are observed. Radiation within a radio band causes noises and whistle sensations. More than twenty years ago it was reported that the radio-audibility effect had been rediscovered. The core point of it is that within the field of a powerful broadcasting station people have heard "inside voices", speech, music and etc.

A complex of negative electromagnetic fields constitutes a direct cause of variety of diseases. A human organism quickly responds to wave load first of all by its performance decrease, then by attention lowering, emotional instability and further on with lots of nervous and cardiovascular disorders, diseases of the most part of internal organs and, in particular, of kidney and liver (5,6).

Relying on data of publications, it is possible to state that electromagnetic fields have negative impact on an organism and under certain conditions may serve a prerequisite for forming pathological states among the population chronically exposed to this radiation. Electromagnetic field causes the development of the ageing syndrome of an organism, the features of which are performance and immunity lowering, various diseases, early disorder in a cholesterol level, reproductive system function depression, development of early age pathology (essential hypertension, cerebral atherosclerosis). The terms of disorders, emerging in an organism, being exposed to electromagnetic field, depend on many factors: frequency band, exposure duration (experience of work), exposure localization (general or local), nature of electromagnetic field (modulated, continuous, intermittent) and others. At this, individual peculiarities of an organism play a significant role. It is experimentally proven that modulated electromagnetic field influence may cause effects opposite to that of non-modulated electromagnetic fields. Using impulse generation of electromagnetic field in the experiment allows to obtain a more marked biological effect than that obtained under continuous radiation. High sensitivity of cerebral cholinergic systems to impulse radiation shows their high biological activity.

In last years it has been clearly proven that the organism functions abnormalities under ultra-high-frequency radiation occur not only because of excess heat generation in tissues. Hence, biophysical mechanisms of electromagnetic fields influence on biological systems can not be limited by the two ones considered above: overheating under ultra-high-frequency fields influence and excitation under low-frequency fields influence. Today the attention of researchers of electromagnetic radiation biological effects is focused on the third mechanism. It is called specific. Most typical feature of this specific effect of electromagnetic fields on an organism lies in the fact that the biological systems' response to extremely low density radiation is insufficient for excitation and heating, but the said responses do not occur in the whole electromagnetic waves range but with certain frequencies. Therefore, the third type of biological systems' responses to electromagnetic fields is also referred to as resonance and weak interactions, frequency-dependent biological effects of electromagnetic fields (1,21,26)

## **FREQUENCY-DEPENDENT BIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS**

Frequency-dependent biological effects of electromagnetic fields described by now are few in number and at the same time various that makes difficult to classify them.

Under the influence of ultra-high-frequency radiation certain bacteria (for instance, colon bacillus) synthesize a peculiar protein – colicin, possessing immunogenic properties with regard to bacteria of other strains. It is observed only at certain frequencies (from 45.6 to 46.1 GHz) with rather low field intensity (up to  $0.1 \text{ W}\cdot\text{m}^{-2}$ ), though the colicin synthesis is also carried out under the effect of other factors. New protein formation is usually explained by the selective action of such factors, including electromagnetic waves of certain frequencies, on a cell's genetic apparatus. Authors of this hypothesis believe that it is not the replication or transcription but translation that changes among genetic information storage and transmission processes (18-24). It is possible that ultra-high-frequency radiation may disturb normal sequence of nucleotides





in a matrix RNA. This results in producing macromolecules, which are not usual for a cell and which are not able to secure full implementation of the relevant functions. Synthesis of “inadequate” proteins first of all affects those substrates, which are actively renewed (for example, enzymes). Changes in the level of metabolic processes and animals’ physiological activity observed by a range of researchers are related with such abnormalities (24,26).

Data about electromagnetic waves effect on cells genetic apparatus are not numerous, they are contradictory and fragmentary. Thus, human gamma globulin loses its antigenic properties if the blood is exposed to electromagnetic radiation of 13.1 — 13.3—13.9 — 14.4 MHz. Electromagnetic fields of other frequencies do not cause the said effect. At the same time it can be explained not using the hypothesis, concerning the electromagnetic waves action on a genetic apparatus. There is an assumption that external electromagnetic fields may interact with the components of plasmolemma. Calcium ions release from the brain tissues exposed to low-frequency electromagnetic radiation is explained in this way (18). This phenomenon occurs only with certain frequencies (6— 16 Hz). Applying ultra-high-frequency fields modulated by low frequencies (with modulation rate being 80—90%) instead of harmonic low-frequency oscillations is particularly efficient.

Calcium hypothesis relies on data about plasmolemma’s structure. Many molecules in its structure have finite chains of aminosugars, protruding into near-membrane space. On cell membrane surface they form multiple areas of immovable negative charges, which are very similar to H- and  $Ca^{2+}$ . These cations are adsorbed by plasmolemma of intracellular medium. It is possible that cations fixed by polyanionic layer of nerve cell plasmolemma may provide its interaction with weak electromagnetic fields. Energy of such fields is not enough for changing ion permeability of an excitable membrane (i.e. for the activation of potential-dependent ion channels in it), but this energy may be sufficient for disturbing electrostatic bonds of cations with membrane aminosugars. As a result cations leave the plasmolemma’s surface and there appears their excess in intracellular medium. According to the calcium hypothesis it refers first of all to calcium ions. Drastic increase of  $Ca^{2+}$  gradient on plasmamembrane of central nervous system neurons may cause excitation since the nerve cells are excited by calciferous current, passing through plasmolemma, covering their bodies (4,12).

In addition to ionic, the membrane and dipole theories of electromagnetic fields interaction with microstructures are considered. Within these microstructures electromagnetic energy conversion into molecule kinetic energy is related with the ideas of fluctuation-probability impact, which is implemented through trigger intensifying mechanisms of a living system (1).

Specific effect of electromagnetic radiation is explained by non-linear nature of the field influence on microstructures. Ultra-high-frequency action mechanism consists in changing the membrane permeability of a cell, which leads to the changes in the nucleotidcyclase system’s function, which influences redox enzymes activity. In humoral way metabolic products cause changes in physiological state. Some authors assume that animals and men possess specific receptors for electromagnetic fields perception.

A.S. Presman (11) offered a new theoretical approach to the problem of biological activity of electromagnetic fields, believing that it should be solved, relying both on the concept of the field-to-organism energy interaction and on the theory of information. In the view of A.S. Presman, electromagnetic radiations of certain (resonance) frequencies can act as signals, i.e. control the release of biological system free energy, without contributing any significant amount of energy to this system from the outside. Excess of the energy of organism responses (changes in metabolism and physiological activity) over the energy of an external field, which has been their cause, represents a parameter of informational exposure of electromagnetic fields. Energy effects of electromagnetic fields are characterized by the fact that the energy of biological system responses is less than that contributed by the field.

Biological effects of weak electromagnetic fields are governed by high selective sensitivity of this or that type of cells to them (in a narrow spectral range). It seems that it is neurons that are most sensitive to weak fields. Specialized electroreceptors have been found



among few representatives of fauna. Human beings have no such receptors. However, the lack of electroreceptors, as well as specific “electric” perceptions does not prove that a human is not able to perceive weak electromagnetic fields. Cerebral neurons interaction with cations (for instance,  $\text{Ca}^{2+}$  according to the calcium hypothesis) when they desorb from plasmamembranes, which have bounded them before, may serve as one of the mechanisms of cerebral neurons selective sensitivity.

Similarly to the principles of an amplifier’s operation (weak incoming signal controls redistributing significant amount of energy at the outlet) the mechanisms of biological system responses on weak electromagnetic fields are defined as amplifying (or cooperative). Weak electromagnetic fields of certain frequencies may act as a pulse driver for some biological systems. They may interact with charges fixed on a cell membrane, as well as evidently with intracellular substrates up to the cell genetic apparatus. However, high gradient of electric potential, existing on plasmolemma, aggravates electromagnetic fields effect on the intracellular systems. Under some pathological states a membrane potential level lowers that may lead to a higher sensitivity of intracellular processes to external fields. This seems to provide patients’ increased sensitivity to atmospheric phenomena.

Last decades’ studies have clearly proven informational role and significance of ultra-weak electromagnetic fields, including those in ultra-low-frequency range under certain laws of their modulation, for biological systems (1).

The development of the idea, concerning the fact that electrons and electromagnetic fields, being more labile than molecules (elements of living matters), bear energy, charges and information, representing a kind of fuel for vital processes, has led many authors to a thought that in an organism there is a system for maintaining bioelectric homeostasis providing normal physiological state of cells. The assumption, concerning the fact that in an organism there is a mechanism for central regulation of physiological processes, which accords with the regularly changing parameters of electric and magnetic fields of the Earth and aimed at protection from strays from sporadically emerging intensive space electromagnetic fields of all frequency ranges, brings us to a thought that in a highly organized organism there is a sensor system, perceiving changes in external medium electromagnetic fields.

Among the regularities in action of ultra-high-frequency fields of non-thermal intensity, detected by different authors, it is possible to distinguish the following ones related with electromagnetic field capability to:

- Influence the course of biochemical responses of intracellular metabolism;
- Impact enzymic activity of proteins – enzymes in the brain, liver and other structures;
- Exert an effect (directly or indirectly) on the processes of genetic information conveyance (on transcription and translation processes);
- Influence the levels of sulfhydryl and other groups, governing polarity of protein molecules;
- Have an effect on neurohumoral regulation and, in particular, on hypothalamo-adrenal and sympatho-adrenal systems;
- Change the dynamics of immune response;
- Change physico-chemical properties of glia and, in particular, its electro-optical density;
- Reconstruct the scheme of pulse flows generated by neurons;
- Change functional activity of receptors and various ion channels.

Thus, as a result of the organism-to EMF electric component interaction three types of biological effects – excitation, heating and cooperating processes – may emerge. Two of them are thoroughly studied and are explained within the concept of energy interaction between a field and an organism. The third effect, which is demonstrated by the biosystems’ perceiving weak electromagnetic radiation, is insufficiently examined. Its origin is evidently related with the fact that in the course of biological systems evolution electromagnetic fields of certain frequencies have acted as carriers of information about the environment. It is evident with regard to light. Informational function of other areas of electromagnetic spectrum has not yet been proved and



properly explained.

## **PECULIARITIES OF DIGITAL NOISE INTERACTION WITH LIVING SYSTEMS AND PROBLEMS OF BIOLOGICAL SAFETY OF ELECTROMAGNETIC RADIATION**

Common use of digital technologies has led to the emergence of a new component of electromagnetic environment of a man, i.e. digital noise. While electromagnetic pollution of the environment is the subject of ecologists' anxiety, a possible role of the digital component as a factor of additional risk has not been considered yet. The necessity to distinguish digital noise out of the electromagnetic background spectrum is imposed by experiments, regarding quite new peculiarities of biological effects of digital noise at the cell level (10).

Introduction of any new technology related with emitting electromagnetic waves into human environment is inevitably accompanied by discussing possible impact on health. With regard to mobile communication it is of particular importance since nowadays it is widely known that ultra-high-frequency radiation may be quite unsafe and a transmitter of a subscriber's set operates directly near a ear in several centimeters from the brain. However, multiple studies have not yet given a clear answer how harmful cellular phone radiation is for its user. Complexity of the problem, insufficient funding, lobbying of manufacturers contributes to the fact that it is unlikely that unambiguous conclusions will be drawn with regard to the problem in question in foreseeable future. That is why we have used the regularities well-known in electromagnetic biology, as well as certain provisions of physics of living world for qualitative assessment of possible consequences of a cellular phone electromagnetic radiation influence on a human organism.

Main safety factor is considered to be smallness of an increased electromagnetic radiation dose, which is defined relying on the fact that a permissible limit of radiation should be considerably lower than the threshold at exceeding which significant changes in a human organism are observed. International safety standards establish the threshold of the so called *Specific Absorption Rate* - SAR of time derivative of electromagnetic field energy, which is absorbed by a mass unit in a body volume of a specified shape and density. Depending on a local standard in different countries SAR varies within  $10^{-2}$ - $10^{-3}$  W /g, that is equal to  $10^{-3}$ - $10^{-4}$  W/cm<sup>2</sup> if converted into power flux density with regard of time slot of averaging. Such values are sure to exceed (approximately by an order of magnitude) the level of radiation obtained in sample calculations and in the course of experiments with experimental volunteers. Let's note, however, that all calculations and measurements refer to carrier frequency. Beyond an operating band in the range of ultra-high-frequency – extremely-high-frequency relative radiation power level does not exceed 10% and may seem to comply with the safety standards.

It is evident that being guided by the principle “the less – the safer”, the standards' authors considered only linear dependence of possible biological effects of an absorbed dose. This is actually true for the so called thermal factor responsible for biological tissue heating at electromagnetic radiation absorption. However, multiple experiments, concerning ultra-high-frequency and extremely-high-frequency fields effect on living systems of very different organization level – from a microbe cell to a man – show fundamental non-linearity of receptiveness (in this case “informational factor” is meant). As a result, the notion of biologically safe intensity becomes vague, to put it mildly.

Moreover, till recently biological response dependence on radiation (monochromatic or noise-type) density has been considered to be though not non-linear but yet monotone. As it succeeded to be shown (10), digital noise gives a new property to biological effects of electromagnetic fields – non-monotone dependence: as intensity lowers the effect may disappear and reappear even showing a tend to changing the sign.

Let's mention one more aspect of the considered problem and namely the issue, concerning “usefulness” or “harmfulness” of this or that electromagnetic radiation frequency band for an organism. Ultra-high-frequency range is usually more likely considered to be “harmful”, including ultra levels of electromagnetic radiation power ( $< 10^{-7}$  W/cm<sup>2</sup> ). With regard to extremely-high-frequency



everything is not so simple. In particular, it is shown that positive for an organism (medicinal) influence of radiation of this part of spectrum, for instance, in extremely-high-frequency therapy techniques, exists only if a set of conditions is met. And, in particular, ultra-low intensity (equal to that of thermal noises ( $<10^{-19}\text{W/cm}^2$ ) and strictly determined localization of exposure. According to multiple experiments in a common case, the biological effects with different signs may be observed. This means that if one is not too optimistic, he should take into consideration a potential hazard of physiological consequences of low-density electromagnetic radiation effect and, in particular, for the brain and auricle where there are many active points.

What are the peculiarities digital noise effect has on living systems? Within the concept of endogenous coherent field, which creates a uniform electromagnetic framework of a living organism, it is supposed that control action of a weak external signal is possible. It is significant that such action should be resonance and individual in view of frequency composition, which reflects the spectrum of characteristic frequencies of a certain organism. It is evident that digital noise with its “monochromatic broadband” spectrum appears to be a multi-purpose instrument, affecting any living object. At this, if one is governed by the idea of “likeness” of external electromagnetic radiation with the fields of cells of an organism, digital noise at the same time represents a driving force for both reduction (extremely-high-frequency range) and destruction (ultra-high-frequency) processes. What will be the consequences of the resonance action of factors with different vectors on an organism? It seems there is no scientifically based answer for this question yet.

### **METHODS OF LOWERING BIOLOGICAL HAZARD OF WEAK ELECTROMAGNETIC FIELDS EFFECT**

Since it is difficult to limit the radiation level due to its fundamental and technological nature, its potentially harmful exposure may be reduced by changing the spectrum structure of a digital signal, consisting in distributing energy in the spectrum as even as possible. For this purpose its recurrence period should be continuously modified from slot to slot, as a result a generated signal ranges the frequency and its spectrum becomes continuous. This principle has been implemented in products with fractal-matrix topology developed by AIRES New Medical Technologies Foundation.

According to its topological arrangement and initiated physical effect AIRES topologies represents a specially configured broadband diffraction lattice. The lattice is a specially formed structure of 1 micrometer wide topological lines. Calculations data shows that such a structure effectively interacts with electromagnetic radiation with a wavelength of about 10 micrometers. In accordance with Plank’s radiation law such wavelength corresponds to the temperature of a human body in a normal state. At this, the lattice restructures radiation evenly distributed in space in a coherent wave structure, representing a matrix of alternate peaks with the intensity several times exceeding the initial one.

The peripheral part of the fractal-matrix topology represents a similarly shaped graphics with a lower topological lines’ density than in its central part, with an interval varying from fractions of a millimeter to several millimeters (approximately up to 2 mm). This part of the lattice topology effectively interacts with electromagnetic radiation of a millimeter range inherent to a human body as it is recorded in multiple scientific works. The diffraction lattice restructures this radiation in a matrix of alternate peaks with the intensity by tens exceeding the initial radiation as well.

Thus, AIRES fractal-matrix structurizers represent devices, converting electromagnetic radiation of the wide frequency-wave range into a coherent field structure, which corresponds to the main characteristics of stable hypercomplex biological objects, i.e. of a healthy human organism.

When interacting with electromagnetic radiation, AIRES fractal-matrix diffraction lattices form a field with certain characteristics and self-similar fractal structure, which general shape stays unchanged after the interaction with the lattice. In other words, AIRES matrix topologies create certain stable boundary conditions, causing directive restructuring of radiation falling on the lattice, which automatically rearranges itself, adapting its structure for the lattice’s characteristics. As a result, due to the interaction with an AIRES matrix topology pattern industrial electromagnetic radia-



tion is effectively corrected; at this, these are peak field abnormalities in a wide spectral range, which are differentiated first of all.

Thus, structural characteristics of the field space are optimized in the near zone that finally leads to a marked reduction of negative electromagnetic radiation effect as a result of optimization of adaptive capabilities of a human organism. Moreover, multiple scientific studies (9,13,14,15 and etc.) clearly prove that using AIREES fractal-matrix topologies as protective devices not only effectively protects a human organism from electromagnetic radiation effect but also encourages improvement of a range of physiological rates of an organism's state. That is why various modifications of AIREES fractal-matrix structurizers may be considered as physiotherapeutic devices, which being passive resonators (deprived of a power supply) interact with electromagnetic radiation of different origin (background, industrial and human body radiation) and have normalizing effect on an organism.

Considering the fact that the problem of negative electromagnetic radiation effect on people is of current interest and the fact that the civilization will inevitably use various technical devices – electromagnetic radiation sources in future, AIREES fractal-matrix diffraction lattices have wide prospects of their use.

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